Making the most of the catch...

Proceedings from an International Post-Harvest Seafood Symposium

FRDC 92/125.30

Brisbane, Queensland, Australia
25, 26, 27 July 1996

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Role of the National Seafood Centre (NSC) is to add value to fish and fish products through:

- planning, funding and managing short-term market focussed, applied research and development with the potential for high return; and
- keeping industry aware of opportunities and technical developments through the promotion of R&D results, and facilitating collaboration between industry and R&D agencies.

The NSC fits within the Fisheries Research and Development Corporation's Industry Development R&D Program the goal of which is to enhance the competitiveness and resilience of the Australian fishing industry.

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The Centre for Food Technology (including the former International Food Institute of Queensland) is one of Australia's leading food research and technology consulting organisations.

The Centre's post-harvest seafood research and consultancy group is the largest in the country and its Brisbane headquarters is also home to the Australian Seafood Extension & Advisory Service or AUSEAS, an initiative that the Centre shares with the Fisheries Research and Development Corporation.

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Being located at the Centre for Food Technology gives the AUSEAS staff access to the facilities of the Centre such as an additional extensive library; pilot plant; and a large group of widely experienced personnel.

AUSEAS also markets and sells many seafood publications and reports.

Symposium Proceedings

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EDITORIAL NOTE:

We have endeavoured to reproduce as faithfully as possible the references and graphical information supplied by the authors. In some instances it was impossible to obtain suitable reference notations or to reproduce graphical data which was supplied with the clarity desired. Therefore if you require further reference or graphical information for any of these papers please contact the author direct.

INTRODUCTION

The papers published in this book were all presented at the Symposium *"Making the Most of the Catch..."* held in Brisbane, Australia, 25-27 July 1996.

The contributors came from many countries and from many different institutions. They were selected in an endeavour to present a broad spectrum of information at a range of levels such that there would be topics of vital interest to each of the participants, whether they were involved in research, industry or regulation. The topics also represent many of the issues which are of current and future concern to the Australian industry, whose export markets are mostly in Asia, particularly Japan. Domestic issues were not neglected and presentations concerned aquaculture as well as the capture fisheries.

This Symposium was organised deliberately to immediately precede the Second World Fisheries Congress which was being held in Brisbane to cover regulation, biology, stock assessment and political issues in fisheries. In view of the fact that the world's fishery resources are fully exploited, the theme of *"Making the Most of the Catch..."* was considered to be highly appropriate to the current situation. The theme was brought out in its many aspects including:

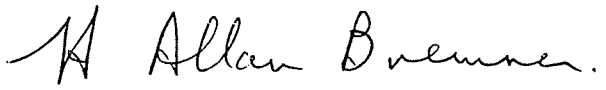
- trading issues;
- the scope of the markets;
- the market demand;
- the need for:
  - better marketing,
  - care of the catch,
  - more reliable products,
  - obtaining better yields,
  - making safe products; and
  - utilising more of what is caught, including material classed as waste.

The funding investment in, and conduct of, research and how best to ensure transfer of results and information, and to effect improvements in communication and training added to the theme. The influence that different practices in feeding, harvesting and transportation may have on live and aquacultured species and how these practices can be controlled to result in a better product broadened the theme. The latest in safety issues, the challenges of inspection, HACCP, better techniques for the development of new products and the influence of process variables extended matters. A notable inclusion was in the example of the integration of catch data with complex process information thus creating a nexus of pre- and post-catch information to optimise yields and to plan fishing operations, a concept not yet employed, and probably unheard of, in fisheries management.

The Symposium was solely organised through the Centre for Food Technology, a unit of the Queensland Department of Primary Industries which also organised an international seafood conference in 1991. However, apart from a conference organised by FAO and held in Melbourne in 1984, *"Making the Most of the Catch..."* is the first international symposium of Australian origin in the field of seafood technology from which written papers have been submitted and published as a proceedings. The Symposium attracted many of the workers from the major institutions around Australia who have involvement in some aspect of seafood research. Probably more important was the fact that it was attended by many scientists from overseas. That result and these proceedings amount to an injection of intellectual capital into the Australian scene facilitating the forging of personal links between scientists working on a similar problem in different situations. It is not just the exchange of knowledge and the continuing value of the material in the written proceedings, but, it is these ongoing personal links from which new and important contacts are made which provide overwhelming justification for meetings such as this.

For the industry to increase its potential earnings by value-adding to its products, by improvement to its quality and through processing its by-products and waste streams into valuable products, it must remain up-to-date with overseas technical advances and understand the technical requirements of its significant markets. It must also identify and support applied research and seek ways of effectively disseminating technical information and in training and recruiting proper staff. This Symposium and these proceedings are a step along the way in helping this happen in *"Making the Most of the Catch..."*. It is anticipated that this volume will be of value to industry technologists, marketers, trainers, inspectors, QA personnel, educators, students and researchers and that it will prove to be a valuable source of information for years to come.

As initiator of the Symposium and Chairman of the organising committee, I wish to thank all the participants and the international committee who reviewed the contributions, the sponsors who underwrote the costs of staging the Symposium and the staff of the Centre for Food Technology who provided such marvellous support in organising the Symposium without external help and in compiling these Proceedings. Special thanks are due to Bev Austin who took on most of this work and can still smile.



Allan Bremner
SYMPOSIUM CHAIRMAN

INVESTING FOR TOMORROW'S CATCH

By Peter Dundas-Smith and Deon Mahoney[1]

Abstract

There is considerable pressure on operators within the Australian fishing industry to adjust their fishing patterns to maximise the value of production from limited, and in some cases, declining wild resources. Most of Australia's commercial wild fisheries are fully exploited. Therefore, the future profitability and sustainability of the fishing industry depends on how the industry responds to fisheries management, stock and environmental constraints and its ability to assess and satisfy market needs. These last two issues also relate to aquaculture.

The ability to increase the net value of products from existing fisheries and from aquaculture will be a key to industry growth. This will be achieved through:

- improved marketing, incorporating product identification; and
- value-adding by improving handling techniques designed to maintain product quality and by developing new products.

Consumer behaviour and food consumption trends demonstrate there will be increased demand for foods which offer convenience, while remaining minimally processed and retaining all their nutritional properties. Unfortunately, the Australian seafood industry has been slow to explore value-adding opportunities.

The Fisheries Research and Development Corporation (FRDC) is working to ensure that opportunities to add value to the catch are not lost, by investing in activities which enhance the competitiveness and resilience of the seafood industry. The Corporation continues to actively support post-harvest research through its industry development program and is involved in:

- funding research and development through the National Seafood Centre (NSC) which is a joint initiative with the Queensland Department of Primary Industries (QDPI);
- assisting in the provision of technical information and advice through the Australian Seafood Extension and Advisory Service (AUSEAS) which is a joint initiative with QDPI; and
- promoting quality and the adoption of quality management systems through SeaQual which is a joint initiative with the Australian Seafood Industry Council (ASIC) and the Department of Primary Industries and Energy (DPIE).

These initiatives have fostered changes within the industry. As the industry continues to shift its focus from quantity to quality and strives to value-add to finite resources, there will be an incentive for fishers to manage the resource more responsibly.

Keywords: Value-adding; Research and Development; By-catch; Exporters; Environment

Of all the food industries, the seafood industry is the most complex. It is an industry preoccupied with the question of property rights over wild fisheries. It is also preoccupied with the consequential incentive — or disincentive — for anyone to put capital investment into the industry. And there are question marks about future access to the resource — stemming from environmental legislation and actions.

Historically, the seafood industry has largely been a cottage industry, rustically romantic, fragmented,

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fiercely independent and focused on the catch. It is certainly not market-driven — not even producer-driven — but fixated on the ritual and challenge associated with the resource.

So how does an industry with that background make more from its catch? Throughout these proceedings many experts will attempt to answer that question and also a concentration of thoughts on value-adding, in many cases related to particular species.

Is value-adding the right direction for the industry? How important is value-adding to the seafood industry's future?

This paper will answer these questions and will begin with a very basic analysis of the future directions for the seafood industry. To make money a business has to: *increase income* and/or *decrease costs*. To increase income, the options for the seafood industry appear to be *to catch more fish* or *to get higher prices for fish (or both)*.

World production from wild fisheries has been contracting in recent years, because most fish stocks are fully exploited or over-exploited.

The volume of **Australian** fisheries production has declined slightly in recent years and there is limited potential for substantial increases in production from Australia's wild fisheries in the medium term. However, as stocks recover, improved fisheries management may allow production from wild fisheries to rise over the longer term.

Prospects for discovering major new fisheries are relatively poor. However, production levels of a number of species, currently under-utilised, could increase if the demand was greater. At present, large amounts of incidental catch are discarded because the selling price would not cover handling, processing and marketing costs. Regardless of the need to reduce by-catch in the interests of ecological sustainability, better marketing of these species may increase returns on current production levels. Such marketing would aim to reduce consumers' uncertainty or lack of awareness about the species.

Restructuring of fisheries to meet the demands being placed on the industry will continue to be a major need. For output-controlled fisheries, changes in quota allocations will change incentives in terms of catch size, harvest techniques, seasonality of harvest and development of individual and collective marketing arrangements. For input-controlled fisheries, changing management arrangements to reduce effort will affect the efficiency of operators. Restructuring will affect the ability of some to remain viable in the industry.

On the other hand, restructuring should increase the income of fishers who remain in the industry, which may lead to increased demand for industry-related and unrelated goods and services. The overall effect on the economy will depend on the balance of these impacts.

In contrast to production from wild fisheries, supply of fish from the aquaculture sector — at present accounting for about 16% of Australia's gross value of production of fisheries products — is likely to increase, particularly in crustacean production, despite hindrances of disease, environmental problems and production costs.

Therefore, the potential to catch more fish appears to be with increasing fish stock through aquaculture — which includes re-stocking of fisheries, albeit there is little evidence of the potential for re-stocking.

Reducing fishing effort will enable some fishers to catch more fish. However, the economic benefit to the industry as a whole is doubtful.

What about getting higher prices for fish? Concern for the environment and conservation of marine resources are major issues affecting the economic performance of Australia's fishing and aquaculture sectors. Production potential may be reduced by changes in ecosystems. Measures adopted to avoid environmental problems may increase costs of production for the fishing and aquaculture sectors. In addition, perceptions of environmental problems are likely to influence consumer preferences and demand for seafood products.

Changing demand affects Australia's exports, as do international exchange rates, international agreements and trade negotiations.

An increase in non-tariff barriers could counteract benefits to Australian exporters from lower tariffs resulting from the final Uruguay Round of GATT. In particular, a recent proliferation of regulations, including protection of non-fish by-catch, customs procedures and hygiene, sanitary and phyto-sanitary measures, has occurred in response to environmental requirements. Whether incidental or by design, these regulations may also act as trade barriers to protect domestic producers. Such non-tariff barriers are difficult to identify and measure, making it difficult to quantify their effects.

Both tariff and non-tariff barriers act to fragment markets and discourage trade, reducing the international competitiveness of exporters and returns to the Australian harvesting sector. Against this marketplace scenario, fish consumption is likely to leap by an extra 30m t by the year 2000.

Clearly, the future market-place for Australian seafood is going to be complex, requiring a greater appreciation of market forces. The industry has resisted industry-wide marketing initiatives, but this will need to change. The generic promotion activity of the newly-formed Australian Prawn Promotion Association (APPA) is a sign for other sectors of the industry to follow.

Recent research has indicated trends among consumers that will impact on the food retail and food service sectors, and the types of food to be developed. The following factors shaping future consumer behaviour have been identified:

- Consumers will become more affluent and more highly educated.
- They will become more pressed for time.
- They will become more demanding through having travelled more widely.
- They will choose in favour of healthier diets.

Food production, acquisition, preparation and consumption will become more innovative in response to changes in technology and consumer demands.

Already in evidence in countries such as the USA and Australia, these trends are predicted to occur in the cities of East Asia.

Therefore, the potential to get higher prices for fish and fish products appears to lie with targeted and well-funded promotion and marketing — aimed at convincing consumers to pay more for a quality product, and producing a quality product through value-adding.

On the other side of the balance sheet to decrease costs, the options for the seafood industry appear to be to *improve processes* or to *reduce operating expenses*.

Research has shown that in some organisations up to 40% of effort can be attributed to re-work and waste: that is, 40% of output that consumers are not prepared to pay for. The industry needs to integrate into all its activities a "quality approach" that ensures that all work is performed according to a systematic, controlled process, in an environment conducive to a philosophy of continuous improvement. In the food industry, there is a real link between the quality of the food product and the process that produces it.

Operating expenses fall into two broad categories — *discretionary* and *non-discretionary*. At times it is difficult to distinguish between the two.

Non-discretionary expenses would include levies, tariffs and so on. These can only be reduced through a credible industry profile that will ensure more effective communication with government and other regulatory bodies. In today's economic climate, such reductions will be difficult to achieve.

Discretionary expenses would include those over which operators have some control and which can be reduced through better management or innovation. Feed costs, for example, could be reduced through Research and Development (R&D).

Figure 1 shows that there are four keys to making more of the catch. These keys listed here will be detailed further on:

- selective aquaculture;
- targeted, well-funded promotion and marketing;
- value-adding through product development; and
- value-adding through quality assurance.

However, the picture also shows that there are essential links between these elements. For example, value-adding without marketing will be unlikely to realise optimum profit levels.

For many of you, this is not news — and indeed over the last three to four years the industry has embraced, to varying degrees, these keys to its future. I hasten to repeat my opening remarks, however, that by and large the industry remains focused on the catch and its right of access to the catch. For many reasons most, probably 80%, of fisheries R&D funding will continue to be directed towards achieving sustainable levels of the wild catch. Nevertheless, it remains for those organisations, such as the FRDC, with the capacity to assist in furthering the industry to ensure its sustainable development.

Previously in this paper, four keys to ***making the most of the catch*** have been identified. This paper will now focus on these keys and explore the role the FRDC plays in facilitating the further development of the Australian seafood industry.

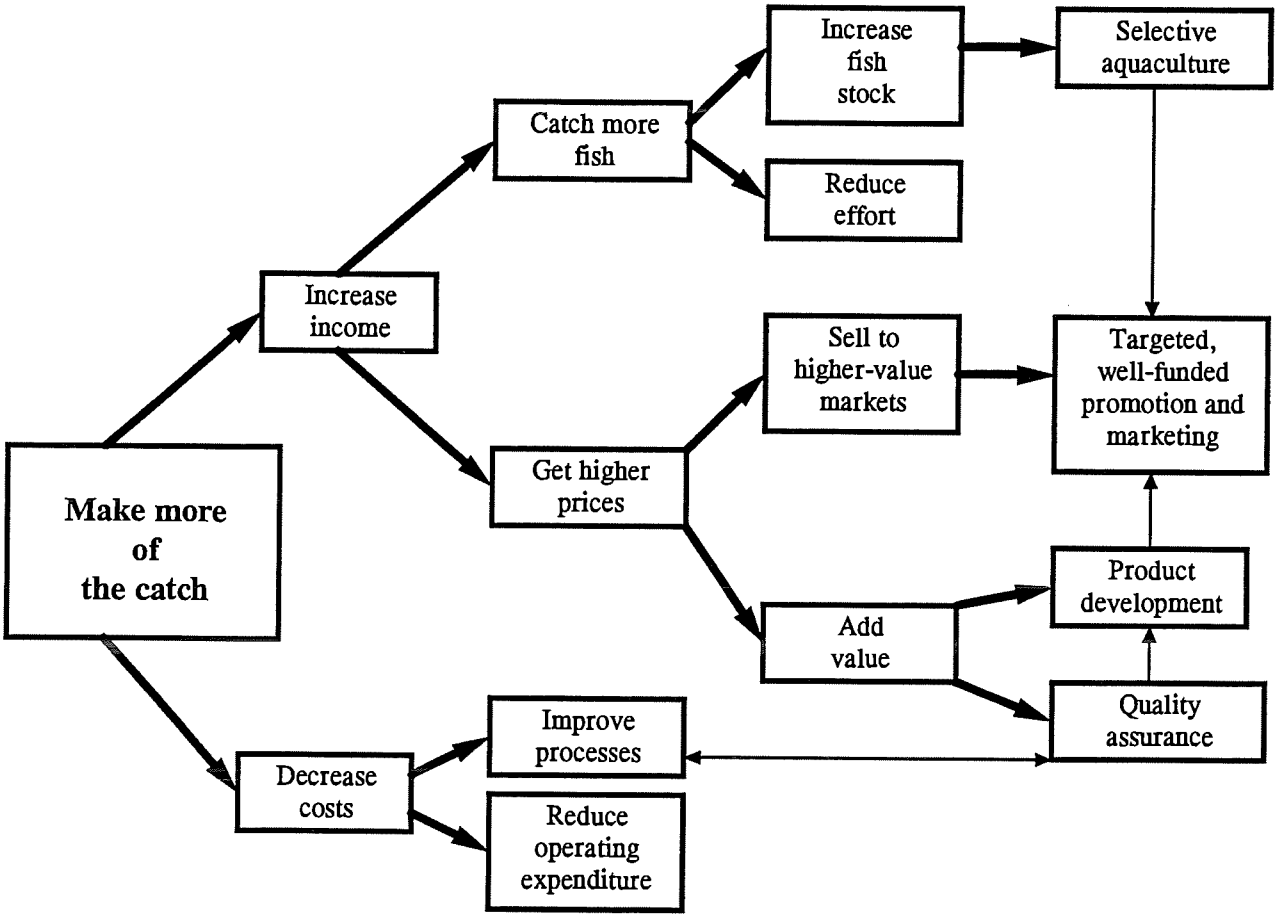

Figure 1: Today's investment for tomorrow

EFFECTIVENESS OF R&D EXPENDITURE

The strategies used by the FRDC to maximise the effectiveness of its R&D expenditure are:

- providing leadership in R&D;
- developing and maintaining R&D programs that meet the needs of its stakeholders;
- investing in R&D with the greatest potential return;
- managing R&D programs efficiently and effectively; and
- promoting technology transfer and/or commercialisation of R&D results.

These imperatives require the FRDC to devote a significant proportion of funds to development, technology transfer and evaluation.

SELECTIVE AQUACULTURE

It is beyond the scope of this paper to address the development of aquaculture in Australia. In fact we could devote the whole symposium to addressing the role of aquaculture in increasing seafood production and in stock replenishment.

The FRDC funds aquaculture R&D under the Industry Development program. Examples of projects currently being undertaken include:

- A vision of Tasmania's aquaculture and fishing industries by 2005 and industry development plans to achieve it.
- Huon estuary study - environmental research for integrated catchment management and aquaculture
- Aquaculture diet development subprogram - Diet validation and feeding strategies
- The development of aquaculture techniques for production of the WA dhufish (*Glaucosoma hebraicum*)
- Development of the aquaculture capability of the brown tiger prawn, (*Penaeus esculentus)*

PROMOTION AND MARKETING

While there is increasing demand for high quality seafood in Australia, there is also substantial and growing export market opportunities for Australian seafood products, particularly in Asia. However, we need to examine the way we put product into the marketplace. Specifically, we must be focussed on the needs of the market rather than being

production driven. Unfortunately, there are insufficient resources directed towards the gathering of market intelligence, developing marketing strategies and marketing of seafoods. Some examples of projects addressing marketing and promotion are:

- Electronic marketing of fisheries products.
- Evaluation of factors influencing prices of domestic seafoods.
- Seafood market trends in the Republic of Korea.
- Scallop aquaculture: The growth, processing and marketing of live scallops.
- Fishing Industry Marketing Strategy.

There is no statutory marketing authority for the seafood industry, and any attempt to create such an entity has always been vigorously opposed. Nevertheless APPA funds promotional activities designed to enhance the sale of sea-caught prawns in export markets.

PRODUCT DEVELOPMENT

While the Australian seafood industry is renowned for the diversity of high quality fresh fish and seafoods, especially in the food service sector, the same cannot be said about processed seafood products at the retail level. With few exceptions, the majority of highly processed seafood products (marinades, terrines, canned products, etc) are imported. Large quantities of seafood continue to be sold as chilled fillets and whole fish. In fact the industry is often criticised by the food service sector because of the widespread inability to deliver products which are:

- quality assured;
- portion controlled; and
- price controlled.

Recent economic studies have found that research confers the largest benefit to the agriculture sector by adoption of *"best practice"* productivity measures. This is particularly pertinent to fisheries given that most Australian fisheries are fully exploited, future profitability will come largely from increasing the net value of products from existing fisheries. This can be achieved through:

- improved marketing, incorporating product identification;
- enhanced processing and handling techniques designed to maintain product quality; and
- the development of new and innovative seafood products.

The food service sector is a very large customer of the seafood industry and it is constantly concerned about erratic supply, over-pricing, lack of species identification, dubious wholesale practices, lack of product innovation, etc.

The Australian seafood industry has been slow to explore and exploit the market potential of value-added seafood products. This is surprising as seafood enjoys a high level of acceptance by consumers because of public perceptions about the role it plays in a healthy diet. Supermarkets and fish shops sell very few processed or pre-prepared seafood products. In contrast there are a multitude of convenience foods based upon chicken meat.

This situation is due in part to the opportunities to market Australian seafoods on lucrative export markets. As a result, our seafood processors tend to be brokers, rather than being involved in food processing and value-adding. This places great pressure on domestic supply and results, at times, in volatile raw material prices. Unfortunately, much of the industry has failed to grasp the opportunities to utilise under-valued species, manufacture seafood products from by-catch or by-products, or to examine true value-adding opportunities because of:

- a lack of technical expertise and knowledge;
- insufficient investment in research and development; and/or
- a poor understanding of the market and poorly developed marketing skills.

While the term value-adding has been over used in recent years, its true meaning is not well understood. It is not about increasing the price of the final product by increasing the input costs. It is about increasing the final value of the product by innovative handling, processing, packaging, etc without significantly adding to the cost.

Care in the capture, handling, packaging, and transport of marine finfish such as coral trout, so they may be sold in the Hong Kong live finfish market is a form of value-adding. So too is taking processing by-products such as shark backbones, and converting them into powdered shark cartilage. The use of by-catch reduction devices may also be a form of value adding. The exclusion of non-target species and marine mammals results in less damage to the catch, less effort in sorting, and the achievement of environmental obligations.

The FRDC invests in value-adding R&D projects and infrastructure designed to facilitate and progress value-adding opportunities. This is particularly pertinent as market research has indicated that future buying patterns and consumer behaviour in the retail and food service sectors will be influenced by:

- consumers being more affluent and more highly educated;
- the changing tastes of consumers and their demand for new and innovative food products;
- the need for greater convenience especially as consumers are more pressed for time; and
- changing perceptions about food quality, nutrition and healthy diets.

Examples of projects addressing value adding are:

- New product development from low value species
- Value adding to seafood by application of modern drying techniques
- Prawn presentation and product development
- Post Harvest and value adding techniques for jellyfish

As well as funding R&D projects examining value-adding, the FRDC has strived to establish infrastructure to support industry development initiatives in the post-harvest sector of the fishing industry. Some of these initiatives are briefly discussed below:

National Seafood Centre

The National Seafood Centre (NSC) was established in 1992 under a joint arrangement between the FRDC and the Queensland Department of Primary Industries (QDPI). The role of the Centre is to add value to fish and fish products through:

- planning, funding and managing short-term, market focused, applied R&D; and
- facilitating the dissemination, adoption and commercialisation of the results of R&D.

The NSC has funded in excess of 25 projects across a broad range of seafoods and industry sectors. Increasing the efficiency and effectiveness of the seafood industry is an important means of ***making the most of the catch***. NSC projects have developed fish skinning equipment resulting in reduced labour costs and improvements in the quality of the final product.

Work on improving the techniques and logistics of live transport of finfish provides another good example of what can be achieved with carefully planned R&D investment. In recent years there has been rapid expansion in both the volume and number of species of fish which are sold as live product. Live seafood products must be captured, handled, held, packaged and transported with great care. If performed effectively, processors can achieve good returns from the sale of relatively small numbers of fish. This change in focus from quantitative to qualitative has the additional benefit of reducing pressure on many of our fisheries resources.

The NSC is taking an active role in facilitating the expansion and growth of the live seafood industry. The Centre recently commissioned a review of the live seafood industry with the objective of assisting in the development of the industry by enhancing the flow of information, improving communication and broadening market opportunities. The results of an industry survey and preliminary results of FRDC funded research were released at the **Live Seafood Transport Forum** which was held in Hobart in October 1995. The NSC is also funding research into the oxygen requirements of finfish during transport, and work on live transport of the tropical lobster.

The tuna farming work in Port Lincoln is an example of R&D working to improve the value and quality of Southern Bluefin tuna in the Japanese market. Investment has been made through the whole chain: capture, farming, diet development, harvesting and post-harvest handling.

AUSEAS

The Australian Seafood Extension and Advisory Service (AUSEAS) located at QDPI's Centre for Food Technology provides the seafood industry with a comprehensive extension service on post-harvest seafood technology, facilitating the adoption of leading-edge technology. For more details see paper titled "Start spreading the news" at the back of these proceedings.

Quality assurance

The relevance and importance of quality management practices to the seafood industry has been discussed widely in other forums (Mahoney 1996).

Seafood processors striving for a long and profitable future need to introduce quality management systems and embrace the concept of continuous improvement. Quality management must be a strategic decision of an enterprise; as it strives to meet the identified requirements of the marketplace, improve its products and processes, reduce costs and improve efficiency.

The FRDC is working with the seafood industry to raise awareness of quality management by investing in quality management projects and quality initiatives.

A major initiative has been the formation of SeaQual which is a partnership between FRDC, ASIC, and DPIE to facilitate the spread of quality management systems throughout the seafood industry. This will be achieved by developing: a quality management inventory; a seafood quality strategic plan; and a seafood quality investment framework. Ultimately, SeaQual will increase awareness of the benefits of quality management in the seafood industry and assist the industry to adopt world's "best practice".

CONCLUSIONS

The FRDC is committed to the sustainable development of Australia's fisheries and aquaculture resources. This is clearly demonstrated by the Corporations ongoing investment for tomorrow's catch. The Corporation has invested $A33m in 370 projects during its first 4 years. Our 1996/97 Annual Operating Plan provides for the investment of $A13.5m in more than 200 new or continuing projects.

While the industry increasingly recognises the Corporation's leadership in industry development, much remains to be achieved. The industry must continue to explore opportunities to ensure we are ***making the most of the catch*** and to invest in R&D.

Australian seafood industry has considerable potential to expand in both domestic and export markets. Whilst a clear understanding of the needs of the marketplace is essential for success, it must be underpinned by sound technical knowledge, appropriate infrastructure, and product innovation.

REFERENCE

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LIBERALISATION WITHIN THE APEC REGION

The Australian fisheries and aquaculture industries

By Rebecca Standen, Peta Every, Michael Schuele, and Deborah Brown[1]

Abstract

The Asia Pacific Economic Cooperation (APEC) region represents a significant market for Australian seafood exports. In 1994-95, the total value of Australian fisheries exports to the APEC region was valued at $A1.14b, a 3.2% increase over 1993-94. Australia exports around 88% of its fisheries products into the APEC region and sources 75% of Australia's total fisheries imports from that region.

Currently, Australia's major seafood exports are high value unprocessed species catering for niche markets and attracting relatively low tariffs. It is likely that barriers to trade have been influential in the composition, volume and destination of Australian seafood exports, mainly through their effects on retarding growth in exports of processed product and denying Australian seafood exports access to some markets.

Trade reform is one of three broad themes in the APEC agenda, the others being trade facilitation and development assistance. On trade reform, the APEC commitment is to achieve free and open trade and investment by the year 2020 for developing countries and 2010 for industrialised countries.

The objective in this paper is to discuss the implications that the APEC liberalisation process will have for Australia's seafood industry.

Keywords: Asia Pacific Cooperation; APEC; Trade barriers; Aquaculture; Imports; Exports

BACKGROUND

The APEC forum was established in 1989, in part, as a vehicle for reducing impediments to trade. Originally, a major purpose of APEC was to promote the Uruguay Round of GATT negotiations. As such, one of the guiding principles of APEC is that any trade liberalisation between member countries be consistent with GATT principles (Phillips *et al.* 1993). More recently, an important feature of the APEC process has been one of promoting free and open trade and investment between member countries beyond that agreed under the Uruguay Round.

In November 1994, the APEC Economic Leaders Declaration of Common Resolve (the Bogor Declaration) set out a commitment to achieve free and open trade and investment by the year 2020 for developing member countries and 2010 for industrialised member countries (APEC 1994). It represented the first formal declaration for achieving regional cooperation among the economies of the Asia Pacific region since APEC's inception. In addition to achieving free and open trade by 2020, the declaration also set out commitments to accelerate the implementation of the Uruguay Round agreement, to actively support the multilateral trade system, to continue unilateral trade and investment liberalisation and to endeavour to refrain from a return to protectionism (Bureau of Industry Economics 1995).

The APEC trade liberalisation process is based on a commitment to open regionalism which involves regional economic integration without discrimination against economies outside the region (Garnaut 1994). Within this commitment to open regionalism, APEC is relying on a process of consensus, flexibility, peer pressure and a sense of regional community to achieve its goals

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(Standen 1996). There are currently 18 APEC member economies — Australia, Brunei, Canada, Chile, China, Hong Kong, Indonesia, Japan, Malaysia, Mexico, New Zealand, Papua New Guinea, the Philippines, South Korea, Singapore, Taiwan, Thailand and the United States.

While the Bogor Declaration provided a commitment to achieving free and open trade and investment, it did not give any indication of how this would be achieved. This question was addressed at a meeting of APEC leaders held in Japan in November 1995. The Osaka Action Agenda was established at this meeting to carry through the commitments established at Bogor (APEC 1995a). The Osaka Action Agenda consists of two parts. The first part is concerned with liberalisation and facilitation, setting out a list of general principles to be applied to the entire APEC liberalisation and facilitation process as well as a framework for liberalisation and facilitation. The second part is concerned with economic and technical cooperation within APEC (APEC 1995b).

Member countries are to provide the first of several action plans in 1996, to give a specific outline for 1997 and a broad outline for later years of their trade liberalisation programs. The submission of the action plans is necessary before there can be any progress made on the objectives which have been set by APEC as a cooperative body.

FISHERIES AND THE OSAKA ACTION AGENDA

The major underlying problem in most Australian fisheries is that there is substantial excess capacity in the industry. This leads directly to overfishing and considerably less than the maximum profitability in most fisheries. Similar problems are faced by a number of APEC member countries. In order to promote the long term optimum use of the region's fisheries resources, cooperation among member countries is required.

This area of fisheries is addressed in the second part of the Osaka Action Agenda, dealing with economic and technical cooperation (APEC 1995b). According to the Osaka Action Agenda, APEC economies will set priority on the following:

- promoting the conservation and sustainable use of fisheries resources, the sustainable development of aquaculture and habitat preservation;
- solving common fisheries resource management problems and aquaculture disease control;
- enhancing the food safety and quality aspect of fish and fisheries products; and
- promoting sector specific work related to trade and investment liberalisation and facilitation.

These priorities are to be met by the APEC Fisheries Working Group under the general principles of the Osaka Action Agenda.

The APEC Fisheries Working Group was set up to investigate existing agreements on international cooperation in fisheries management and identify areas needing improvement. The goal of the APEC Fisheries Working Group is to maximise the economic benefits from, and the sustainability of, fisheries resources for the common benefit of all APEC members. In achieving this goal, the APEC Fisheries Working Group is guided by a number of basic principles, including shared responsibility for the sustainable development of the region's fisheries and aquaculture resources, shared experiences in dealing with common interest issues, liberalisation of trade and investment within the region in a GATT consistent manner and the advancement of economic growth, education and training throughout the region (APEC Fisheries Working Group 1995a).

A number of joint activities have already been completed by the Fisheries Working Group in achieving its goals. Among others, these include the development of an inventory of fisheries training facilities within the APEC region, a survey of non-tariff barriers affecting trade in fisheries products (in association with the Pacific Economic Cooperation Council [PECC] Fisheries Taskforce) and a workshop on the Hazard Analysis and Critical Control Points (HACCP) approach to quality assurance.

A study on improving market information on seafood trade within the APEC region was completed in late 1995. The study originated from concerns within the APEC Fisheries Working Group that opportunities to improve the contribution of trade to economic welfare within member countries were being lost because of a lack of adequate information. Specifically, information about fish stocks, catches, delivered supplies, species and products and prices in key centres within the region were identified as being inadequate (APEC Fisheries Working Group 1995a).

The results of the study indicated that the prospects for improved information were fairly good, with much of the information already being collected and with the technology needed to process, store,

transmit and retrieve this information available. The study also found there was a willingness among member countries to cooperate and commit resources to this initiative. However, a number of impediments to improving market information within the region were also identified. These impediments related to problems such as accessibility, timeliness, accuracy and completeness of data.

Other medium-term activities currently being undertaken focus on areas such as the level of subsidies that exist in the fisheries sectors of member nations, the use of HACCP based principles for product quality and food safety, information on investment laws specific to the fisheries and aquaculture sectors, technical cooperation in resolving resource management issues and information on barriers to seafood trade (APEC Fisheries Working Group 1995a).

Long-term activities focus on such issues as the promotion of harmonised standards for fisheries products and an analysis of the impacts of subsidies in the fisheries sector on trade, resource management and conservation. Economic instruments are to be used to address environmental and resource management challenges and there is to be development and implementation of cooperative programs designed to encourage sustainable development in fisheries and aquaculture (APEC Fisheries Working Group 1995a).

FISHERIES TRADE WITHIN APEC COUNTRIES

The major importing countries of fisheries commodities within APEC are Japan and the United States (Table 1). Japan is the most significant importer of fisheries commodities within APEC, with imports in excess of $A14b in 1993. The major fish commodities imported by the Japanese in that year were fresh, chilled or frozen tuna and salmon. Frozen shrimp, prawns and crabs were among the major crustaceans imported, while frozen squid, cuttlefish and octopus the major molluscs imported (FAO 1995).

In 1993, US imports of frozen shrimps and prawns (FAO classification) were valued at over $US2b, around a third of the total value of fisheries commodity imports for that year. In 1993, the major fish products imported by the United States included frozen fish fillets, fresh, chilled or frozen tuna, fresh, chilled or frozen salmon and prepared or preserved tuna and bonito (FAO 1995).

The United States is also a significant exporter of fisheries products within APEC (Table 1). The majority of fisheries commodities exported from the United States are frozen fish. Frozen salmon, frozen fish fillets and frozen liver and roe are among the major commodities exported (FAO 1995).

Table 1: Fisheries trade within APEC countries (current prices - $USm)

	Imports			Exports		
	1991	1992*	1993*	1991	1992*	1993*
Australia	360	379	360	578	639	670
Brunei	7	7	6	1	1	1
Canada	675	687	821	2,168	2,085	2,055
Chile	9	22	19	1,067	1,252	1,125
China	438	681	576	1,182	1,560	1,542
Hong Kong	1,232	1,398	1,377	643	623	562
Indonesia	47	56	100	1,186	1,179	1,419
Japan	12,085	12,832	14,187	848	792	767
Malaysia	171	245	265	265	295	307
Mexico	53	74	128	397	317	431
New Zealand	37	34	36	556	655	648
Papua New Guinea	35	36	48	14	14	14
Philippines	96	111	95	468	394	478
Singapore	461	544	567	5,500	494	482
South Korea	578	505	546	1,500	1,366	1,335
Taiwan	242	na	na	780	na	na
Thailand	1,053	942	830	2,901	3,072	3,404
United States	6,000	6,024	6,290	3,282	3,583	3,179
TOTAL APEC	**23,579**	**24,577**	**26,251**	**18,336**	**18,321**	**18,419**

* Totals for 1992 & 1993 exclude Taiwan as figures were not available. na = not available.

SOURCES: FAO 1995; Department of Agriculture and Forestry Taiwan 1992.

Table 2: Major seafood exporters to selected APEC countries

Importers	Major exporters
Australia	Thailand; New Zealand; Canada; United States
Canada	United States; Japan; Thailand; Hong Kong
Hong Kong	United States; China; Japan
Japan	United States; Taiwan; China; South Korea; Thailand; Indonesia
Malaysia	Thailand; Indonesia; Japan; Taiwan; India (non-APEC)
Singapore	Malaysia; Thailand; Taiwan; Myanmar (non-APEC)
South Korea	Russia (non-APEC); United States; China; Argentina (non-APEC); Japan; Indonesia; New Zealand; Canada; Chile
Taiwan	Chile; Japan; United States; Australia; Hong Kong
Thailand	Taiwan; United States; Japan; Indonesia

SOURCE: APEC Fisheries Working Group 1995b.

Thailand is the other major exporter of fisheries commodities in the region, with exports valued at $US3.4b in 1993 (FAO 1995). Frozen shrimp and prawns are the major export commodities from this country, with exports of frozen shrimp and prawns valued at $US1.47b in 1993. The majority of these exports are derived from aquaculture. Canada, China, Indonesia, South Korea and Chile also export fisheries commodities in significant quantities (Table 1).

Intraregional trade is dominant within APEC, with APEC membership being the main source of supply for the major importing members (APEC Fisheries Working Group 1995a). This dominance of trade among APEC members is illustrated in Table 2.

AUSTRALIAN EXPORTS TO APEC COUNTRIES

APEC member countries account for the majority of the total value of Australian seafood exports. In 1994-95, nearly 90% of the total value of Australian seafood exports were derived from APEC countries. The major markets for Australian seafood within APEC are Japan, Hong Kong, Taiwan and the United States.

Rock lobster is the most valuable Australian seafood export commodity, with total rock lobster exports valued at $A474m in 1994-95 (ABARE 1995). The majority of rock lobster is exported to APEC members, with over 77%, by value, destined for the region in 1994-95. The major export markets within the region are Hong Kong, Taiwan, Japan and the United States (ABARE 1995).

The composition of rock lobster exports has changed considerably over recent years. Specifically, there has been a trend toward the export of live, fresh or chilled rock lobster. Hong Kong is the major market for this product, with exports of live, fresh or chilled rock lobster valued at over $A92m in 1994-95. Taiwan and Japan are the other major markets for this product. In contrast, exports of rock lobster tails fell over the same period, with exports to the United States (the major market for this product) falling considerably over recent years (ABARE 1995).

Total Australian exports of prawns were valued at over $A231m in 1994-95, with prawn exports to APEC member countries valued at over $A216m for the same period. Japan is the major export market for Australian prawns within APEC (ABARE 1995).

In 1994-95, exports to the region accounted for 99% of the total value of abalone exports. Japan was the most important export market for fresh, chilled or frozen abalone in 1994-95, followed by Hong Kong. Japan was also the most important market for canned abalone in 1994-95, followed by Taiwan, Hong Kong and Singapore (ABARE 1995).

APEC IMPORT DEMAND

A number of factors are likely to influence the level of demand for fisheries commodities within APEC. These include consumer preferences, income levels and population growth.

Consumer preferences for fisheries products are relatively strong within APEC. Consumption of fisheries products within the region accounts for about half of total fisheries products consumed worldwide (APEC Fisheries Working Group 1995b). Average per person consumption of fisheries commodities for the region was approximately 29.7 kg/yr for the period 1988-90, almost double the world average for the same period (FAO 1995).

Japan has the highest per person consumption of fisheries products within both APEC and the world (Table 3). Hong Kong, South Korea and Taiwan are also relatively large consumers of fisheries products.

Table 3: Consumption of fisheries products per person in APEC countries (kg/yr)

	1982-84	1984-86	1986-88	1988-90
Australia	16.0	16.2	18.6	18.6
Brunei	37.7	42.7	31.0	28.9
Canada	21.4	22.4	26.9	22.9
Chile	18.7	19.4	19.9	23.4
China	4.9	6.1	8.0	9.4
Hong Kong	45.0	46.1	50.9	53.5
Indonesia	12.6	13.6	14.0	14.8
Japan	74.5	69.3	71.2	71.9
Malaysia	44.1	36.6	30.1	27.5
Mexico	9.9	9.9	9.8	11.0
New Zealand	12.2	12.9	13.0	27.5
Papua New Guinea	15.1	18.2	24.8	23.0
Philippines	35.7	33.7	33.8	35.5
Singapore	35.7	40.7	34.0	29.4
South Korea	44.4	51.1	49.6	48.1
Taiwan	34.4	37.0	42.7	47.2
Thailand	21.6	21.6	20.8	20.4
United States	17.4	18.4	20.5	21.3
World	**12.1**	**12.4**	**13.1**	**13.3**

SOURCES: FAO 1995; Department of Agriculture and Forestry Taiwan 1992.

Economic growth is particularly strong within the South-East Asian APEC countries (Table 4). These countries have experienced high growth in recent years and this is expected to continue over the medium-term. The effect of increases in income on the demand for fisheries products is, in part, dependent on how consumer preferences will be affected by such factors as the distribution of income, cultural and social attitudes and the nutritional status of the population.

As the region is characterised by diverse economies, the medium-term effect of an increase in income will be different for each member economy. If economic growth led to higher incomes per person, then it may be the case that in countries such as Japan, Hong Kong and South Korea there would be greater demand for luxury products such as lobster.

APEC member countries have a combined population of 2.17b, nearly 40% of the world population (FAO 1995). Population growth rates within the developing Asian economies are relatively high, compared with the world rate, particularly within the Philippines, Malaysia, Indonesia and Singapore. If current trends continue, population growth in the APEC region will lead to greater demand for seafood products.

Table 4: Economic growth rates for APEC countries* (%) (Growth in GNP or GDP in constant prices)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Australia	1.8	4.6	4.7	4.3	1.2	-1.3	2.5	3.6	5.1	3.6	3.0
Brunei	na	na	na	na	na	na	na	na	na	na	na
Canada	3.3	4.2	5.0	2.4	-0.2	-1.8	0.8	2.2	4.6	2.5	2.5
Chile	5.6	6.6	7.3	9.9	3.3	7.3	11.0	6.3	4.2	na	na
China	8.5	11.1	11.2	4.3	3.9	8.0	13.2	13.8	11.9	10.0	9.0
Hong Kong	11.1	14.5	8.3	2.8	3.2	4.2	5.0	5.8	5.5	5.5	5.0
Indonesia	5.9	4.9	5.8	7.5	7.2	7.0	6.5	6.5	7.3	7.7	7.5
Japan	2.6	4.1	6.2	4.7	4.8	4.3	1.1	-0.2	0.5	0.5	2.2
Malaysia	1.0	5.6	8.9	9.2	9.7	8.7	7.8	8.3	8.7	9.0	8.5
Mexico	-3.8	1.9	1.2	3.3	4.4	3.6	2.8	0.6	na	na	na
New Zealand	3.3	-0.8	1.2	-1.0	2.6	-2.0	2.2	4.8	6.1	3.8	2.8
Papua New Guinea	5.7	2.8	2.9	-1.4	-3.0	9.5	11.8	14.4	na	na	na
Philippines	3.4	4.3	6.8	6.2	3.0	-0.6	0.3	2.1	4.3	5.5	5.5
Singapore	1.8	9.0	14.2	9.4	8.1	7.0	6.4	10.1	10.1	8.0	7.5
South Korea	12.4	10.7	11.3	6.4	9.5	9.1	5.1	5.8	8.4	9.5	7.5
Taiwan	11.6	12.3	7.3	7.6	4.9	7.2	6.5	6.1	6.5	6.5	6.5
Thailand	4.9	9.5	13.3	12.2	11.6	8.4	7.9	8.2	8.5	9.0	8.0
United States	1.0	5.0	4.5	1.5	0.0	-1.8	3.5	3.5	5.9	3.4	2.8

* ABARE assumptions. na = not available.

SOURCES: ABARE 1995; International Monetary Fund 1996.

BARRIERS TO SEAFOOD TRADE WITHIN APEC

A survey undertaken by the Pacific Economic Cooperation Council (PECC) found that within the APEC region, tariffs were higher, on average, for fisheries products than for other industry groups. For example, unweighted tariff averages within APEC were around 15% for fisheries products in 1993, compared with 13% for agricultural products. Tariff rates were found to be directly related to the level of processing, with higher tariffs associated with higher levels of processing. A key finding of the survey was that tariffs tend to be high in sectors where domestic producers are not competitive (PECC for APEC 1995). This situation is not restricted to fisheries, with similar findings in other sectors such as agriculture. For example, Tarchalski *et al.* (1996) found tariff protection of highly processed wheat products to be substantially above tariff protection for lightly processed products which were in turn substantially greater than tariffs for unprocessed wheat for a number of member of Association of South-East Asian Nations (ASEAN).

However, the PECC survey found non-tariff barriers to be below average for fisheries products when compared with other industry groups. The non-tariff barriers surveyed were described as core non-tariff barriers and included such measures as quantitative restrictions and anti-dumping measures. Core non-tariff barriers for imports were classified as barriers which control the volume of imports, barriers which control the price of imports, monitoring measures, export restraint measures, and technical barriers. The incidence of core non-tariff barriers on fisheries products was found to be around 11% in 1993, compared with around 16% for agriculture. However, the incidence is likely to be considerably higher once all non-tariff barriers are taken into account (PECC for APEC 1995). Export restrictions, such as export quotas and taxes imposed by economies to control exports, were not included in the study.

BARRIERS TO AUSTRALIAN SEAFOOD TRADE

Despite the Uruguay Round of GATT negotiations, significant tariff and non-tariff trade barriers remain in place in some APEC member countries, notably Taiwan, South Korea and China.

An important point to note is the distinction between processed and value-added products. Although there is a process involved with exporting live products it is still considered unprocessed and is classified as being value-added. Any canned or bottled product would be considered processed.

Tariffs on imports of Australian seafood products are relatively low for most of Australia's major seafood export markets (Table 5). This is because the majority of Australian seafood exports are unprocessed fisheries products and tariffs are generally lower for unprocessed fisheries products than for processed products. As indicated in Table 5, tariff measures in Taiwan are relatively high compared with Australia's other major export markets. This may be attributable to the fact that tariff application within Taiwan is not based on the actual import price, but on an 'average declared value'. Some commentators believe this is often less than the actual value of many of Australia's high value seafood exports to this market (The 1996).

The majority of Australian seafood exports are subject to non-tariff measures, such as quantitative restrictions and/or sanitary and phyto-sanitary regulations. Table 6 provides an indication of the types of core non-tariff barriers affecting Australian seafood exports to Japan, South Korea and Taiwan. Both tariff and non-tariff barriers act to fragment markets and discourage trade, potentially reducing the international competitiveness of exporters and the returns to the Australian harvesting sector (Dennis & Battaglene 1995).

Table 5: *Ad valorem* tariffs affecting Australia's major seafood exports to selected countries 1995 (%)

Product	China	Hong Kong	Japan	Taiwan	United States
Rock lobster	0-45	0	3-7.5	42.5	0
Prawns	0-45	0	3-7.5	22.5	0
Abalone	55	0	0-10	15-50	0
Scallops	0-55	0	10-15	25	0
Tuna	30-65	0	5-15	12.5	0-35
Salmon	25-65	0	5-15	20-35	0-12.5

SOURCES: Department of Foreign Affairs and Trade; Austrade

Table 6: Major non-tarrif measures affecting Australian seafood exports to selected APEC countries 1995*

Product	Country	Barriers
Fish - live	Japan	Quantitative restrictions, subsidies
	South Korea	Quantitative restrictions, licensing, sanitary regulations
	Taiwan	Quantitative restrictions; licensing; quarantine restrictions
Fish - fresh or chilled	Japan	Quantitative restrictions, subsidies
	South Korea	Quantitative restrictions, licensing; sanitary regulations
	Taiwan	Quantitative restrictions, licensing; sanitary regulations
Fish - frozen	Japan	Quantitative restrictions, subsidies
	South Korea	Quantitative restrictions, licensing, sanitary regulations
	Taiwan	Quantitative restrictions, licensing, sanitary regulations
Fish - fillets	South Korea	Quantitative restrictions, licensing
Crustaceans	South Korea	Quantitative restrictions, licensing, sanitary regulations
	Taiwan	Licensing, sanitary regulations
Molluscs	Japan	Quantitative restriction; subsidies
	South Korea	Quantitative restrictions, licensing, sanitary regulations
	Taiwan	Licensing; sanitary regulations

* Some liberalisation may have occurred since 1995
SOURCE: Department of Foreign Affairs and Trade

PROSPECTS FOR AUSTRALIAN SEAFOOD TRADE AND AQUACULTURE

There is potential for growth in the value of Australian seafood exports in response to growing world demand for fisheries products, attributable to population growth, consumer preferences and rising incomes within industrialising nations. However, with most of Australia's wild fisheries fully or over-exploited, the capacity to increase the volume of local supplies is constrained. Improvements in technology are likely to increase the productive capacity of the Australian aquaculture industry, providing potential for further growth. However, there are a number of challenges facing the Australian aquaculture industry.

The availability of sites is one important challenge facing the industry, with intense competition from other users. Offshore aquaculture offers space as well as high water quality. However, there are considerable investment costs associated with establishing such sites. The development of inland sites may also offer opportunities, but again there are considerable investment costs involved. Risks of disease may slow growth in aquaculture, as may environmental concerns.

Aquaculture in Australia, with the exception of pearls and edible oysters, is still an emerging industry. It has strengths in certain areas such as shellfish culture, pearling and cage fish farming and is developing expertise in prawns, abalone, eels, marine finfish, and freshwater crayfish and finfish. Australia, through the APEC liberalisation agenda, is in a good position to benefit from Asian technology and expertise. Thailand is acknowledged as a world leader in prawn culture and in the preparation of prawn feeds and nutrition. Japan has a highly developed aquaculture industry with a wide variety of species cultured including pearls, oysters, prawns, seaweed and farmed and ranched marine finfish species such as snapper and salmon. Other countries in APEC have developed aquaculture systems for freshwater finfish, shrimp and eels.

Given the constraint on the volume of Australian production from wild catch, any major increase in Australian export revenue from wild caught species will arise through improved product quality, higher prices, better use of under-utilised species, improved marketing initiatives, efficiencies in the harvesting and processing sectors and a reduction in trade barriers.

THE APEC LIBERALISATION AGENDA

The greatest potential for sustainable growth in the value of Australian seafood exports is likely to lie within the APEC region. The APEC free trade agenda provides the vehicle for such gains to be made.

Allowing access to markets within APEC which are currently protected should lead to increased real prices for fisheries products. This is to be achieved, in part, through the removal of market restrictions such as ensuring transparency in the application of quarantine and inspection systems. The Bogor Declaration stated the importance of removing non-tariff barriers which restrict access to markets. Although the removal of tariff barriers remains important, the removal of non-tariff

barriers is of greater consequence for Australian fisheries products because tariffs are already quite low for Australia's largely unprocessed export volume.

Several studies have predicted significant gains in real income and real gross domestic product as a result of APEC trade and investment liberalisation (Murtough *et al. 1994*; Dee *et al.* 1996). This may lead to further increases in demand for and hence real prices of seafood products.

The APEC free trade agenda is likely to provide the potential to explore new markets for existing Australian export products where barriers were previously prohibitive and the potential to explore markets for new products. Given the constraint on the volume of Australian production, a major outcome from the APEC liberalisation process for the Australian seafood exporting sector is likely to be market diversification.

CONCLUSIONS

The ability of APEC, as a cooperative body, to achieve trade liberalisation by the dates which were set in Bogor relies crucially on individual member countries actively pursuing their own action agendas as part of the goal of trade liberalisation. At the next APEC ministerial meeting in late 1996, the individual action agendas will be assessed and a specific schedule is to be set for achieving trade liberalisation. The role of the various working groups, of which the Fisheries Working Group is one, is to report progress in the areas which are being monitored by each individual group.

The APEC region offers substantial prospects for Australian seafood exporters. Consumer preferences for fisheries products are relatively strong in the region, with average per person consumption being almost double the world average. Economic growth is particularly strong in South-East Asian APEC countries and this is expected to continue over the medium-term. APEC member countries also represent almost 40% of the world's population, with high population growth rates among the developing Asian economies. If APEC realises its goal of trade liberalisation, income growth in the region will be further increased, resulting in greater demand for seafood products.

Australia's major seafood exports are high-valued, unprocessed seafood products that cater for niche markets and attract relatively low tariff levels. The APEC liberalisation process is likely to open up opportunities which may have previously been prevented by trade barriers. The removal of non-tariff barriers will create opportunities by allowing Australia's largely unprocessed seafood exports access to markets within the APEC region. The removal of tariff barriers will provide an opportunity for the Australian industry to become more involved in the market for processed seafood products.

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EXPORT OF SEAFOOD
Strategic alliances

By Leith Doody[1]

Abstract

The Australian Trade Commission (Austrade), through its network of over 80 offices worldwide, is continually helping to win exports for Australian companies and to bring investment into Australia.

Total seafood exports to our three major markets Japan ($A445m), Taiwan ($A200m) and Hong Kong ($A200m) have increased by over 20% in the last three years.

The demand for seafood continues to grow and more opportunities are emerging in niche market segments. A competitor analysis of countries exporting to Japan, Taiwan and Hong Kong based on trade statistics will be presented and competitive opportunities and trends identified.

Strategic alliances are increasingly important in the seafood industry for securing investment, gaining market access and facilitating quality control from sea to platter. Austrade through its global network of offices and its considerable international marketing experience can assist Australian seafood companies in identifying market opportunities, facilitate market entry and locate suitable strategic alliance partners.

Austrade helped to identify a suitable investor in a South Australian company air freighting Southern Bluefin tuna to Japan. The Japanese company was a distributor of fish to restaurants in Tokyo and the resulting strategic alliance allowed it to by-pass the fish market in Japan whilst providing setup capital to purchase and develop floating tuna holding pens.

The do's and don'ts of forming strategic alliances within the seafood industry will be highlighted, successful Australian case studies examined and information provided as to how Austrade assists exporters and parties seeking to invest in the Australian seafood industry.

Keywords: Australian Trade Commission; Austrade; Seafood; Exports; Networks; Prawns; Oysters; Rock lobsters; Quality assurance; Case studies.

INTRODUCTION

The gross value of Australian fisheries production is forecast to fall by 6.5% in 1995/96. Industry can no longer expect to rely on increased catches to sustain revenue growth as most fisheries are nearly fully exploited. The alternatives to increased catches are the farming of seafood or increasing the value of existing stocks by premium pricing. Obtaining premium pricing requires industry cooperation, sophisticated marketing and quality control.

I would like to share with you today some thoughts relating to more innovative ways of capturing overseas opportunities for premium pricing and thereby building a more viable and sustainable position for the marketing of our catch internationally.

Let us touch on some different kinds of alliance arrangements - from both sides - that is, the grouping of Australian companies into networks or alliances with Australian or foreign companies as a means of building a sustainable position in the international marketplace. We will look at harnessing investment as a way of building global relationships, and lastly how overseas alliances may lead to globalised production.

Throughout this paper, we will also look at how Austrade assists Australian companies in the formation of strategic alliances, in market entry strategy, in market support and in the identification of opportunities and impediments to trade.

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STRATEGIC ALLIANCES

Selection of partners for strategic alliances

Successful strategic alliances are usually built on strong personal relationships. Compatibility of management, members and business culture are important considerations. With some alliances, this is the most significant issue. Expected outcomes should be defined, discussed and understood. Detailed risk analysis should be undertaken before final formation.

Networks

Austrade has been instrumental within a number of industries in developing and implementing the formation of networks and also assisting networks with market entry.

Networks can produce a range of tangible and intangible benefits, including market intelligence, foreign market promotion activity, the involvement of Austrade and other support agencies, foreign market contacts, and coordination with other Australian companies.

Network participation can also represent a convenient vehicle for entry into a foreign market. Austrade's own network of posts, in combination with Business Units, provides industry networks with the necessary support both in market and in Australia and also provides the necessary "government hat" which is so vital to success in many Asian nations.

Other benefits of networks are :-

- *marketing synergies* - the ability to provide continuity of supply and to coordinate quality assurance;
- *economies of scale* - resulting in decreased unit costs for members;
- *critical mass* - networks provide members with greater bargaining power, firstly, in the ability to influence the market price and secondly in achieving savings from suppliers through bulk purchasing.
- *financial stability* - through the sharing of bad debts;
  focal point - the network acts as a focal point for government programs and funding, eg Austrade's Export Market Development Grant (EMDG);
- *economic rationality* - cooperation and coordination between members avoids wasteful duplication throughout the value chain;
- *export access* - networks can give members access to international business opportunities and marketing strategies which may be way out of the reach of each member individually.

These benefits are best illustrated by some successful examples of where cooperation between producers have transformed segments of the seafood industry.

For instance, the Australian Prawn Promotion Association (APPA) is changing the export focus of the entire Australian prawn industry from that of "selling a commodity" to the "marketing of a premium product".

APPA was formed to ensure the long term survival of the Australian wild prawn industry when faced with price competition from cultivated prawns (now 40% of world supply).

It has taken seven years to gain cooperation in the industry but legislation was introduced in 1996 allowing a small levy on export prawns.

The promotion is aimed at positioning Australia's wild prawns at the premium end of the market as natural, unpolluted prawns, a strategy well beyond individual companies.

The initial focus is in Japan creating a premium brand image, the "Pierre Cardin" of prawns.

APPA also acts as a focal point for government assistance to the industry and is fulfilling the pivotal role of uniting the traditionally disparate prawn catchers.

Austrade provides in-market and other support for APPA. During 1995 for instance Austrade in Japan designed an APPA brand mark for the Japanese market and arranged for one of these brand mark stickers to be placed on supermarket's retail tray packs of Australian wild prawns.

In April 1996, Austrade participated in the APPA marketing launch in Japan and will continue to provide APPA with expert marketing advice.

A good example of how an industry can transform itself from a price taker to a price maker is the Oyster industry in Tasmania.

Tasea Enterprises Pty Ltd (Tasea) was formed in 1993 ago to counter the strong market power of local Tasmanian oyster processors and to coordinate marketing activities. Tasea now represents 60% of Tasmania's total oyster production and exports quality oysters to Japan.

Previously, a price taker, Tasea now commands a premium price for it's oysters.

Fundamental to this shift in market power has been the coordination of Tasmanian growers and the resulting ability to guarantee all year round supply plus consistent quality assurance, having developed a code of practice.

In fact, during 1995 Tasea's Japanese distributor exhibited at Foodex with Austrade.

An additional benefit to growers of this cooperation has been the savings Tasea can obtain for them from bulk buying, from economies of scale and the sharing of bad debts.

The Western Rock Lobster Development Association in Western Australia is another example of how cooperation between industry members accompanied by generic industry marketing can create a united front to overseas buyers, resulting in premium pricing.

Austrade continues to assist the association in the development of new markets.

Austrade has recently facilitated the establishment of a premium food network "Fine Fare Australia" targeted initially at the supply of gourmet Australian food products and services to Japanese restaurants.

Australian producer's products are accredited based upon "culinary excellence", that is, a taste test.

Exports are demand driven by the chef's in Japanese restaurants. Can you imagine more discerning customers? The Japanese chefs are "trained" in how to prepare the products by Australian chefs flown to Japan and are kept fully informed of product availability.

"Fine Fare Australia" was established in 1996, as a joint initiative of Austrade, DIST and DPIE. It has already accredited quality suppliers of prawns, scallops, oysters, rock lobsters, marron and tuna in the seafood product line and many more select suppliers of non-seafood Australian gourmet foods. Austrade continues to play a strong role in the marketing of "Fine Fare Australia: in Japan.

The "Fine Fare Australia" label is marketing itself as a guarantee of quality and seeks to establish itself as the Australian benchmark for fine food exports. First sales are currently under way.

Another Austrade network, "The Southern Seafood Network", is concentrating purely on premium seafood products. It's nine members produce abalone, oysters, mussels, marron, yabbies, fin fish, herring and pilchards. They are small and medium sized companies and are targeting the food service industry in Malaysia and Singapore. The major benefits of the network to members are continuity of supply, volume and range of product plus providing the vehicle for government assistance.

Austrade conceived the network in conjunction with the Great Southern Development Commission, funding was provided by DPIE. Austrade continues to play an integral role in developing the network's export marketing strategies.

Yet another benefit of networks is the flow-on effect to the rest of industry.

In the South Australian oyster industry, promotional efforts by OYSA have increased total demand and prices benefiting non-participating oyster growers.

OYSA was formed four years ago by the South Australian Oyster Growers Association to market member's oysters and to set quality assurance parameters. It now markets over 75% of South Australia's oysters. OYSA has found that as it focuses on the premium end of the oyster market, it creates a gap in supply at the lower end allowing non-members to obtain greater sales.

Nevertheless, it sets a quality benchmark for the rest of the industry to aspire to, with the reward of premium prices and consistent orders.

Once a network is established, it may use other Australian companies for sub-contracting. This further promotes market entry for smaller companies, encouraging them to meet the quality and product demands of the export market.

Key success factors

Key success factors in forming and sustaining a network are:

- a continuing commitment by growers to meet the quality standards and product requirements;
- an independent hard working manager to administer the network, coordinate the members and resolve their internal disputes;

- a focused marketing strategy by the network; and
- ownership of the network, the brand name and the marketing strategy by all network members.

BUILDING ALLIANCES IN EXPORT MARKETS

Alliances have become an important way for small and medium sized enterprises ("SMEs") to take their first step towards insider status in export markets. These overseas alliances can be either formal or informal arrangements. They can be with an Australian partner or with other foreign partners operating overseas.

Smaller firms tend to start their alliance building with informal cooperative agreements, often to obtain access to distribution channels.

A good example of an Australian seafood network benefiting greatly from an informal alliance with an overseas company is Quality Tasmanian Abalone Pty Ltd (QTA).

QTA was established in 1987 by 20 abalone divers, and now markets 20% of Tasmania's abalone, 99.6% of which is exported, mainly to Taiwan, Hong Kong and Singapore.

The company entered into an alliance with a customer in Taiwan which researched the Taiwanese market and identified a need for sliced vacuum packed abalone, which QTA then developed and successfully exported to Taiwan. There is now also strong interest in Japan for this product.

Another success story for QTA is in the exporting of mussels to Singapore and Hong Kong where Austrade identified the market need and set up the complete distribution chain for QTA.

The prevalence and significance of alliances throughout Australian industry should not be underestimated. A survey of 1 000 firms conducted by the Australian Manufacturing Council in 1992 found alliances to be the most important source of improved business performance.

Many small and medium sized enterprises have used foreign equity participation in their firm. The AMC/McKinsey Study on Emerging Exporters in 1993 found 53% of emerging exporters had used this approach. Most of those firms used alliances to obtain better access to key markets.

INWARDS INVESTMENT

The use of foreign equity participation to facilitate better access to key markets was successfully adopted by a South Australian company.

Southern Bluefin Tuna owned a quota for the catch of these fish. The company was already airfreighting chilled fish to Japan within 28 hours of being caught.

Unfortunately, the company's potential for increasing the volume of its business was limited by the quota. However, management developed a plan to increase the weight of the tuna exported using a fish farming technique.

The plan involved the use of large sea cages which would be moored in the ocean. Young, underweight fish would be "caught" (as defined by the quota), kept alive and placed in the large sea cages. These fish would then be fed until they reached an appropriate size for the export market. This gain of weight was not included in the quota and would allow the business to increase the scale of its operations.

This strategy had the added benefits of reducing the seasonality of the catches, enabling fish to be almost "made to order" for particular customers, so that their fat content (and therefore their price) was higher.

The company did not have the financial capacity to fund the purchase of the sea cages and the additional operating costs. In conjunction with Austrade, the company developed an Information Memorandum, prepared by one of the "Big Six" accounting firms.

In late 1994, the Austrade Investment Commissioner in Tokyo identified a suitable investor. The Japanese company was a distributor of fish to restaurants in Tokyo, and an investment in this Australian project would enable it to improve its own operation through by-passing the fish market in Japan. This marketing synergy between the two parties was very important in the success of the deal. The Japanese company initially invested set up capital in the Australian business, followed up by a subsequent injection a few months later.

Another Australian company which initially used equity from a foreign partner and is now a major Australian success story is Tassal Limited (Tassal). This Tasmanian company was set up as a government initiative in the early 1980's through a joint venture with Norwegian producers, providing Norwegian technical and marketing expertise.

Tassal quickly progressed and honed it's own leadership role in the industry and developed unique technology. It is now a public company producing 4 000 tonnes of Atlantic Salmon annually and has 65% of the Australian production.

Chilled Tasmanian salmon are now attracting premium prices in Japan despite strong competition from Norway, Canada and Chile.

Approximately 50% of production is exported as fresh chilled whole salmon and processed salmon.

The wholly owned subsidiary, Tassal Japan Limited, which is based in Japan allows Tassal to deal on a daily basis with it's customers, resulting in increased sales and outlets in Japan. Tassal has identified the opportunity for extended third party trading, that is, the sourcing of other seafood products globally to it's customers' needs.

Success by Tassal in Japan was substantially enhanced by Austrade's in-market representation particularly at the regional level.

CONCLUSION

There are no pots of gold or instant fortunes to be made through joint ventures and strategic alliances but there are many opportunities for excellent businesses to be established and to deliver returns over time on the energy and commitment put into the venture.

Austrade is involved in all aspects of the internationalisation of Australian business, including areas outside the more traditional export facilitation and promotion roles. We are becoming increasingly involved in services such as forming and promoting of networks, selecting appropriate foreign partners and distribution channels, advising on the costs or impediments to trade in a particular market, and identifying the market opportunities.

Austrade has 85 offices in more than 60 countries and can help individual companies or networks in the seafood industry. Austrade has dedicated seafood marketing specialists in Japan, Hong Kong and Korea complementing our Australian based marketers. In Melbourne, Austrade has a team of Japanese food marketing specialists which is currently working on several seafood projects.

Strategic alliances can give companies the added propulsion of contacts, market know-how and the energy of a team approach to succeed. By further cooperation within the seafood industry, Australia can position itself to become a renowned quality marketer of premium seafood globally and continue the metamorphosis from being a shipper of seafood to a marketer of premium produce.

ASIA PACIFIC REGION
Future demand for fish

By David James[1]

Abstract
Fish has traditionally been a very important component of the diet in the Asia Pacific region. Much of the population of this region draws a significant proportion of animal protein supply from fish, both from marine and freshwater sources. The strong cultural association with fish as food and the resulting nutritional demand have seen *per capita* availability more than double since 1960. However, projected increases in population, coupled with rising incomes (which will result in higher consumer demand) imply a growing gap between fish supply and demand in the very near future as resources are constrained. Substantially greater levels of exploitation are unlikely.

The paper reviews the magnitude of future demand, perhaps an additional 5-10m t/yr, and makes suggestions on the source of possible supplies to satisfy it.

Keywords: Asia Pacific; Diet; Protein.

INTRODUCTION
The Asia Pacific region, considered here as consisting of four areas: South Asia, South East Asia, East Asia and the South Pacific, is the predominant region in the world both for the production and consumption of fish. The region produces more than 50m t of fish/yr, 46% of the world's total, and directly consumes 44.7m t, or 65% of the world's fish production[a]. In a period when the sustainability of fisheries throughout the world is under threat it is becoming increasingly difficult to maintain supplies to consumers in this vast region.

FISH IN NUTRITION AND AS FOOD
In the Asia Pacific region in general, fish figures prominently both as a nutritional constituent of the diet and as a culturally and traditionally gratifying food item. There are, however, some disturbing demographic and economic trends which will affect the supply of fish in the future, particularly the lower socio-economic groups. These are considered below after a brief outline of the role of fish in the diet in various parts of the region.

In South and South-East Asia, fish makes an important contribution to the diet of a high proportion of the population as a source of protein and essential fatty acids. In South-East Asia, the members of the Association of South East Asian Nations (ASEAN) countries, as well as Myanmar and Cambodia derive more than 40% of their animal protein supplies from fish.

With the exception of Cambodia, most countries have shown a significant increase in the availability of fish. In many cases, this has doubled since 1960. The picture in South Asia is more difficult to interpret from the available statistics which show only a slight rise in *per caput* availability since 1960 and a relatively low proportion of fish in animal protein. The figures are skewed by the high number of vegetarians, who do not consume fish in India, although they are included in the overall availability[b]. The fish consumption of the actual fish eaters in India is in fact quite high. In this part of the region, both Bangladesh and Sri Lanka derive more than 50% of their animal protein from fish, and the Maldives as much as 85%.

Likewise, in East Asia, fish is an important and highly appreciated component of the diet, despite the marked differences between the political and economic systems of an area which includes China, Japan, Korea and Taiwan.

Available *per caput* supplies have increased sharply in all countries between 1961 and 1993, having almost doubled to 44 kg/head/yr in the Democratic Peoples Republic of Korea (DPRK), shown a four-fold increase to 52 kg in Republic of Korea (ROK) and a five-fold rise to 15 kg in China. *Per caput* supplies in Japan increased by 20 kg/year to 68 kg. The relative importance of fish is seen in its proportion in total animal protein supply ranging from 65% in DPRK 50% in ROK and Japan to 28% for Taiwan Province.

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Any estimates for China must be treated with caution as availability is assessed over the whole population whereas a large proportion, (particularly in the west) have no access to fish, obtaining their nutritional requirements of protein from other sources. As a result, the figures considerably understate consumption and the importance of fish to the actual consumers (principally in inland areas with access to Chinese carp and people in the coastal zones). There are, however, implications for the future, as these are the areas of fastest growth where the demand can be expected to grow more strongly.

The diet of the Pacific Island States is heavily dependent on fish as a source of protein and essential fatty acids. Most States obtain a high proportion of their animal protein supplies from fish, ranging from a high of 69% for Kiribati, with almost all States deriving over 25% from this source rather than animal meat, eggs and milk. Actual fish consumption is difficult to estimate due to limited statistics and an unknown contribution from unrecorded household catches. The figures for *per caput* availability provided by FAO probably underestimate overall consumption. These figures have shown a steady upward trend over the years and range up to 100 kg/head/yr for Tokelau. Most States have fish availability above 20 kg/head/yr, which is high by international standards.

ECONOMIC DEVELOPMENT AND TRADE

The countries of Asia have shown the world's most dynamic development in recent decades. While the strength of the Japanese economy speaks for itself, in the rest of Asia income growth has been significantly higher than in other parts of the world as shown by the World Bank Development Report. For example in Southeast Asia overall Gross Domestic Product (GDP) growth rates in 1995 varied between 4.8% for the Philippines to 9.5% in Vietnam. In South Asia growth rates ranged up to 6.2% in India, although in Bangladesh and Sri Lanka they were considerably lower. There are obvious differences between the countries of Asia with regard to the structure of the economies, the degree of industrialisation, the availability of infrastructure (transport, power, markets and financial institutions), etc. The one common characteristic is productivity growth driven by technology.

The dynamic industrial policies of the region have encouraged the development of open trade, particularly through regional co-operative arrangements, to facilitate the free flow of goods, services, capital and labour across international boundaries. The regional economic groupings include Asia Pacific Economic Cooperation (APEC), Association of South East Asian Nations (ASEAN), East Asian Economic Caucus (EAEC) and ASEAN Free Trade Association. In a wider forum, the World Trade Organisation (WTO) is also having a stimulating effect. As an example, the Republic of Korea has agreed to progressively reduce import tariffs on fish before the end on 1997.

While fisheries and the fish trade are not very important components of the mandates of these regional and international organisations, the immediate effect of their activities will be to promote intra-regional trade, including that in fishery products, through tariff reductions and trade liberalisation. Membership of the WTO by countries in the region will accelerate the tendency towards integration of the inter-regional trade with the global fish trade. The argument advanced below is that fish trade in the Asian region will become part of the international market place and that economic development and strengthened demand will result first, in more intra-regional movements of fish, then globalisation.

Looked at in value terms, the region is a very significant importer of fish, $US19.1b out of a world total of $US44.6b. Japan, at $US14.9b, takes an overwhelmingly large share (Table 1).

Table 2 shows fish production and trade for Asia in 1993. Domestic supply will have to be augmented by increased imports which will have to be obtained from the global market place. Clearly, this has economic and policy implications but there are also knock-on effects on guarantees of quality assurance and public health safety as the proportion of fish which is traded internationally rises.

The region contributes about a third of the world's exports with $US14.4b, out of a total of $US41.2b. Leaving Japan aside, the region is a net exporter although an increasing proportion is traded within the region. With the established strong demand from Japan, and rising demand from elsewhere, particularly from the newly industrialised countries which is already evident, it is postulated that we are on the verge of a global market and that it is only a matter of time before the region becomes a net importer.

Table 1: 1993 imports and exports by value ($US'000)

	World	Asia	Japan
Imports	44 621 848	19 084 589	14 187 149
Exports	41 193 792	14 452 946	

Table 2: Asian fish production by country

Country	Production*	Non-food Uses*	Imports*	Exports*	Supply*	Availability (kg/yr)	Population ('000)	Imports *per caput* (kg)
Bangladesh	968.90	5.20		35.50	928.20	8.20	112,700.00	
Brunei	1.70		4.50	0.30	5.90	21.90	300.00	15.00
Cambodia	112.60				112.60	9.40	9,400.00	
China	17,568.00	490.00	623.00	846.00	16,854.00	14.30	1,175,540.00	0.03
India	4,200.00	391.30		266.20	3,542.50	4.00	88,405.00	
Indonesia	3,445.70	28.00	8.70	491.00	2,933.50	15.50	188,700.00	0.60
Japan	8,128.00	3,055.00	3,792.00	412.00	8,452.00	67.80	124,670.00	30.40
Korea PDR	1,780.00	1.00	1.00	28.00	1,005.00	43.60	23,048.00	
Korea Rep	2,649.00	327.00	380.00	423.00	2,306.00	52.20	44,137.00	8.60
Laos	29.80		0.20		30.00	6.70	4,550.00	0.03
Malaysia	650.00	186.40	315.30	225.40	553.50	29.50	18,800.00	16.80
Maldives	84.30	1.30		54.00	29.00	126.00	200.00	
Myanmar	802.00	102.90		20.50	678.60	15.50	43,700.00	
Pakistan	563.40	183.80		100.10	279.50	2.20	129,300.00	
Philippines	2,282.50		157.00	154.60	2,284.90	36.10	63,400.00	14.30
Singapore	12.30		262.20	167.40	101.10	36.80	2,700.00	19.60
Sri Lanka	208.40		83.30	4.50	287.20	16.30	17,700.00	4.70
Taiwan PC	1,416.00	1.00	167.00	809.00	772.00	37.10	20,823.00	
Thailand	3,179.50	1,186.30	662.70	1,210.20	1,445.70	25.30	57,000.00	11.60
Vietnam	1,066.80	29.30		100.80	936.70	13.40	69,700.00	8.00
Totals	49,148.90	5,988.50	6,456.90	5,348.50	43,537.90	581.80	2,194,773.00	129.66

* '000 tons liveweight.

FUTURE DEMAND

Projections of demand for fish are inherently difficult and can, at best, only be indicative of future changes under certain assumptions. The three major factors that must be taken into account are: population growth, increased incomes and the effect of a constrained supply on prices. While population growth can be estimated from the United Nations World Population Report it is more difficult to predict rises in income or to know in advance how consumers will respond if fish prices continue to increase at a higher rate than competing protein products. There have been dramatic lifestyle changes in the region in recent decades and younger middle-class consumers in some countries (e.g. Japan, Singapore and Thailand) are tending to a more "Western" style of diet with more meat rather than retaining traditional values. If this trend is sustained, it may tend to dampen demand, particularly if fish becomes relatively highly priced.

A somewhat conservative view of future demand is to assume that it will be possible to maintain *per caput* availability at today's levels. Projecting population increase to 2010 reveals demand rising from present supply levels, for the whole region, of approximately 43.5m t to 51.5m t. Of the 8m t additional requirement the share of South and South East Asia will be about 3m t, the Pacific area 70 000 t with the balance for East Asia. Even without making an allowance for income growth as a result of economic development, which would tend to inflate the projected demand, increasing supply by a further 8m t is a daunting challenge. Whether this demand can be satisfied remains to be seen but it will certainly result in fish prices continuing to increase at a faster rate than competing products. The impact of higher prices will have an uncertain impact on demand.

Added to the difficulties is the trend to increasing urbanisation. All over the world people are leaving the countryside to live in cities and the Asia Pacific region is no exception. United Nations estimates published in 1994 indicate that on a world basis the proportion of urban dwellers will rise from 44.8% to 66.1% between 1994 and 2025. Overall for Asia there will be a 20% rise from 34% to 54% with perhaps a similar increase in the Pacific. It is difficult to ensure supplies of a perishable product to urban consumers without significant investment in a cold chain infrastructure, including ice plants, refrigerated storage, transport, etc. Continued strong economic development will be essential if the infrastructure is to be provided and maintained. For some countries the tendency for fish to go into trade rather than domestic consumption will eventually require policy consideration.

SUPPLIES

Despite a declining rate of growth, the world's fish production is still increasing. FAO figures indicate that 1994 production amounted to 109.5m t. However, for many years, FAO has been sounding a note of alarm about the state of marine stocks, which make up the major part of production. The FAO has observed that 70% of conventional species are at present fully exploited, over-exploited, depleted or in the process of rebuilding as a result of depletion and that the situation is non-sustainable

with major economic and ecological damage already visible. While stocks in the Asia Pacific region do not appear to be as heavily stressed as those in the Atlantic and the North Pacific they are under considerable pressure and with few exceptions, such as South Pacific tuna, they are unlikely to respond with significant increases even if management regimes were improved. At best, the prognosis is that marine catches will remain stable, with perhaps a marginal increase. Inland fisheries also seem to be capable only of marginal increase, having been seriously affected by environmental degradation and agricultural development. The fact that very little more can probably be squeezed out of wild stocks to meet the projected demand is serious, particularly in view of the fact that 44.7m t out of a world total of 73.4m t, or 65%, of fish for direct human consumption is produced in the Asia Pacific region.

The prospects of increased supplies from aquaculture are more encouraging. Aquaculture is one of the most rapidly growing food producing systems, with growth averaging 9% a year since the 1980's. During the last 10 years world aquaculture production has doubled by weight to 22.6m t, and tripled by value to $US35.7b. These increases can be compared with growth of only 2.8% a year for livestock meat; noting that this production is mainly in other areas than Asia and the Pacific. Aquaculture on the other hand is predominantly carried out in Asia, where 89.5% by weight and 81.7% by value of world production is currently produced. China alone accounts for almost 60% of total production. Although the proportion is high value shrimp and finfish, grown in brackish water and which enter directly into trade, is increasing, aquaculture also produces relatively low-cost fish, affordable to many in low-income Asian countries. The greatest increases in production have been in Chinese carp culture which fits into this category.

Continued increases in aquaculture production imply an intensification of the production system which has already been shown to be economically and environmentally costly. The availability of many other inputs such as research, land and feed must also be guaranteed. For instance, the trend towards urbanisation mentioned earlier will reduce land availability for aquaculture close to centres of population. Another potentially disturbing feature is the concentration on high value shrimp and finfish which are carnivores, requiring high-quality feed, often based on food-grade fishery resources. It can take up to 4 kg of feed (trash fish or fish meal) to produce 1 kg of shrimp. The net result of such aquaculture, on a mass balance, is fish consumption rather than fish production. Resources that could be used for direct human consumption but which are transferred to aquaculture potentially remove fish from the food basket of the poorer sections of the community, and can pose a threat to food security. In view of this, and increasing pressure from environmental groups about the damage that this type of intensive aquaculture does to the environment, governments are likely to come under greater pressure to regulate the activity, or at least, to ensure that the poor are compensated for lost resources by transfer payments or other means. An obvious avenue is to encourage the culture of lower-value species which are omnivorous or herbivorous and can grow adequately on a diet of lower nutritional quality. The present situation where feed production for aquaculture in Asia is growing at 30%/yr cannot continue without causing perturbations and seriously limiting the available quantity of fish of lower market value. Research to stimulate the search for alternatives to fish protein and fish oil in aquaculture diets is essential to ensure both stability of feed supplies and availability of fish for low-income consumers. However, it must be borne in mind that the resources presently used for feed are not immediately suited for conversion to direct human consumption.

MEETING THE DEMAND

The above indicates a demand which is stratified into higher value products for the upwardly mobile consumers of the region and additional supplies of low-cost fish to satisfy the requirements of the region's traditional diets. At the same time, supply increases from the region are constrained by resource limitations. In searching for solutions, it is assumed that the demand for the higher priced products will be met through competition in the global market place by consumers who have sufficient disposable income to cope with rising prices. More creative solutions are required to meet the bulk demand. Some of the additional supplies can come from the international market but the region as a whole will have to find ways of putting more resources onto the tables of the poorer sections of society. For instance, the projected demand for the South Pacific area of 70 000 t is small in relation to the rest of the region but is significant to the island communities. The lagoon and coastal resources cannot be expected to yield more but very little of the offshore tuna resource is consumed in the islands, because of its traditional inaccessability. Policy input from the governments and a campaign to change food habits could help to close the gap. The importance of traditional food habits, and the difficulties of changing them, should not be overlooked.

The major resources that could be diverted for human consumption are the small pelagic species, about 40% of which, on a world basis are destined

for the production of fish meal and oil. These contribute indirectly to human nutrition through meat and farmed fish production, but are inherently suitable for direct consumption. In 1993, 31% of the world's marine fish production was converted to fish meal and 98% of that was derived from small pelagic species. There are difficulties in using these resources for human consumption but these can be overcome by technology and trade. The small pelagic species of the region and the major resources of the South East Pacific can be developed to contribute to the gap but it must be acknowledged that the demand for fish meal, both for livestock and fish feed, is likely to grow. At present, this provides better returns to producers than attempting to develop markets for human consumption which would require a new economic perspective which could in fact be encouraged by an increase in the disposable income of consumers. About 1m t of fish meal is produced in the region and a further 1.5m t is imported, equivalent to 12.5m t liveweight, indicative of the importance of this product. More cost effective substitutes for use in fish and animal feed would have to be available before the resources could be diverted for human consumption, unless demand-induced price rises for fish change the perspective.

Another potential source of supplies is the very high quantity of fish that is caught and wasted. Wastage results from post-harvest losses which can be reduced by technology and improved infrastructure. It is difficult to put a figure on such losses but in some parts of the region they are quite substantial; either as physical loss or as a loss of value. Shrimp trawling throughout the region contributes large quantities of by-catch of other, less valuable, species which are landed and poorly utilised (except as fish feed). A considerably larger quantity is caught but discarded at sea, resulting in a net loss. The reasons for this are complex and include: economics, lack of on-board storage space, marketing difficulties and lack of technology for fishing gear selectivity to ensure that only desired species are retained. A recent FAO Technical Paper suggests that losses as a result of discarding could be as high as 27m t/yr. This estimate is possibly too high and is currently being revised but it is indicative both of a problem and of a potential resource. A full solution requires the introduction of effective fisheries management plans to limit discards and wastage but there is also a strong role for both catching and post-harvest technologies.

To make use of a proportion of the by-catch, the discards and more of the small pelagic species will require development, coupled with market research and development.

CONCLUSIONS

In conclusion, it is certain that demand for fish in the Asia Pacific region will rise strongly in the immediate future, probably at a faster rate than that for the rest of the world. As supplies are constrained it is almost inevitable that fish prices will also rise steeply. In many countries of the region rapid economic development will generate sufficient spending power to enable fish consumption to be maintained. Taste and tradition imply that in general people will be prepared to spend more on fish. In the very near future the region will probably become a net importer, competing for supplies in the international market place, after strong growth in intra-regional trade.

While the wealthier section of the community will be able to assure supplies it will be more difficult to sustain supplies for the poor. Among the promising avenues which could be followed are: development of aquaculture for low-cost species, diversion of some of the small pelagic fish now used as fish meal raw material to human consumption and improving utilisation of by-catches and discards.

The participation of fish technologists in this changing world will be vital as the things that must be done include: better arrangements for quality assurance as more products will be traded internationally, and must meet increasingly stringent standards; introduction of government policies to maintain fish consumption; sustained inputs to research in low-cost aquaculture and product development, and consumer education to change food habits.

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[a] Statistics in this paper are taken from the FAO Fisheries Department FISHDAB except where indicated.

[b] It is important to differentiate between availability and consumption. The per caput availability figures presented by FAO are derived by subtracting from the official figure for total fish production fish which is destined for non-food uses and exports, adding imports and dividing by head of population. The resulting figure is an amount that is theoretically available to each person but in no way does it indicate consumption which can only be determined by very expensive household food surveys. The actual consumers are those that can afford to purchase fish or those who can find it on the market. The household food surveys that have been conducted, however, do show that the lower socio-economic groups do tend to spend a higher proportion of their total "meat" expenditure on fish rather than on other sources of animal protein.

NEW COMMERCIAL PRODUCTS
From waste of the fish processing industry

By Jan Raa[1]

Abstract

By-products of the fish and shellfish processing industries are still regarded as waste in many places and accordingly discarded. Such by-products may constitute more than 60% of the weight of food fish and shellfish and consist of scales, shells, skin, bones, liver, gonads, stomach, gut, heads, gall bladder, etc, in addition to extractives which are washed out with the processing water. These products are rich sources of feed ingredients, nutrients, nutraceuticals, enzymes, pharmaceuticals and other products with existing and potentially new applications within many sectors, including the food and feed industries.

The current trend to incorporate a modern biochemical industry into the traditional fish processing industry will be illustrated with a number of successful examples from Norway, including the extraction of enzymes and other biochemicals that in turn are used as processing aids to upgrade and increase the value of seafood products. The paper will also discuss the application of components in fish waste as feed ingredients, resulting in improved feed utilisation, growth and improved health.

Keywords: Waste; By-products; Fish; Shellfish; Fish silage; Enzymes; Processing;

INTRODUCTION

In this paper I have focussed on Norway and have used examples from my own experience where the results of basic and applied research have been used in commercial activities. But let me first put the subject into a broader perspective.

About ⅓ of the total catch of fish in the world is thrown back into the sea. These are low-value species or by-catch. The fish processing industry, either on board modern factory ships or on land, throw away large volumes of processing wastes. The fish filleting industry may produce as much as 60% of the raw material weight as processing wastes.

According to FAO, the discard from fishing vessels amounts to 27m t. The discard of offal from the seafood processing industry, is an aesthetic problem in many places as well as an ethical problem. There is an ethical aspect to such waste and I am sure world opinion will pay more and more attention to this matter in the years to come. Fish and other aquatic food species are after all a limited resource on a global basis, and the catches have reached the upper limit.

There is fortunately a growing awareness that there are commercial opportunities in many of the unique components present in the offal, and we can in our country see an emerging bioindustry based on what are left-overs from the table of the rich.

BY-PRODUCTS OF SEAFOOD PROCESSING

Table 1 shows the by-products which attract most attention by the emerging marine bioindustry of Norway.

Table 1: The high value by-products of seafood processing

Product	By-product
Stomach	Enzymes and peptone
Gut	Enzymes and tryptone
Milt	DNA and nucleotides
Fish roe	Caviar, phospholipids, feeds
Backbones	Dietary calcium and protein
Skin	Leather, gelatin and collagen
Scales	Pearl essence, fibrous protein
Cartilage	Medicinal products
Shrimp shells	Chitin, chitosan and pigment
Fish eyes	DHA (22:6 n 3)
Liver	Oil + protein/lipid
Scallop by-products	Biochemicals
Processing water	Biochemicals, flavour
Lectins	Diagnostics

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There is a rapidly growing demand for cod stomachs in Norway as a raw material for the production of enzymes and a special peptone for certain applications. Buyers have sometimes paid more for the cod stomachs than for the whole cod, due to this demand.

There is a notable interest at present to replace tryptic enzymes from cattle by-products with corresponding enzymes of marine origin. One application of these enaymes is for ripening of fish fillets (herrings).

One company in Norway is specialising in extracting DNA from fish milt and producing nucleosides.

Cod roe is used in production of certain caviar-products, but much is still discarded. The same has been the case for roe from sexually immature salmon. There is now an outlet of "surplus" roe for speciality products.

There is a growing interest in obtaining collagen and gelatin from fish, to replace corresponding products from warm-blooded animals. But this is still in an early phase, although the technology has been developed to pilot scale.

Fish scales are recovered from a new technology to make fish fillets with skin-on, without scales. A new and very simple biotechnological process has recently been developed to separate pearl essence, soluble collagen and the fibrous protein of fish scales.

There has been difficulty producing chitosan of a purity required by the cosmetics industry. A new patented process developed by our institute is now at a pilot scale level for commercial production of a well-defined and pure chitosan for the cosmetics industry.

Cod liver is used for the production of cod liver oil. A new cold extraction process makes a better and more healthy product, which received a higher price. Moreover, a new process for cleaning cod livers before canning has been the basis for creating a new industry in Norway.

FISH FARMING AND BY-PRODUCT UTILISATION

It was the fish farmers who were the first to consider the offal as a valuable resource and they contributed significantly to reducing local pollution and wastage by upgrading the waste to a valuable feed. The successful start of Norwegian salmon farming was to a great extent due to the fact that cheap feed was available close to processing plants, which also marketed the farmed fish. The fish feed industry is presently using large quantities of protein, peptides, amino acids and lipids made from fish offal.

FISH SILAGE

Production of fish silage from a mixture of processing waste has become a significant industry in Norway, due to the demand for the partly digested protein of fish silage as a component of salmon feed. The silage, or silage concentrate, also contributes other valuable nutrients

Most important, however, is the fact that fish silage used as injection liquid in the extrusion process improves the technological properties of the feed pellets and adds attractive taste to the feed. Moreover, we have recently shown that certain peptides produced in fish silage, act as immunostimulants that activate the lymphocytes of fish. We speculate therefore that there are components responsible for improved health and performance of animals which receive low levels of silage in their diets.

Inclusion of high levels of fish silage in diets of animals (fish, pigs, chicks) may also cause reduced growth. However, close scrutiny of experimental data show that low levels have a growth enhancing effect. Immunostimulants have the same anabolic effect at low concentrations and inhibitory at high. There are certain peptides which have such effects and it is a challenging opportunity to direct the hydrolysis so that the immunostimulatory peptides are formed in known levels.

THE FUTURE FISHING INDUSTRY

Recycling of processing waste as feed for aquaculture is one important step ahead towards a more diversified and modern fishing industry. We look for a future fishing industry in which the traditional fishing and processing is integrated with aquaculture, storage and feeding of live wild fish, feed production and a new bioindustry based on the by-products. In the remaining part of my presentation, I will try to describe the position of the emerging bioindustry in this general picture.

THE MARINE BIOINDUSTRY

The emerging marine bioindustry produces by-products from seafood processing raw materials. By-products include enzymes, fine chemicals, vaccines, immunostimulants, and feed ingredients. The outlets for these products include the seafood industry and aquaculture, as well as many sectors with a traditional distance to the fisheries sector. The existing bioindustry of Norway is still of small

size compared to the traditional fisheries sector and aquaculture. However, it is profitable and even more important, it has contributed to a significant added value of both aquaculture and the seafood processing industry. It can be made as a general statement, that a new industry like this will not succeed and survive, unless the users of the new technology benefit more than the owner of the technology. Fish vaccines worth 100m NOK ($US15m) are sold in Norway every year, generating an extra income of 10 times as much for the fish farmers. The same value adding proportion applies to other sectors, such as the use of marine enzymes as tools in seafood processing.

THE USE OF ENZYMES IN SEAFOOD PROCESSING

Different enzymes are used in commercial production of caviar, to remove scales from the skin of fish, to remove the rubbery skins of various squid species, to remove connective tissues and parasites on cod liver and to remove pigment and globular proteins from collagen in fish skins and fish scales.

Farmed salmon has to be slaughtered before the fish is sexually mature, when the gonads are still small and before the eggs can be released from the connective tissues by mechanical methods. An enzyme which loosens the eggs from the connective tissues without attacking the corion of the eggs, is used commercially for the production of a supreme quality salmon caviar in Norway and other countries. This is the most expensive seafood product from Norway. It is made from raw materials of low, or close to no, value by means of an enzyme by-product also obtained from seafood processing wastes.

Certain markets ask for fish fillets with skin on, but without scales. This applies to haddock and hake. An enzyme technology has been developed to remove the scales in a very gentle process which yields a product of superior quality compared to the corresponding product descaled mechanically. One distinct advantage with hake is a low degree of mechanical damage to the flesh. Moreover, the enzyme treatment strips off surface bacteria and therefore extends the shelf life. With Patogoonian toothfish from the South Atlantic, the yield of quality fillets was much higher after enzymatic descaling of fresh caught fish on-board the ship, than when the frozen fish had to be descaled mechanically in land-based processing plants after thawing. The economic advantage of this is significant for the ship owners.

As a result of this new technology, clean fish scales can be collected and used to produce another by-product. We are at present looking at the chemistry of such scales and trying to develop new applications for the fibrous protein which is left in the fish scales after extraction of pearl essence, pigment, soluble protein and collagen.

The skin of squid species is very difficult to remove mechanically, in particular from the tentacles, the wings and inside the belly. The use of enzymes has solved these problems and complete processing lines for deskinning of squid with enzymes are in use world-wide.

COLD-ACTIVE ENZYMES

The marine environment is in general cold. I disregard in this connection the many extreme environments in the oceans, where life exists at temperatures above 100°C at high pressures, without oxygen and in the presence of gases which are toxic to the majority of living organisms. The organisms we harvest for food, are in general adapted to lower temperatures than terrestrial animals and this is the case also for the enzymes they contain.

The activity of marine enzymes at low temperatures and their corresponding heat liability, offers many distinct advantages for certain applications. I will present only two examples, namely alkaline phosphatase from the Arctic shrimp (*Pandalus borealis*) and an antibacterial enzyme from the Arctic scallop (*Chlamys islandica*).

There is a notable difference in heat stability of alkaline phosphatase from calf intestines and from shrimp. The latter can be inactivated completely after 10 min at 65°C.

This property of the shrimp enzyme offers a significant advantage in gene cloning technology. The classic procedure for insertion of isolated genes into bacterial plasmids involves opening the plasmids with a restriction enzyme, followed by addition of the gene and the enzyme which splices the gene to the open plasmid forming a new circular plasmid with an inserted gene. This is a very inefficient process, however by removing the phosphate groups at the terminal ends of the opened plasmid, before adding the gene and ligase, the efficacy of gene insertion is very much increased. But it is an absolute necessarily to remove the phosphatase completely before the ligase and gene are added; otherwise the phosphate groups on the naked gene would also be removed and annealing would become impossible. This is where shrimp alkaline phosphatase rather than enzymes from other organisms is advantageous. The alkaline phosphatase from shrimp can be inactivated by heating to 65°C for 15 min, a temperature which

does not interfere with the stability of the plasmid DNA. Inactivation of the calf enzyme, requires a very laborious process (Table 2). As a consequence, the whole process can now be carried out using shrimp enzyme by a 15 min incubation at 65°C without any extraction procedure.

Table 2: Inactivation of alkaline phosphatase using calf enzyme in gene cloning technology

- heat inactivation at 80°C in the presence of SDS (60 min)
- twice phenol extraction (15 min)
- precipitation in 100% alcohol at -70°C (10-15 min)
- centrifugation (15-20 min)
- resuspension in 70% alcohol (5 min)
- centrifugation (5-10 min)
- drying in vacuum centrifuge (10 min)
- solubilising pellet (2 min)

Scallops are able to filter out and digest live micro-organisms, algae and detritus from the water. Scallops living at extremely low temperatures, for instance close to the polar ice, should accordingly contain enzymes with high capacity to degrade micro-organisms at low temperatures. In accordance herewith we found in the Arctic scallop *Chlamys islandica*, a peptide with lysozyme activity not much affected by temperature down to 0°C. This enzyme is completely different from chicken egg lysozyme in biochemical composition, molecular weight, pH optimum, etc. and it is active against both Gram positive and Gram negative bacteria. The enzyme activity can be abolished by heating, but the peptide retains a notable antibacterial activity. An antibacterial enzyme and peptide, active at cold room storage conditions for food against a wide variety of bacteria, has obvious commercial potentials. But there is no future in producing such a product from the scallop processing waste; the quantities are too small and the costs of extraction are too high. Therefore, this is an example of a product which may be made by recombinant DNA-technology, using a marine organism as the gene source for the product.

THE FUTURE

This leads naturally to the question whether all good products which can be extracted from seafood processing waste, may be made by fermentation of recombinant micro-organisms. If so, the processing discard may become waste again in the future.

For many fine chemicals of protein nature this may be the case. However, complex molecules of carbohydrate and proteoglycan character can not be made by this technology at the present time and there are economic reasons why the offal will remain a preferred source of protein/peptides, oil and flavour for food and feed use.

PROCESSING WASTES
Exopeptidases from shellfish

By Fernando L. Garcia-Carreno[1], Rocharake Raksakulthai and Norman Haard[2]

Abstract

The aquatic environment contains a wide diversity of organisms that inhabit unique biological niches and may also contain enzymes with unusual properties. Aquatic invertebrates in the crustacea and mollusca have an unique digestive system that includes a midgut gland or hepatopancreas. This digestive organ is a by-product of processed shellfish (i.e. shrimps, lobsters, crayfish, crabs, squid and clams). It contains a wide variety of exopeptidases (exo), proteolytic enzymes that catalyse the hydrolysis of amino acids, di- or tri-peptide from the α-amino (aminopeptidases) (AP) or α-carboxyl (carboxypeptidases) ends of the polypeptide chain of protein.

Approximately 60% of all industrial enzymes are proteases. Commercial proteases typically have a high ratio of endoproteinase/exopeptidase activity. High endoproteinase (endo) activity can be a major limitation of using protease as processing aids (e.g. in accelerating the ripening of cheese).

Given the need for industrial exopeptidases with low endoprotease activity, we have examined these enzymes in the digestive gland of several aquatic invertebrates. Research on hepatopancreas digestive processes that will be described include:

1. a method to measure the ratio of endoproteinase/exopeptidase activity in mixtures of proteases;

2. methods to decrease the endoproteinase activity while maintaining exopeptidase activity of hepatopancreas extracts; and

3. use of exopeptidases as food processing aids.

Keywords: Shellfish; Exopeptides; Endoproteinase; Wastes; Enzymes; Hepatopancreas.

INTRODUCTION

Cheddar cheese ripening is a complex biochemical process that involves selective degradation of caseins (Fox 1989a). Ripening time takes as long as 2 years to develop a mature Cheddar product. The use of proteolytic enzymes to accelerate Cheddar cheese ripening has not been successful because soft texture and bitter off-taste develop (Law & Wigmore 1982; Law 1987; Fox 1989a, 1989b; Habibi-Najafi & Lee 1996). Bitter taste in cheese is caused by peptides with a high degree of hydrophobicity (Ney 1979). Caseins, notably beta-casein, have a high hydrophobicity and thus ripening cheese has considerable propensity to develop bitter peptides (Habibi-Najafi & Lee 1996). Strong bitterness is associated with peptides from beta-casein that have at least six amino acids, arginine at the N-terminal position and a hydrophobic amino acid at the C-terminal position (Kanehisa & Okai 1984). Intense bitterness is also associated with peptides having at least two hydrophobic amino acids in the C-terminal position (Shinoda *et al.* 1985) and increases with the number of leucine (Ishibashi *et al.* 1987) and proly l-prolyl residues (Shinoda *et al.* 1986). AP and groups of proline-specific peptidases cleave the hydrophobic peptides generated by the enzyme Neutrase in ripening cheese (Habibi-Najafi & Lee 1996). Crude enzyme preparations with proline-specific peptidases obtained from lactococci are now commercially available in the United Kingdom. Generation of free amino acids, notably glutamic acid and methionine, in aging cheese contributes to the sweet taste and flavour of the product (Weaver & Kroger 1978; Puchades *et al.* 1989). Products of methionine degradation, such as methanethiol and methional, also aid in the development of Cheddar flavour (Fox *et al.* 1995).

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Industrial grade enzymes marketed as peptidases normally contain proteinases that may cause defects in ripening cheese (Garcia-Carreno & Haard 1994).

Commercial use of enzymes from fishery by-products is a relatively new and growing industry (Haard 1992; Haard *et al.* 1994a). The digestive system of aquatic invertebrates may be a good source of peptidases. For example, krill hepatopancreas enzymes release 15% of the amino acids in casein as free residues (Osnes 1979). Hepatopancreas peptidase activities have been characterised in langostilla crab (*Pleuroncodes planipes*) and crayfish (*Pacifastacus astacus*) (Osnes 1979; Delaruelle *et al.* 1992; Garcia-Carreno & Haard 1993; Garcia-Carreno & Haard 1994; Garcia-Carreno *et al.* 1994), squid (Hameed & Haard 1985), shrimp (Jiang *et al.* 1991; Lan & Pan 1991), and lobster (Marquez-Mendez 1992; Mykles & Haire 1995). Squid hepatopancreas enzymes have been used as industrial fermentation aids to promote flavour formation in squid and capelin (Lee *et al.* 1982; Raksakulthai *et al.* 1986; Raksakulthai & Haard 1992a, 1992b).

Hepatopancreas proteinases and peptidases from crab, crayfish and squid were studied in order to separate peptidases from proteinases. An exopeptidase enriched enzyme fraction from squid hepatopancreas is being studied for use as a Cheddar cheese ripening aid.

MATERIALS AND METHODS

Enzyme sources

Samples of langostilla crab (*Pleuroncodes planipes*) were obtained during experimental catch by the "B/O El Puma" vessel in Vizcaino Bay, Baja, California Sur, Mexico, 28°40'61" N, 114°35'54", at 125m depth. The crabs were processed to obtain a protease extract as described previously (Garcia-Carreno 1992). Crayfish (*Pacifastacus astacus*) were obtained from California Crayfish Marketing Association, Sacramento CA and transported live to the laboratory where the hepatopancreas was collected and an enzyme extract was prepared (Garcia-Carreno & Haard 1993). Squid (*Illex illecebrosus*) hepatopancreas was obtained from a processing plant in New Jersey. A crude enzyme extract was obtained by homogenising hepatopancreas tissue with 0.20 M Tris-HCl, pH 7.0 (1:4 w/w) and centrifuging at 10,000 x g for 20 min. Enzymes were further purified to increase the ratio of exo/endo (peptidase/proteinase) as described in the Results and Discussion. Commercial peptidases (Flavozyme and Neutrase) obtained from Novo Nordisk Biochem North America Inc., Franklinton, NC and were also evaluated for exo/endo activity ratio.

Enzyme assays

Proteinase (endo) activity was estimated by hydrolysis of azocasein or casein as described elsewhere (Garcia-Carreno & Haard 1994). Hydrolysis of azocasein was also monitored by pH-stat to determine the percentage of peptide bonds hydrolysed (degree of hydrolysis, DH%) (Garcia-Carreno & Haard 1994). Leucine AP (Leu-AP), carboxypeptidase A and carboxypeptidase B, and dipeptidylaminopeptidase (cathepsin C) were assayed with synthetic substrates (Garcia-Carreno *et al.* 1994). Other AP (Gly-, Ala-, Val-, Pro-, Met-, Glu-, Lys-, and Arg-AP) activities were assayed with p-nitroaniline (p-NA) derivatives obtained from Sigma Chemical Co., St. Louis, MO. The assay mixture was composed of 1.9 mL of 1 mM p-NA amino acid derivative in 50 mM sodium phosphate, pH 7.2 and 0.1 mL of appropriately diluted enzyme solution. The absorbance change at 405 nm was monitored at 37°C. The molar extinction coefficient of p-NA was found to be 9316 M^{-1} cm^{-1}. One unit of enzyme activity was defined as the amount of enzyme required to release 1μmole of p-NA per min under the specific reaction conditions. Protein concentration of enzyme solutions was determined by the method of Lowry (1951). The exopeptidase to proteinase activity ratio was estimated by dividing the activity of azocasein digestion determined by pH-stat with the activity determined by A_{440} of TCA extracts (Haard *et al.* 1994). Since the dye bound to azocasein is more or less randomly distributed on the substrate, hydrolysis of a few peptide bonds by a proteinase (endo-protease) would normally be expected to yield more dye (A_{440}) in the TCA soluble fraction than would hydrolysis of the same number of peptide bonds by an exo-peptidase. Thus, the ratio of DH%/A440nm is expected to be higher for an exopeptidase than it is for a proteinase. The proteinase trypsin gave a ratio of about 30 during the course of a 4h digestion. In contrast, the exo-peptidase Leu-AP had a DH%/A_{440} ratio of 80-90 given the same reaction conditions (Garcia-Carreno & Haard 1994). The exo-/endo ratio was also estimated by dividing the amino acid - AP specific activity by the proteinase specific activity with casein or azocasein substrate.

Inhibition assays

The inhibition of enzyme activities was conducted as previously described (Garcia-Carreno & Haard 1993).

RESULTS AND DISCUSSION

Decapod hepatopancreas proteases

The presence of Leu-AP, carboxypeptidases A and B, and cathepsin C activities were demonstrated in both langostilla crab and crayfish enzyme extracts. Crayfish hepatopancreas had more Leu-AP activity and less carboxypeptidase activities than langostilla crab (Table 1). The dipeptidyl hydrolase activity of cathepsin C was not detected in crayfish extracts.

Table 1: Peptidases activities (units/mL) in the hepatopancreas of two decapods

Enzyme	Crayfish	Langostilla crab
Leu-AP	0.023	0.007
CP-A	31	124
CP-B	45	177
Cathepsin C-transferase	0.093	0.163
Cathepsin C-dipeptidyl	0.000	0.013

The ratio of DH%/A_{440} for these extracts was relatively low, ranging from 21-28. The low ratio's are consistent with the large amount of proteinase activity in these extracts. It is known that decapod hepatopancreas tissue contains several serine proteinases, including trypsin, trypsin-like enzymes, collagenase and elastase (Galgani & Nagayama 1988; Sakharov & Litvin 1990; Garcia-Carreno 1992; Garcia-Carreno & Haard 1993). The effect of several site directed proteinase inhibitors on the endoproteinase activity of crayfish and langostilla hepatopancreas extracts is shown in Table 2.

Table 2: Inhibition of azocasein hydrolysis by directed site proteinase inhibitors

Inhibitor	Langostilla enzyme (% inhibition)	Crayfish enzyme (% inhibition)
Serine:		
- SBTI, 5 μM	58	33
- SBTI, 10 μM	75	69
- TLCK, 100 μM	37	32
- TPCK, 100 μM	1	0
- PMSF, 2mM	55	41
Cysteine:		
- E64, 10 μM	4	0
- PHMB, 1 mM	0	0
Aspartyl:		
- Pepstatin A, 1.4 mM	0	0
Metallo:		
- O-phenanthroline 2 mM	21	14
- EDTA, 1 mM	10	32

Azocasein hydrolysis by decapod hepatopancreas extracts was most sensitive to serine protease inhibitors, notably soybean trypsin inhibitor (SBTI), and was also inhibited somewhat by metalloproteinase inhibitors. Extracts were inhibited less by the more specific trypsin inhibitor (TLCK) and were not affected significantly by the chymotrypsin inhibitor (TPCK). On the other hand, SBTI and the other serine proteinase inhibitors did not significantly influence the activities of the amino- and carboxy-peptidases in these extracts, with the exception that carboxpeptidase B was inhibited 7% by 10μM SBTI.

On the basis of these results, we employed SBTI affinity chromatography with the aim of removing proteinases and improving the exo-/endo-protease activity ratio in these extracts. The results of separating langostilla and crayfish hepatopancreas extracts on SBTI-Agarose are shown in Tables 3 and 4 respectively. The specific activity of the material that did not bind to the affinity column was enriched 13.7-fold in Leu-AP and 342-fold in carboxypeptidase A activity (CP-A). The ratio of exo- to endo- activity based on activity with synthetic substrates increased about 10-fold for Leu-AP and 200-fold for CP-A (Table 3).

Table 3: Endo-/Exo- activity ratio's of langostilla hepatopancreas extract and SBTI affinity chromatography fractions

	L-AP/ Casein	CP-A/ Casein	DH%/ A_{440}
Extract	7.8	0.43	22
Unbound Fn	80.0	8.88	50-70
Bound Fn	0	0	30-35

About 40% of the peptidase activities and only 1% of the casein hydrolytic activity were recovered in the unbound fraction. In contrast, all of the trypsin and chymotrypsin activities were recovered in the bound fraction. Moreover, the ratio of DH%/A_{440}, used as a general indicator of exo-/endo-protease activity, was improved considerably in the unbound fraction.

Similar results were obtained with the crayfish hepatopancreas extract (Table 4), although the increase in exo-/endo-protease ratio's was less. The specific activities of Leu-AP and Carboxypeptidase-A were 4.8 and 2.7-fold higher in the unbound fraction than in the original extract. Recoveries of activities in the unbound fraction were Leu-AP (29%), CP-A (95%) and casein hydrolase (2%).

Table 4: Endo-/Exo- activity ratio's of crayfish hepatopancreas extract and SBTI affinity chromatography fractions

	L-AP/ Casein	CP-A/ Casein	DH%/A_{440}
Extract	52	14	21-28
Unbound Fn	139	21	50-69
Bound Fn	0	0	36-39

Table 5: Aminopeptidase activities identified in squid hepatopancreas extract

Substrate	Crude Extract		Semi-purified		Fold increase
	μ/mg p	Exo-/ Endo	μ/mg p	Exo-/ Endo	Exo-/Endo
Casein	4.7	-	1.13	-	-
Leu p-NA	10.9	2.30	161.58	142.99	62
Gly p-NA	20.	0.40	60.23	53.30	133
Ala p-NA	9.5	2.02	336.52	297.80	147
Val p-NA	2.5	0.50	65.97	58.38	117
Pro p-NA	1.6	0.36	14.80	13.10	36
Phe p-NA	2.6	0.56	35.46	31.38	56
Met p-NA	16.6	3.55	94.73	83.83	24
Glu p-NA	11.3	2.41	258.43	28.70	12
Lys p-NA	9.0	1.93	163.41	144.61	75
Arg p-NA	14.3	3.06	273.86	242.35	79

These results show that a simple, one-step procedure of SBTI-affinity chromatography can be used to increase the exo- to endo-protease activity ratio in decapod hepatopancreas extracts.

Squid hepatopancreas proteases

Squid hepatopancreas extract did not contain significant amounts of carboxypeptidase A and B activity. However, the extract contained several AP activities (Table 5). Several of the AP identified in squid hepatopancreas extract, notably Pro-, Arg-, Met- and Leu-, are expected to be effective in reducing bitterness and improving the flavour of Cheddar cheese. However, the exo- to endo-protease activity ratio was relatively low in the crude hepatopancreas extract. The methods used to improve this ratio are discussed later in the text.

The influence of site-directed protease inhibitors on the activity of squid hepatopancreas proteinase and AP activities is shown in Table 6. The results differ from those shown in Table 2 for crayfish and langostilla hepatopancreas enzymes. The proteinase activity was insensitive to the serine proteinase inhibitor, Perfabloc, and was completely inhibited by the cysteine proteinase inhibitor p-mercuribenzoic acid.

The AP activities differed in their response to inhibitors but were generally most sensitive to PCMB and the peptidase inhibitor bestatin. Much to our surprise, the AP were not generally sensitive to the metallo-protease inhibitor EDTA. These results must be interpreted with caution since the enzyme preparation was a crude extract. However, they do show that the endoproteases of squid hepatopancreas are primarily cysteine proteases. This observation was further substantiated by the stimulation of activity by thiol compounds (Table 7). In addition to general proteinase activity, Gly-, Val-, Glu- and Arg- AP appear to be thiol proteases.

All AP activities were markedly stimulated by $ZnSO_4$ as shown by the increase in ratio of AP to casein hydrolysis (Table 8).

Table 6: Influence of inhibitors on squid hepatopancreas proteinase and aminopeptidase activities

Substrate	Relative Activity	% Control			
	Control	10 mN EDTA	1 mM Perfabloc	1 mM PCMB	10μM Besttin
Casein	100	99	103	0	97
Leu p-NA	100	88	93	55	73
Gly p-NA	100	391	0	0	0
Ala p-NA	100	115	61	67	62
Val p-NA	100	101	50	49	62
Pro p-NA	100	106	54	81	48
Phe p-NA	100	105	48	62	13
Met p-NA	100	123	104	81	98
Glu p-NA	100	83	109	27	107
Lys p-NA	100	107	75	75	52
Arg p-NA	100	113	80	85	76

Table 7: Influence of thiol compounds on squid hepatopancreas proteinase and Aminopeptidase

Substrate	Relative Activity	% Control		
	Control	1 mM Cysteine	10 mN DTT	1 mM Cysteine and $CaCl_2$
Casein	100	364	237	241
Leu p-NA	100	104	95	90
Gly p-NA	100	280	186	475
Ala p-NA	100	96	61	99
Val p-NA	100	242	298	248
Pro p-NA	100	103	85	105
Phe p-NA	100	93	41	259
Met p-NA	100	109	118	116
Glu p-NA	100	123	114	121
Lys p-NA	100	98	99	103
Arg p-NA	100	115	140	107

Table 8: Activation of Aminopeptidase by Zn^{2+} and other divalent cations

Substrate	Relative Exo/Endo				
	Control	1 mM $ZnSO_4$	1 mM $MgCl_2$	1 mM $CuSO_4$	1 mM $CaCl_2$
Leu p-NA	1	55	1.0	2.1	1.3
Gly p-NA	1	524	1.0	3.8	9.0
Ala p-NA	1	63	1.0	4.1	1.9
Val p-NA	1	84	1.0	0.0	1.7
Pro p-NA	1	553	0.0	76.7	8.0
Phe p-NA	1	172	0.5	5.1	4.8
Met p-NA	1	41	0.8	3.0	1.3
Glu p-NA	1	19	1.0	3.2	1.2
Lys p-NA	1	52	1.0	4.9	2.0
Arg p-NA	1	41	1.2	6.1	2.0

pH stability of squid hepatopancreas proteinase and AP

Preliminary studies showed that the proteinase activity of squid hepatopancreas extract was unstable at neutral and alkaline pH values. Accordingly, experiments were designed to determine the influence of pH on proteinase and AP activities. In the pH range 6-7, the activities of AP were recovered at 60-80% after 1 h at 30°C and 80-90% after 20 h at 0°C. Under these same conditions only 30-45% of the proteinase activity was retained. Accordingly, incubation of the crude extract at pH 7 for 20 h was employed in a purification scheme designed to increase the ratio of exo- to endo-protease activity.

Purification procedure

On the basis of the above results, a purification scheme was designed to maximise recovery of AP and minimise recovery of proteinase activity. The scheme involved incubation of the squid hepatopancreas homogenate at pH 7.0 for 20 h at 0°C, treatment with 1 mM $ZnSO_4$, ammonium sulfate fractionation (20-80% saturation), and dialysis against 25 mM $ZnSO_4$ (Table 9). The yield of proteinase activity was only 1.95%, whereas AP recoveries were as follows: Leu (20.3%), Gly (44.4%), Ala (47.9%), Val (18.2%), Pro (14.5%), Phe (14.1%), Met (16.8%), Glu (36.7%), Lys (27.1%), and Arg (25.2%).

This resulted in substantial increase in the exo- to endo-protease activity ratio's (Table 5) ranging from 12-fold for Glu-AP to 147-fold for Ala-AP.

Comparison of the exo/endo ratio's of partially purified squid hepatopancreas with two commercial exopeptidase preparations are shown in Table 10.

Table 9: Purification of squid hepatopancreas AP

Step	Yield (%)		
	Proteinase	Leu-AP	Met-AP
Homogenate	100	100	100
0°C, 20 h	74	92	90
1 mM $ZnSO_4$	33	102	73
Amm. Sulfate	18	35	28
Dialysis	2	27	23
Freeze Dry	2	20	17

Table 10: Exo-/endo activity ratio's of squid hepatopancreas and commercial exopeptidases*

Substrate	Exo-/Endo		
	Semi-purified	Flavozyme	Neutrase
Leu p-NA	143	79	<1
Gly p-NA	53	<1	<1
Ala p-NA	298	<1	<1
Val p-NA	58	<1	<1
Pro p-NA	13	<1	<1
Phe p-NA	31	<2	<1
Met p-NA	84	<2	<1
Glu p-NA	29	<1	<1
Lys p-NA	145	9	<1
Arg p-NA	242	3	<1

* Endoproteinase activity based on casein hydrolysis; Flavozyme and Neutrase were from Novo Nordisk Biochem

CONCLUSIONS

The hepatopancreas tissue of aquatic invertebrates is a rich source of peptidase activity that may be useful as a food processing aid. However, for applications, such as for cheese ripening, the high level of proteinase activity is a problem. By understanding the basic properties of the complex mixture endo- and exo-proteases it is possible to selectively remove proteinases from exopeptidases thereby improving the exo- to endo- protease activity ratio. Cheese ripening trials are currently underway in our laboratory using a semi-purified AP preparation from squid hepatopancreas. Preliminary results of this trial are encouraging.

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FISH WASTES
Profit from processing

By Ted Sloan [1]

Abstract
The traditional method of processing and value-adding fish processing wastes has been the production of fish meal and fish oil.

Fish meal plants have high capital, energy, maintenance and emission control costs and are generally suitable only for large processing operations.

The small processor has often relied on private or municipal landfill operations for the disposal of unwanted offals. Even in very remote sites this is no longer acceptable on social, economic and environmental grounds.

The potential for small, remote or island fish processors to produce liquid fish protein for integration into local economies is examined.

Suitable equipment is described and the economics discussed.

Keywords: Fish waste; Processing; By-products; Silage; Fertiliser; Liquid fish products

INTRODUCTION
The cost of disposing of fish wastes is increasing. Some national and international regulations are moving to prohibit disposal of wastes at sea. On land, authorities are less willing to accept fish wastes in landfill dumping facilities. This unwillingness has been brought about by the problem of leaching of oily and proteinaceous material from the dump sites into groundwater and surface stream flows, causing unacceptable rises in biological oxygen demand.

In this age of "user-pays", local authorities are looking to retrieve the real cost of containing wastes in properly engineered dump sites.

This has resulted in acceptance charges for fish waste at landfill facilities exceeding $100/t plus the transport charges.

In many places, the social aspects of dumping fish wastes is not acceptable.

This is particularly so where modern processing facilities have been located in the midst of subsistence or low socio-economic communities. In this type of community, utilisation of traditionally captured fish is often particularly high.

The sight of large amounts of fish material, or reject whole fish being dumped can cause serious resentment and can result in widespread scavenging at landfill sites, with consequent risks of injury and disease.

In most communities, the widespread dumping of fish waste is no longer acceptable on financial, environmental or social grounds.

The increased recovery and utilisation of fish by-products provides an obvious answer.

THE NATURE OF FISH WASTES
The nature and volume of fish waste from processing plants varies greatly depending on the mix of species being processed and the degree of processing, the level of by-catch and reject fish and seasonal influences.

The volume of waste as a proportion of total catch can range from zero for an operation that sorts or grades whole frozen fish to 60% in some filleting operations and higher where, for example, roe collection is the prime activity or where reject and spoilage rates are high.

The size of fish may range from sardine to large pelagics of several hundred kilos.

Oil contents could range from a low of 3% to 40% or more of the total wet weight.

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Before a comprehensive by-products strategy can be determined for a fish processing plant, a very accurate description of the wastes and an assessment of volumes must be made in relation to each species processed.

Typical information includes:

- Annual Volume
- Monthly Variation
- Components (e.g. head, gut, skin, etc.)
- Proximate Analysis
  - Crude Protein %
  - Oil %
  - Ash %
  - Water %
- Seasonal variation in proximate analysis
- Weight range of individual fish
- Notes on other physical characteristics such as toughness of skin and skeletal units.

BY-PRODUCT PROCESSING OPTIONS

Options for utilising by-products are numerous. These include:

- Fish baits
- Removal and processing of individual organs for pharmaceutical, industrial or luxury food items (e.g. swim bladders, mullet gizzards)
- Tanning fish skin for specialty leathers
- Oil extraction
- Fish meal
- Fish sauces
- Fish bone meal
- Liquid fish protein

The options investigated for a given processing plant will depend largely on the following factors:

- markets for the recovered by-products;
- capital and operating costs of any processing required;
- the cost of alternative means of disposal e.g. paying a specialist by-products processor to remove wastes from the primary fish processor.

Even with some removal and processing of individual fish parts, most fish processing operations still have a large proportion of 'waste' that must be disposed of.

In large operations, the waste materials have been traditionally converted to fish meal and fish oil.

Both these products are internationally traded commodities for which there is a ready and increasing demand.

However, fish meal plants are very expensive to establish and operate. Generally, the minimum practical capacity for a fish meal plant is 2.5 t/h working for a minimum 16 h/day. This equates to a total of 40 t/day.

Fish meal plants also produce high levels of odours and, in the smaller plants, high levels of very polluting effluents. In many areas, the cost of meeting environmental standards can prohibit the establishment of fish meal plants or force the closure of existing plants.

The often overlooked option to fish meal operations for small to medium fish processors are the various treatments to produce liquid fish products. The rest of this paper will look at this subject.

LIQUID FISH PRODUCTS

Liquid fish products are not new. The absence of a reference list at the end of this paper is deliberate as the literature contains a very large volume of information on this subject and enquirers are advised to access information specific to the species processed or to proposed end uses through local search facilities.

The oldest forms of liquid fish products are to be found in the various forms of fish sauces found in many parts of the world. Some south east Asian communities obtain a high proportion of their dietary protein from fish sauces.

Other fish liquification processes produce liquid fish products for animal feed supplements and for fertiliser.

Liquid fish products are known variously as fish emulsions, fish silage, fish hydrolysate, liquid fish protein as well as a number of proprietary names.

The methods of producing liquid fish products can involve one or more of the following processes:

- Autolysis
- Caustic hydrolysis
- Acid hydrolysis
- Enzyme hydrolysis
- Fermentation
- Heat treatments
- Centrifugation
- Concentration
- Stabilisation

Processes can range from holding fish waste in an unlined open pit for an extended period of time to very sophisticated, food grade processes. Obviously, the open pit method is unlikely to be acceptable in most communities due to problems with vermin and odours that occur as the fish protein is converted to microbial protein.

At the other end, sophisticated food grade processes are unlikely to be economic unless the end products fill a well established market requirement.

In the middle ground, there are very simple processes using simple equipment to produce high grade animal and fish feed protein and excellent organic fertiliser. In the case of oily fish wastes, high grade fish oil can also be recovered.

PAST RECORD OF LIQUID PROCESSING

In the past, many attempts to produce and market liquid fish fertilisers and feed supplements have floundered. The major reasons for these failures can be summarised as follows:-

- poor understanding of the raw materials;
- poor understanding of the requirements of the target market;
- inappropriate equipment;
- inappropriate process options.

Also, liquid fish is bulky with high transport costs compared to fish meal - the weight of liquid fish is virtually identical to the weight of the original waste material whereas fish meal is typically 20 - 30% of the original weight due to the moisture loss in drying.

There is no established commodity market for liquid fish products other than fish oil.

ADVANTAGES OF LIQUID FISH PRODUCTS

Processing quality

Fish wastes including heads, frames, skin and gut can be extremely high quality protein and contains varying levels of oils and minerals including all essential trace elements. A well constructed and operated liquification plant can retain virtually 100% of the nutritional value of the original fish whereas the heat processes in fish meal production result in some degradation of the protein. A poorly designed liquid plant can also result in losses in quality.

Capital cost

The capital cost of a fish liquification operation will be only a fraction, typically 10% - 20% of that required for a fish meal plant. For small fish processors, a fish meal operation is financially prohibitive.

Equipment can be very simple and, as always, where there is abundant cheap labour there can always be a substitution of labour for capital.

Running costs

The operation of a liquid plant requires minimal inputs of energy, supervision and maintenance. A good design will allow any repairs to be carried out on-site using very basic engineering facilities and standard components.

ENVIRONMENTAL

Liquid fish processing has very low environmental impact. A properly designed process will produce no odour and no liquid effluents. The entire volume of waste can be converted to liquid or a combination of liquid plus solid by-product (bone and scale).

PROCESS VARIATION

The basic process can be optimised for a given type of raw material and, as an example, equipment can be selected to liquefy bone. Similarly if there is an advantage in the end product having low phosphorus, as in aquaculture feeds, the process can be set up to remove bone material, the major source of phosphorus.

Shelf life

Properly processed liquid fish has a virtually unlimited shelf life.

Economics

The economics will vary from place to place and profitability will revolve around two factors:

- cost of alternative disposal methods
- saleability of the end product

In general terms. profitability can be initially assessed on the following lines.

The direct cost of manufacture - The direct cost of manufacture, anywhere in the world, is unlikely to exceed $80/t processed with 100% yield.

Offset - The direct offset of alternative cost of disposal.

Saleability - The base comparison for determining a price for a liquid product is to compare with fish meal and fish oil on an equivalent oil and protein price in the local economy.

Increments may be possible on this base price in terms of special benefits to specific enterprises and marketing expertise.

For example, specialist end uses such as fur farming, fish farming and pet food flavourings may command premium prices.

Similarly, with careful marketing of the benefits, correctly processed liquid fish as a fertiliser for growing plants can lead to profitable sales.

It must be stressed, however, that marketing of liquid fish can be very hard work and base values for protein and oil may not be attainable. Making the product is relatively easy by comparison.

It is essential for processors considering making liquid fish products to have undertaken serious market research before manufacturing their first litre.

A basic economic exercise might be as follows:-

Direct cost of manufacture	$70.00/t
Less cost of alternative landfill dumping	$70.00/t
Net Direct Cost	**$00.00/t**
Base value of liquid product per tonne of liquid	
Crude protein - 170kg @ $1.00/kg	$170.00
Crude oil - 100kg @ $0.40/kg	$ 40.00
Potential gross margin per tonne	$210.00

Capital and administration costs have been left out of this exercise because of the extreme variability that will occur between operations.

INTEGRATION INTO LOCAL ECONOMY

Because of the constraints of bulk and no established commodity market it is essential that markets be established or uses found relatively close to the point of production.

This does not exclude more distant markets as our company's New Zealand manufacturing facility exports liquid fish protein to Australia and Japan and our licenced Tasmanian operation has good export prospects in South East Asia. However, a sound local market should be the base for any operation.

As an example of the potential for liquid fish products in a local economy, I will take the example of Pohnpei State in Micronesia - an island state with a population of about 30 000 people. The Pohnpei Fisheries Corporation (PFC) processes large pelagics, mainly yellow fin and big eye tuna plus a by-catch of marlin and shark.

Typically, five tonnes of waste is dumped daily at the adjacent landfill facility. A liquid fish processing operation will convert all PFC fish waste to liquid with the exception of larger bone material which will be ground into bonemeal once it is stripped of all protein.

The liquid is to be utilised in the following ways.

1. Incorporated with imported cereal as a protein source for the very substantial domestic pig production. This will allow substitution for the import of fully formulated pig rations.
2. Fertiliser for developing cut flower enterprises that will air freight orchid and anthurium blooms directly to Japan as well as enhancing the production of the other main domestic crop - pepper.
3. Export of fish fertiliser to the West Coast of North America, taking advantage of cheap west to east shipping rates that exist in the Central Pacific. This product will be marketed as a premium organic fertiliser highlighting the purity of product caught in the Central Pacific Ocean.
4. The production of fish sauces to complement the other value-added products produced by PFC which include tuna jerky and other smoked and dried products and also utilising the superb local pepper.

VITEC COMPACT PLANT

Our company, Vitec Pty. Ltd., operates as Vitec Fertilisers, manufacturing and marketing fish and seaweed fertilisers, and as Sloans Natural Resource Engineers.

We have a wide background in agriculture, including horticulture, organic waste recycling, rendering and liquid fish production.

As well as individual designs, we can now offer a compact, turnkey, liquid processing system. This can be shipped within a 20ft shipping container and requires only connection to a suitable electricity supply and an infeed system to be operational.

The basic unit will process 6 t/day with virtually any type of waste. With optimisation for a particular waste stream, 12 t/day will be possible with most waste types. The construction is rugged and uses componentry that can be readily sourced or repaired in remote locations.

Should relocation be required the entire unit could be prepared for removal in one or two days.

CONCLUSION

Processing fish wastes into liquid products offers a low cost, low impact solution for many small to medium sized fish processing operations - especially in island and remote sites. However, to be successful, the process or processes should be optimised to suit the particular waste streams. Equally, the end products should, as much as possible, be married into the local economy to overcome the substantial disadvantages of bulk and the lack of an international commodity market for liquid fish products.

SEAFOOD WASTE
Utilisation for human consumption

By Jayanthi Weerasinghe and Ian Boyle[1]

Abstract

World-wide, there appears to be a significant waste problem through discard from the seafood processing industry. It is desirable to minimise food loss and wilful waste in both developing and industrialised countries and the question of how to manage and promote this waste for human consumption is still largely unanswered. Global statistics on the quantity of seafood processing waste are limited and have little relevance to the seafood processors.

The seafood industry, which is structured to handle only high value products such as abalone, prawns, lobsters and economically valued fish, has been unable to broaden its scope of operation to encompass the handling and processing of waste. Possibilities for utilisation of the waste are influenced by the structure and nature of the seafood industry, as well as the ability to apply technology and create a product which has demand in the market place.

At present, the seafood waste that can be utilised for human consumption is discarded or is used for relatively low-value applications such as fish-meal production. Measures should be taken to manage these resources so that the waste is minimised. One possible way to make use of the waste for human consumption is to improve the quality of the raw material so that it is suitable for products such as sauces, soups, fermented products and savoury mixtures which are quite popular in South-East Asian countries.

These facts underline the need to address the issue of utilisation of seafood processing waste for human consumption as a vital area of investigation. The implementation techniques and technical and economic feasibility of producing such products on a commercial scale needs to be evaluated, as this factor attracts both suppliers and manufacturers. Waste and by-product processing can be easily carried out with the available technologies in a way that makes high valued products acceptable and profitable to seafood processors.

Keywords: Waste; Human consumption; Seafood; Processing; By-products; Fishmeal; Silage.

INTRODUCTION TO PROCESSING OF INVERTEBRATES

The most commercially valuable and consequently the most vulnerable and highly exploited group of seafoods are the invertebrates. This group of marine organisms consist of bivalve molluscs (scallops, mussels, oysters and clams), cephalopod molluscs (squid and octopus) as well as crustaceans (shrimps and crabs). According to the Australian Bureau of Statistics (ABS), invertebrates cover approximately 37.4% of the total Australian Fisheries production.

Invertebrates usually undergo some form of preservation such as freezing, drying, canning, pickling and smoking between the time of harvesting and reaching the consumer for the following reasons:

- convert the raw material to a more desirable form;
- maintain quality of the raw product;
- fully utilise the raw product;
- assure safety;
- avoid spoilage;
- make handling and transportation easier;
- make the product available throughout the year.

In almost every processing operation, the raw product is subjected for a washing cycle to remove all foreign substances such as mud and sand

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embedded in the tissues. The washing operation is always followed by a sorting and cleaning operation, where the raw material is shelled or stripped for removal of internal organs which may enhance spoilage if any delays occur in processing. As a result of the washing and cleaning operations involved in the processing of invertebrates, considerable amounts of waste, consisting of shells, viscera and residual meat, are generated. This can amount to a major waste disposal problem and can be a cost to the industry.

Consequently, the importance of taking steps to increase the utilisation of seafood processing waste needs to be emphasised.

THE PRESENT STATES OF SEAFOOD PROCESSING WASTE

The most economically valued parts of invertebrates are processed and the rest is discarded. The literature indicates that crustacean waste generated from the seafood processing industry alone represents approximately 70% of total landings. Seafood manufacturing companies cannot afford to be perceived as threatening the environment. As a result of increased public awareness to environmental issues, companies can no longer rely on disposing their processing waste into the ocean or in landfill dumping sites.

In recent years, with the rapid growth of the seafood processing industry, the waste accumulated from this source has been enormous. Therefore to minimise present and future environmental liabilities associated with disposal problems and to demonstrate a genuine concern for the Australian environment companies have already started using seafood waste to manufacture the following different products:

- Animal feeds/ feed additives
- Fertilisers
- Chitin and Chitosan
- Ornamental products
- Industrial oil/ lubricants
- Fish bait
- Pet food
- Fish silage
- Fish meal
- Road building materials
- Buttons
- Paint.

NEED FOR UTILISATION OF WASTE FOR HUMAN CONSUMPTION

The number of processors producing products from seafood waste such as fishmeal and silage is decreasing due to the problems with pollution and other environmental issues. Firstly from vapour arising during processing, and secondly from the liquid effluent from the washing down of the plant. Both in fact can be harmful and most easily noted by the public. They can be a source of embarrassment and a problem area for a by-product manufacturing factory. Further, current products that are manufactured using seafood waste have less significant effect on human nutrition.

Therefore, there is a need for the rapid education of consumers and processors regarding the possibilities of utilisation of waste for human consumption. This will also help to develop the seafood processing industry in Australia for the following reasons:

- develop national assets;
- increase the activities of the fishing and fish marketing operations;
- make better use of our food supply by value-adding;
- expand our export industries;
- provide employment opportunities;
- increase the need for research and development in specialist areas;
- promote better living environments and to reduce potential health hazards;
- balance seasonal processing demands.

NEW AND PROMISING BY-PRODUCTS FROM SEAFOOD PROCESSING WASTE.

Processors are always interested in looking for opportunities to increase production efficiency and profitability. Conversion of underutilised waste material into highly marketable value-added products not only provides such benefits but also minimises disposal problems.

Examples of such value-added food products are as follows:

1. The wash water containing proteins, non-protein nitrogenous compounds and other solids collected from washing cycles and the shucking operation of invertebrates and can be utilised in products such as soups, broths and stocks. These products can be developed by concentrating waste water to three times its original solids content by boiling, vacuum evaporation and ultrafiltration processes. The resultant liquid will have the specific flavour,

aroma and colour characteristics of the particular raw product.

2. The waste water can be dehydrated to form powdered or flaked specific characteristic flavour ingredients and used as condiments in other foods. The dehydrated food ingredients have greater versatility than liquid broth due to lower storage and distribution costs. These products can be obtained by freeze drying or spray drying. To prevent stickiness of the end product, low DE dextrins can be used as carriers when spray drying washing water.

3. The flesh parts or muscle-like membranes that are currently discarded with shells can be hand picked, minced and mixed with other ingredients such as spices and starches to develop new flavouring ingredients for dips and sauces.

4. The viscera and small amount of left over meat collected from processing invertebrates can be utilised for manufacturing high quality protein enriched amino acid hydrolysates for possible use as bases in other products such as sauces.

5. The residual meat collected from under-processed raw material can be utilised for the preparation of formulated mince-based products such as crab and prawn cakes.

6. The waste can be cooked to extract useful flavour-active components and used in highly marketable and more desirable seafood products such as soups and surimi-based products.

7. A mixture of components such as gills, viscera and roe can be fermented from an enzyme digestion process of tissues in the presence of salt to manufacture seafood sauce used as a condiment and a substitute for cooking salt.

8. Both squid tentacles and scallop mantles can be readily converted to a puree. With the addition of phosphates, polysaccharides and salt, this mixture can then be block frozen and used for the manufacture of moulded products such as crab fingers, sausages, prawn cakes, etc.

CONCLUSION

The use of the seafood processing waste for human consumption is an urgent and important area which must be addressed more vigorously and co-operatively than it has been hitherto. It is a problem that can be solved with currently available technologies in a way that makes solutions acceptable and economically viable to different seafood processors, wherever waste is accumulated.

FISH GELATIN
Kosher and Halal food requirements

By Joe Regenstein[1]

Abstract

Gelatin, normally derived from beef and pork, is a major food ingredient because of its unique functional properties, (e.g. the ability to form a reversible cold-setting gel that melts below human body temperature). However, currently available gelatins do not meet mainstream kosher (Jewish) and halal (Muslim) standards. Both religions prohibit the use of pork products and require cattle to be slaughtered by special methods in accordance with their religious laws. Fish with fins and scales are kosher. Most fish species, including catfish, meet halal requirements.

Fish skins from different fish species yield gelatins with very different melting points ranging from 12°C to 27°C, but with bloom values (gel strength) similar to beef and pork gelatins, which melt at about 30°C. Fish gelatins (for the religious market) or mixtures of fish gelatin with beef or pork gelatin (for other markets) have intermediate melting temperatures. The viscosity of fish gelatins are also similar to those from beef and pork. Model products have been tested and the fish gelatin-derived water gels were preferred.

Future work will focus on answering the following questions:

1. What is the impact of the melting point (i.e. the phase change) on the sensory properties of various gelatin containing products?

2. Given that the melting points of fish gelatins are closer to those of many commercial fats, what is the potential role of fish gelatins in low fat food products?

Both religions also would prefer the use of fish gelatins in medicines also meet religious dietary standards. Work on both soft and hard capsule manufacture is needed.

In manufacturing products for the kosher market, a number of rules need to be followed. With products for the Muslim market, the avoidance of pork (or any product derived from pork) and of alcohol (including alcohol in flavour extracts) are the major requirements affecting current industrial/commercial food production. Both religions also have procedures for cleaning equipment prior to commencing production of kosher or halal products.

Keywords: Gelatin; Halal; Kosher; Fish skins; Dietary food requirements.

Gelatin is an important industrial biopolymer that is normally derived from either beef and pork. It is also a major food ingredient that is used for increasing the viscosity of aqueous systems and for forming aqueous gels. It is unique among food-grade "gelling" materials in being both thermoreversible and melting below the temperature of the human body.

Estimated world usage is 200 000 t/yr with USA usage being about 30 000 t/yr for food and about 10 000 t/yr for pharmaceutical applications (Herz 1995).

Jones (1977) and Anon. (1980) described the major food-related and other industrial uses of gelatin. Gelatin's largest single use is in gel desserts. Another major historical use of gelatin in foods has been as a stabiliser for frozen desserts where it functions as an inhibitor of ice crystal growth and lactose recrystallisation during frozen storage of dairy products (Keeney & Kroger 1974; Morley & Ashton 1982; Fiscella 1983; Morley 1984). It is also used in confectioneries, meat and fish products, and delicatessen products (Jones 1977). Gelatin can also be used as a clarification and stabilising agent for beverages (Jones 1977). Other industrial uses of gelatin include both hard- and soft-type drug capsules (Wood 1977) depending on the Bloom and the use of

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gelatin binders for light-sensitive "emulsions" in the manufacture of photographic films (Kragh 1977).

Unfortunately, the traditional sources of gelatin present problems for various communities, including Jewish, Muslim, Seventh Day Adventist and some vegetarians (Regenstein & Regenstein 1987). A gelatin made from fish, depending on the species from which it is obtained, would be acceptable to many of these groups. Some vegetarians will eat fish occasionally even though they do not eat any red meats. Many consumers are moving towards a more vegetarian diet without actually becoming vegans. Kosher (fit or proper in Hebrew) foods, in particular, have become a major part of modern food production. In the USA, it is estimated that almost 40% of the items in a supermarket are kosher. Furthermore, many companies in the food industry would prefer to operate all of their processing lines as kosher because of the complications and cost involved in switching back and forth. For these companies, the absence of a widely accepted mainstream kosher gelatin is probably the most significant ingredient holding up further expansion of kosher food production.

Some Orthodox rabbis accept some types of traditional gelatins as kosher. However, this is not true for the mainstream Orthodox community in most countries (e.g. the major kosher certifying agencies in the US do not accept any beef or pork gelatins except if made strictly from kosher slaughtered animals). The currently available kosher beef hide gelatin is very expensive.

The acceptance of some beef and pork gelatins by some Orthodox rabbis presents real problems for some of the other consumer groups mentioned above who normally also purchase kosher foods but would not want to use beef or pork gelatin. It is estimated that ⅔ of the kosher market is non-Jewish. Thus, a kosher fish gelatin would help all of these groups. The different types of gelatin accepted by different rabbis is a constant source of confusion in both the food industry and among kosher consumers (Regenstein & Regenstein 1987).

Most Muslims accept all seafood products as halal (acceptable). Pork gelatin is forbidden and beef gelatin from animals which have not been slaughtered according to their religious laws is not desirable. Some Muslim sects have some limitations with respect to the species of fish that are considered acceptable. In particular, shellfish may not be acceptable. However, the fish gelatins discussed in this paper would be obtained from traditional teleost species. In serving the 1.2b Muslims around the world, particularly those in an almost continuous belt from Malaysia/Indonesia through the Middle East and into Northern Africa, the use of fish gelatins would have a significant marketing advantage. Codex Alimentarius, working within the GATT framework, is currently trying to draw up specific standards for the production of halal food products.

Kosher fish species must be those with fins and scales. Scales are defined as those which can be removed without tearing the skin. Cycloid and ctenoid scales are acceptable, while placoid and ganoid scales are not. Thus, catfish, monkfish (anglerfish), eels, sharks, sturgeon and swordfish are common examples of fish that are not kosher. All shellfish, both molluscan and crustacean are unacceptable. Lists of kosher and non-kosher fish are available (e.g. Regenstein & Regenstein 1981).

For more detailed discussions of kosher and halal regulations, see Regenstein and Regenstein (1979); Regenstein and Regenstein (1988); and Chaudry (1992).

A number of alternative approaches to manufacturing products without gelatin have been tried. For water dessert gels, carrageenan and other gums have been used. However, the absence of a low temperature melting point and a greater pH sensitivity, has limited the usefulness of these alternative materials. The addition of various ingredients to such products is limited and the product actually is "chewed" rather than melted in the mouth.

In recent years, a number of companies have investigated the production of alternative gelatins including a beef hide gelatin solely from kosher slaughtered beef (Kolatin, Lakewood, NJ) and others are exploring fish gelatin for food applications (Norland Products, New Brunswick, NJ; Croda, Widnes, Cheshire, England; Aqua-Gel, London; Food Industry Technology, Miami Beach, FL; and SeaSource Technology, Weston, CT). Some no Bloom (zero gel strength) gelatin has previously been available, but in recent years gelatins with Blooms of up to and above 300 Bloom units have been produced from fish gelatins.

Bloom is the industry's standard method for measuring gel strength. It is a highly standardised penetration test. A 6.6% gelatin solution aged for about 16-18 h is tested at 10°C. Beef and pork gelatins with Blooms from 100 to 300 are commonly sold around the world. Although many applications require a particular Bloom, gelatins of other Blooms can often be mixed together to give the same results by adjusting the usage level, although the amount of gelatin needed may be increased. Depending on the cost of the different Bloom gelatins, a decision about the optimum mixture to use can be determined.

Patents from Bar Ilan University (Grossman & Bergman 1992) and from Food Industry Technology (Holzer 1996) cover some aspects of skin gelatin

production; other companies rely on proprietary technology. No research or patents have been found that deal with fish bones as a source of gelatin.

The fish industry generates a great deal of waste as it generally only uses about ⅓ of the landed weight as fillets. In order to decrease waste and to generate additional income for the industry, by-product recovery efforts are a valuable adjunct to regular fish processing. Furthermore, as fishing resources become scarce, these additional efforts can also increase employment in the processing sector.

Fish skins are generally available in fillet processing plants as one of their major wastes. The skins are removed on separate equipment from other unit operations in the plant so that skins can be obtained separately from other processing wastes. The use of fish skins for gelatin production would open up new uses for this waste material.

Some plants are currently mechanically deboning various fish parts, the remaining waste stream has very little use, but is available as another potential waste stream for generating gelatin. In this case, it may be necessary to remove the other proteins, possibly by alkaline or enzymatic solubilisation, in order to obtain relatively clean bones. The solubilised protein has many uses. The bones in fact would normally be considered a waste from such a process. Other proposed processes for handling fish waste (e.g. silage) could lead to an easily available fish bone source.

The fish gelatins currently being produced use various proprietary and/or patented procedures. One such procedure, developed by SeaSource Technology received a United States Department of Agriculture Small Business Innovative Research (USDA SBIR) Phase I grant (Herz 1994) to develop the process further and they currently have a USDA SBIR Phase II grant (Herz 1995) to scale up production capabilities to a pilot plant level so that samples of sufficient quantity would be available for further testing. Some of the work for this project is being done at Cornell University and is the subject of this report.

Among the observations to come out of the Phase I work were that fish skins from different fish species led to gelatins with different melting points ranging from 12°C to 27°C. Higher melting points are associated with fish from warmer waters.

The melting point of gelatin is measured by using a colored non-aqueous solution (e.g. chloroform with a reddish brown dye (food colour AFO OWS 550, Wainewright 1977) and noting the temperature at which the colored droplets first fall through the melting solution in a thin test tube in a slowly heating water bath.

Within a single species, using a single preparation method, the melting point and the Bloom strength seem to correlate. Increasing the concentration of gelatin increases the melting point (Lu *et al.* 1994).

Mixtures of more than one melting point gelatin (e.g. either both fish or one fish and one commercially available pork gelatin) lead to intermediate melting points, although the actual melting temperature observed may not necessarily be a weighted average of the original amounts of material used (Lu *et al.* 1994).

Heating the gelatin during dissolution to temperatures above 60°C, (i.e. up to 90°C) does not appear to denature the protein as suggested by it not having a major impact on melting point. This occurred less than with commercial gelatin, which showed a slight heat-induced decrease in melting point.

The gel strength (i.e. force at failure) was measured by compression using an Instron with a gel sample that was a 19 mm diameter cylinder and 19 mm high. This was a modification of a method developed by the US Department of Agriculture NE-123 Northeast Regional Hatch Protein Functionality Project. The method is currently being prepared for publication. Using this technique, we were able to show that gel strength of the fish gelatins were concentration dependent, very similar to that for commercial gelatin (Knox, Kind & Knox, Sioux City, IA). The gel strength as a function of gelatin concentration and pH was also similar to the commercial gelatin.

Similarly, viscosity at 60°C was similar to that for commercial gelatin. Viscosity of a gelatin mixture from a warm water and cold water species again suggested that mixtures could be created where the effect of the two gelatins were not additive. Viscosity was not consistent with Bloom strength (Lu *et al.* 1994).

Solubility using the method of Morr *et al.* (1985) (data not shown) were similar to commercial gelatin. Generally, the material was over 95% soluble when expressed as a percent of the total protein and was over 82% soluble when expressed as a percent of the total weight of the material.

Preliminary work on the sensory properties of the fish gelatins has also been undertaken. We have found that a standardised gelatin dessert block (fairly high gelatin concentration to give a fairly stiff gel) works best. These are served cold. Sugar and a mild flavouring agent (cranberry juice seems to be particularly useful) are usually added and a control (commercial unflavoured pork gelatin, Knox) is provided for comparison. Off-odours and off-flavours are easily determined, particularly using the triangle test. In this case, there was a slight preference for the fish gelatin blocks to those from the commercial gelatin. Both

gelatins, when served unflavoured, have a detectable flavour. The flavour of the fish gelatin is not fishy, but a slightly sweet, fruity chemical flavour.

One issue that has concerned us with respect to Bloom strength in fish gelatins is the definition of Bloom and its official measurement. Some fish gelatins may melt below 10°C, the official temperature for Bloom measurements. With beef and pork one is about 20°C below the melting temperature. To put gel strength on a level playing field, we have been exploring the use of the concept of measuring Bloom at a fixed temperature difference from the melting point, (e.g. a 10°C increment) that would mean that if the fish gelatin melts at 25°C, then Bloom would be measured at 15°C; if the gelatin melts at 8°C, then Bloom would be measured at -2°C (where the gelatin remains unfrozen). Beef and pork gelatin would then be characterised at around 20°C assuming a 30°C melting point.

To test this concept, samples were matured at various temperatures and their "Bloom" measured at approximately the same temperature. By measuring the temperature dependence for specific species linear regression equations were obtained. For tilapia, the equation is as follows (Jee Young Imm, personal communication):

Gel Strength (Bloom) = 383 - 15.2 Temperature
$R^2 = 0.996$

A different curve was obtained for cod.

Thus, the preliminary data suggest that it should be possible to obtain fish gelatins with a wide range of melting points (approximately 8-10°C to 28-30°C or higher) and a reasonable range of Bloom strengths. Given this situation, some basic scientific questions relating to melting point, Bloom, and food functionality can be asked and answers obtained. These questions include:

1. What is the impact of the melting point (phase change) of a system that melts below the temperature of the human mouth on the sensory properties (especially flavour release) of various gelatin containing products?

2. What is the consumer's ideal melting temperature for the particular gelatin containing product?

3. Can we measure and then predict the impact of Bloom and melting point together in food products and then use that information to predict the consumer responses to these products?

4. Given that the melting points of some fish gelatins are closer to those of many commercial fats, what is the potential role of fish gelatins in developing low fat products?

This final question arises out of the fact that the food industry is already using gelatin as one of the ingredients in producing low fat products (e.g., low-fat margarine). However, most fat melting systems melt over a range of temperatures that are more often in the 10 to 20°C range than in the 25 to 35°C range of the currently used beef and pork gelatins.

Thus, in addition to their kosher/halal benefits, it becomes reasonable to ask whether fish gelatins would actually provide a functional benefit in many product applications over those of currently available materials, thus justifying their use in many more applications, despite their higher costs. Coupled with the potential market extension and operational simplicity for food companies with respect to producing kosher/halal foods, there might then be a significant potential market for these products.

The current project at Cornell is focused on obtaining answers to these key basic questions about fish gelatin and illustrating the benefits of fish gelatin. Another goal of this work is to provide the food industry with one or more tests that they can use to evaluate their product specific applications. Dealing with a major phase change (i.e. melting) of one of the components is not a part of the normal sensory testing process and adaptations of current methodology may be required. The work in developing these sensory tests may be helpful to those developing other low-fat and/or gelatin products.

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SEAFOOD RESEARCH
A New Zealand perspective

By James Templeton[1]

Abstract

The New Zealand seafood industry, though small in world terms, is important to the country's economy with foreign exchange earnings worth some $NZ1.2b. The industry is based on a stable resource of around 600 000 t of green weight product. The major species by value are orange roughy ($155m), hoki ($147.5m), rock lobster ($114m), mussels ($87m), ling ($55m) and paua ($53m).

To achieve long-term growth, the seafood industry recognises that merely increasing catch volume is not an option. Improved profitability can only be achieved through technological advances in efficiency and product quality.

Crop & Food Research's seafood programs are designed to assist in this process by developing technologies that will enhance product quality (in all its manifestations) and safeguard its safety.

Such developments, however, can only take place, if appropriate goals are set in collaboration with industry. The fundamental physical, chemical and biochemical properties of the raw materials, and how they affect the product shelf-life and quality, need to be fully understood.

The work our scientists are doing and some of the outcomes in the areas of harvesting, handling, processing, storage and live transportation of fin fish and shellfish will be discussed. A case study will be presented on how our philosophy on quality enhancement created the concept of "rested harvesting" technology and the development of the supporting tool AQUI-S™.

Keywords: New Zealand; Seafood; Research; Quality; Microbiological safety; AQUI-S™; pH; Modified Atmosphere Packaging; MAP.

RESEARCH PROGRAMMES

The primary aim of our research is to understand the key factors that are limiting quality in New Zealand seafood and provide generic methods that will assist industry to overcome them. Some of the current programmes are described below.

Improving stability and functional properties of New Zealand seafood

The aim of this programme is to investigate mechanisms for stabilising fish myofibrillar proteins in order to develop integrated strategies for improving the quality and shelf-life of seafood products. Components of these strategies may include raw material differentiation, processing, production, storage and distribution technologies. It is only by taking an integrated approach that we may take advantage of synergistic interactions between different approaches for improving seafood quality.

The programme has focused primarily on hoki as it is the largest seafood resource and has a relatively short frozen shelf-life. The intrinsic stability and functional properties of hoki muscle proteins have been related to the processing variables of temperature and pH. A further study will determine the frozen storage stability of hoki by developing kinetic models to relate quality loss to time and temperature of storage. This information will facilitate the design of an appropriate cold-chain to distribute consistent, high quality seafoods to distant overseas markets. The current frozen export distribution system is designed for more stable mammalian meats and may not be suitable for cold-water fish species which have a shorter frozen shelf-life.

Cryoprotectants can be used to stabilise muscle proteins (e.g. in surimi) and the mechanisms by which they work have been studied. The chemical structure of potential food cryoprotectants have been related to their effectiveness and blends

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suitable for use in commercial products are being developed.

The seasonal variation in hoki composition is also being studied so that the seasonal changes in the fish can be better understood. This information will enable industry to improve differentiation of raw material fish and so improve overall quality, processing efficiency and final product differentiation.

Improving post-harvest crustacean quality

The aim of the programme is to provide the understanding necessary to allow industry to control the environmental conditions of rock lobsters to prolong their survival and maintain their quality during transport to overseas markets. Rock lobsters are New Zealand's third largest seafood export earner, with premium prices being paid for live animals. Currently, however, market returns are not being maximised as about 13% of the lobsters are exported frozen.

By investigating the effects of stress of capture as well as environmental stress on the condition of the lobsters and survival rate during live transport, the research addresses a major priority of the industry.

Microbiological safety of seafoods

The aim of this programme is to enhance microbiological safety, quality and shelf-life of seafood products by identifying microbiological hazards associated with specific seafood products and developing handling, processing, packaging and storage techniques that eliminate these hazards. The objectives of the current programme include the following.

1. Investigating methods to remove algal toxins from affected shellfish. The ultimate goal is to be able to harvest toxic shellfish, treat them to remove the toxins and have a safe product to sell. To date methods of detoxifying Pacific oysters fed with algae which produce NAP (neurotoxic shellfish poisoning) have been identified.

2. Developing processing regimes in the processing facility that reduce the carriage of bacteria associated with the raw product. The time/temperature relationship that is required during the initial heat shucking (blanching step) in the production of greenshell mussel products of high microbiological quality has been established. The effectiveness of various washing regimes in reducing bacterial numbers on the surface of gilled & gutted fish is being studied.

3. Investigating ways to improve current sanitising regimes with regard to bacterial death, biofilm removal and cost effectiveness (in terms of labour and chemicals). In order to gain a better understanding of the factors which appear to be important in biofilm removal, flow through reactors have been constructed in which coupons can be fouled and exposed to various sanitising regimes.

4. Investigating the safety of modified atmosphere packaging (MAP) of seafood with specific regard to the bacterium of most concern: *Clostridium botulinum*. This is a joint project with the Commonwealth Scientific Industry Research Organisation (CSIRO) which will initially involve determining the growth of the organism under different atmospheres, temperatures, pH levels and salt concentrations in order to develop a preliminary model. The model will be tested using product stored under vacuum packaging and MAP regimes. The long-term goal is to incorporate a full model into user-friendly software which the food industry can use to determine the safety of new processes without having to carry out expensive and hazardous trials.

Mechanisms of autolysis in fish

The aim of this programme is to increase the value of New Zealand seafood by developing methods to control autolytic deterioration in post-mortem muscle texture. By understanding the underlying mechanisms of texture loss this research will support quality improvements to the wide range of species targeted by the seafood industry. New information on the mechanisms of texture loss in species such as hoki and salmon will, in the short-term, enable the industry to improve the quality of its current production. In the longer term, this information will enable the industry to attain its strategies to the economic potential of the targeted species and will impact on the future stability of the fishing industry.

An important outcome from this programme has been our success in achieving considerable quality improvements in salmon through "rested harvesting".

Rested harvesting

The concept of rested harvesting originated from investigations of the impact of muscle fatigue on the post-mortem texture Chinook salmon (*Oncorhynchus tshawytscha*) "white" muscle (Jerrett *et al.* 1996) which highlighted the importance of reducing pre-mortem exercise in the production of high quality muscle.

In these investigations major improvements in muscle quality was achieved, firstly, through gaining a better understanding of the interaction of the animal with the harvest process, then, by designing an appropriate tool (i.e. AQUI-S™, Jerrett 1992) to eliminate the negative aspects of this process.

A key factor in the success of these investigations was the establishment of a population of laboratory-reared salmon. This provided raw material of a known and consistent intrinsic quality and facilitated strict experimental protocols for obtaining "rested" and "exhausted" fish.

Prior to this research, the quality potential of farmed fish was consistently underestimated. Even in this highly controlled "fishery", inconsistent raw material quality, directly associated with autolytic spoilage attributable to fatigue, has proved to be a major obstacle in the design of optimal processing and handling procedures.

Rested harvesting has been successfully implemented by the New Zealand salmon industry where the combination of behavioural conditioning, conservative handling practices and chemical anaesthesia (AQUI-S™) is used to minimise the extent of pre-mortem exercise and produce "rested" fish. The benefits of which, include considerable improvements in fillet yield, reductions in fillet defects such as gaping and blood spotting, less physical damage and improved external appearance of the whole fish. As a result the industry is now able to produce a far more consistently attractive and marketable and higher value product.

AQUI-S™

The implementation of rested harvesting by the New Zealand salmon industry has led to the successful use of the anaesthetic AQUI-S™ as a tool for humane veterinary procedures and husbandry practices. By anaesthetising or sedating fish, crustacean or molluscs, the live animal can be handled, graded or transported in a relaxed stress-free state resulting in virtual total recovery of the animal after release.

AQUI-S™ is a food grade anaesthetic which contains natural ingredients with USFDA GRAS (generally regarded as safe) status. It is also environmentally friendly, as it has the ability to be readily assimilated into the water thus requiring no harmful solvents in mixing.

CONCLUSION

The needs of the New Zealand seafood industry will continue to drive our research programmes.

Helping the industry to achieve their long term growth by developing innovative technologies for the production of safe, enhanced quality and high value products is the goal.

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LIVE FISH TECHNOLOGY

Historical convenience to modern multispecies strategy in Norway

By Kjell Midling[1], Arvid Beltestad and B. Isaksen[2].

Abstract

Traditional fisheries and modern aquaculture are now merging into a new structure capable of supplying the market with value-added fresh products. This paper presents an overview of the historical traditions in Norway on live fish technology from the times of the pioneers in 1880 to today's high technology in fisheries and aquaculture. The research covers several species:

from	**demersals** such as:	cod (*Gadus morhua* L.) and plaice (*Pleuronectes platessa*); and
	pelagics such as:	mackerel (*Scomber scombrus*), herring (*Clupea harengus*), sprat (*Sprattus sprattus*), and saithe (*Pollachius virens*);
to	**invertebrates** such as:	lobster (*Homarus gammarus*), the common crab (*Cancer pagurus*), the king crab (*Paralithodes camtschatica*), and sea urchin (*Strongylocentrotus droebachiensis*).

Technologies and strategies vary largely and this paper presents the historical and recent development of catch and gear modifications, transportation (development of new holding tanks aboard the vessels) and new net pen constructions to receive and store the catches.

Keywords: Norway; Cod; *Gadus morhua*; Plaice; *Pleuronectes platessa*; Mackerel; *Scomber scombrus*; Herring; *Clupea harengus*; Sprat; *Sprattus sprattus*; Saithe; *Pollachius virens*.

INTRODUCTION

The traditional method of short-term storage of any catch from the sea, was store it alive. It was the most convenient method available in times when freezing, chilling and logistic facilities were scarce. The alternatives in the temperate zones were conservation by salting and/or drying, while tropical areas also developed conservation through adding strong spices such as chilli or garlic. These methods were abandoned when it became possible to freeze and store the catches, even in remote places with scattered population, during the post-war rebuilding in the 1950's. Technological developments of this sort were the foundation of the successful development of the Norwegian salmon farming industry. Moorings, net pens and sufficient understanding of fish requirements during transportation and storage had already been developed and understood when the salmon adventure started in Norway in the early 1970's.

With growing domestic and European demand for fresh whitefish species, the former live fish technology experienced a renaissance. From being a convenient method of storage, it became a strategy for part of the industry, as well as the fishing fleet itself, to meet the price variations in the market (see Table 1).

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Table 1: Live fish logistics in Norway

	Cod	Plaise	Wolffish	Saithe	Herring	Sprat	Mackerel	Lobster crab	Sea urchin
CATCH METHOD									
Trawl			x[1]						
Seine net	x	x	x[2]						
Purse net				x	x	x	x		
Trap	x								
Pot	x							x	
Diver									x
Liftnet									x
TRANSPORTATION									
Well boat				x			x		
Holding tank	x	x	x					x	
Net pen				x	x	x	x		
SHORT-TERM STORAGE (up to one month)									
Net pen[3]				x	x	x	x		
Net cage[4]	x	x	x						
Tank		x	x					x	x
WHY									
Production levelling	x	x	x	x	x	x	x		
Guarantee of supply	x	x	x	x	x		x	x	x
Empty stomachs						x			
Higher price	x	x			x	x			
LONG-TERM STORAGE (more than one month)									
Net pen							x		
Net cage	x		x	x			x		
Tank			x					x	x
Feeding for growth	x		x				x	x	x
Feeding for weight maintenance				x			x	x	
WHY									
Production levelling				x					
Guarantee of supply	x		x	x			x	x	x
Increased weight	x		x				x	x	
Quality tailoring	x		x				x		x
Higher price	x		x	x			x	x	x
Volume (tons)	1000-1500	100	20	2000	0.5*	20	200	300	20
Increased price (Kroner/kg)[5]	10-12	3-4	?	5	100*	4-5	20	10-50	40-50

[1] *Anarhichas minor*
[2] *Anarhichas lupas*
[3] Mobile net
[4] Stationary net for aquaculture
[5] 1 $US = 6.5 Kroner
* Kazunoko-kombu

DEMERSAL SPECIES

History

On an industrial level, live fish technology on cod *(Gadus morhua)* goes back to 1880 in Norway, but we know that as early as 1850 it was common to store cod alive in wooden boxes along the southern coast of Norway. From 1875 to 1900, the Norwegian herring *(Clupea harengus)* and cod fisheries off the Icelandic coasts developed. Most of the catches were salted, but during the last two weeks of each trip, the cod were kept alive aboard these rather primitive sailing vessels in wells perforated with one inch holes. The water supply was sufficient as long as the vessel was in motion. If weather conditions allowed it, the Norwegian fishermen sailed to Grimsby in England were they could obtain up to one hundred times higher prices for the live cod than the salted. The fishermen developed a number of techniques, including puncturing the body cavity in order to remove the gas from the swimbladder.

The development of live fish technology was encouraged by the Norwegian Government through several R&D projects such as the introduction of cod traps to the fishing industry in 1913. The Norwegian Live Fish Sales Organisation was founded in 1939. This organisation was primarily a sales organisation based on live storage on a number of species (i.e. cod, saithe *(Pollachius virens)*, eel *(Anguilla anguilla)*, lobster *(Homarus gammarus)* and crab *(Cancer pagurus)*), but it also participated in a number of scientific projects (Sundnes 1957a; Sundnes & Kjelstrup-Olsen 1966). This led to a high level of efficiency, especially in

inland transportation. Standard densities were up to 500 kg/m^3 with no water exchange for 18 h. Specially designed vessels continued to collect these species along the coast until the early 1970's. In 1972, this organisation merged with the Norwegian Fishermen's Organisation and was shortly after shut down. Live fish storage almost ceased to exist, with exception of saithe.

Cod

In 1980, focus was placed on the development of marine species for aquaculture, mainly cod and halibut (*Hippoglossus hippoglossus*). The artificial production of juvenile cod became possible in 1985, and some attempts to ongrow it to market size were conducted. However, so far, the production costs have been higher than what the market has been willing to pay, and the juveniles produced are currently mainly an important tool for sea-ranching and ecological experimentation.

In 1988, 600 000 wild 0-group cod were caught alive in an attempt to copy the Japanese success with Yellowtail (i.e. mojako-fisheries), but this experiment gave marginal profit to the farmers (Olsen & Soldal 1991).

With the breakdown in the Barents Sea cod stock in 1988 and the introduction of vessel quotas in 1990, the fleet experienced a reduction of up to 85% of their previous annual catch. In order to increase the value of these limited quotas, efforts were made to improve quality and hence prices. Another strategy was live capture and ongrowing, a practice that could increase the value of the quotas by more than 100%. The most suitable gear for this purpose was the Danish seine. These vessels have always delivered cod of premium quality, but the live fish technology was not adequate for the volumes involved. While in the old days the boats were only 8-10 m long, and equipped with traps or jigs, the seine-netters were 25-30 m. Catches increased from a few hundred kilogram to 10-15 t a trip. The seine-netters experienced mortality rates in all stages; catching, transportation and in the storage pens. Mean overall mortality was estimated at more than 50%. Dead and dying cod were removed, quality graded and cod suitable for human consumption produced. The price for a live cod is more than twice the price for a low-quality cod. This mortality rate was naturally decisive for the profitability and the growth of a new live fish activity. On this basis, a series of experiments were conducted on cod.

Herding by the ropes and fishing by the seine net at the bottom normally happen at low speed (0.5-1.0 m/s) and cause scarcely any damage to the fish. However, the haulback speed had a direct effect on survival rates, mainly through physical stress and a rapid pressure decrease. The production and absorption of gas from the swimbladder are both slow processes (Tytler & Blaxter 1973; Sand & Hawkins 1974) and the bladder will burst when the surrounding pressure is reduced by 60%. Hence all cod had burst swimbladders when brought on board. A substantial proportion of the fish had too much swimbladder gas left in the bladder/abdomen cavity ("floaters") and did not manage to dive in the holding tanks. When the haulback speed was reduced, more of the excess swimbladder gas was forced out of the abdominal cavity, halving the number of "floaters".

Today's codend materials are usually polyamid and polyethylene, and even if they are regarded as lenient to the cod during lifting, the size of each lift (500 to 700 kg) inflicts high pressure and raises mortality rates. The size of the codend lifting bag was reduced to 300 kg and was equipped with a canvas mounted internally. The canvas lift was closed during fishing to prevent it from acting like an anchor and affecting the fishing operation and selectivity of the gear. During lifting the canvas were opened and filled with water, thus reducing the surrounding pressure on the cod. The canvas lift reduced both the mortality rates and the number of floaters (i.e. the fish were better able to dive in the holding tanks) (Isaksen & Midling 1995).

The water inlets and outlets in the holding tanks were originally very simple. One to four pipes spread the water horizontally in the tank from pumps supplying 300 m^3/hr. The outlet was via overflow through pipes at the top of the tank. The capacity of these tanks were typically 150 kg/m^3 and mortality rates of 5-10% were normal. At greater densities, mortality could be as high as 30%.

Behavioural observations clearly revealed that the horizontal water flow was not adequate for newly caught cod. With a burst swimbladder and peritoneum the cod is negatively buoyant, and in any case, cod have a tendency to swim downward just after transfer to the holding tanks. This leads to an aggregation of cod at the bottom of the holding tank, estimated at more than 500 kg/m^3. Based on *in situ* behaviour studies, the holding tanks were modified and the water was now supplied through a double bottom with less than 1% of perforation. This method increased the capacity to more than 250 kg/m^3 and reduced mortality to zero.

When it was monitored by echosounder, underwater cameras and direct observation by divers the reason for the high mortality rates after transfer from the vessel to the net cages turned out

to be the same as for the holding tanks. The vertical distribution shortly after transfer showed a rapid downward tendency, resulting in a dense aggregation of cod at the bottom. The depth of the net pen itself increased from 10 to 13.5 m. At this stage the cod were still blunt, and the individuals at the net pen bottom could hardly be provoked to swim by the diver. The oxygen levels inside this aggregation were 6.3 mL O_2/L and therefore far from lethal (asphyxia on cod will take place at 0.8 mL O_2/L, Sundnes 1957b). The cause of death is therefore suffocation due to the pressure of other cod, preventing operculum movement rather than the absence of oxygen. In order to deal this behaviour, new net pens with a flat bottom panel (springboard panel) were constructed. Extra water supply through the panel was provided by a mixer, which in addition to providing oxygen also supported the negatively buoyant cod to stay pelagically in the net pen. After 40 h in this net pen, the cod were transferred to a traditional net pen (Midling & Isaksen 1995).

These experiments reduced the overall mortality during seine net catching of live cod to an acceptable level and has led to the development of new holding tanks also suitable for other species (i.e. fish without a swimbladder). In addition, the flatbottom net pen is now being used for ongrowing purposes with species like halibut and wolf-fish *(Anarhichas minor* and *A. lupus)*.

Plaice

Plaice *(Pleuronectes platessa)* have a long tradition as a valuable species. Traditionally they were caught by gillnets and stored in wooden cages. However, the importance of this resource has declined in recent years, and from being three times as well paid as cod in 1950, plaice now only has half its value (first hand, per kilogram). A new project, started in 1996, aims to change this development by applying the new technologies to plaice and other species without swimbladder. New holding tanks designed for high density transportation have raised capacities from 50 kg/m^3 to 750 kg/m^3.

PELAGIC SPECIES

History

Pelagic fish have been stored live for almost two centuries in Norway. The topography of the country, with its fjords, inlets and coves which give shelter from rough seas, was the main reason why Norwegians became pioneers in storing live pelagic fish in beach seines and later, net pens. In coastal areas, schools of herring, sprat *(Sprattus sprattus)*, mackerel *(Scomber scombrus)* and saithe were caught by beach seine, and the fish could be stored live in seines for weeks before the catch was delivered to the processing plants. Live storage was essentially a means of compensating for a lack of production capacity in the fish processing industry in periods of high catches. Since the fishing boats used at that time were too small to carry large catches, most processors had their own carriers that bought the fish from the live storage sites and transported them to the processing plants.

At the turn of the century, purse seining technology was introduced in Norway. Live fish were stored by towing the purse seine boat with the live fish concentrated in the bunt in to the shore, where the fish were transferred to beach seines and stored. This method was still in use up to the 1960's.

Shortly after the end of World War II fishermen started to store live pelagic fish in net pens. The fish were caught by purse seine and transferred to net pens at the fishing ground. The net pens were then towed inshore and moored. This method is still in use for live storage of all the four pelagic species discussed here.

Saithe

Saithe are mostly caught by trawl, purse seine or gillnet. Most of the saithe caught by purse seine are stored live in net pens. Saithe are a tough species and are capable of withstanding severe stress. Saithe can be transported live for long distances in well boats. The fish are brailed from the net pens into the well and transported to the processing plant, where they may be unloaded for immediate processing or transferred to net cages for production later.

The main fishing period for purse seining saithe is the summer. The purse seine catches are usually much larger than the production capacity of the industry. To smooth out the difference between the large catches and production capacity, long-term storage of live saithe was done in the late 1970's. Up to 200 t of saithe were stored in each pen from August/September until February/March the following year. Technologically, long-term storage worked well, with relatively low mortality. This activity ceased in the early 1980's, primarily for commercial reasons. However, today the strategy is once again to store some of catch for long periods, feeding it to maintain weight. This may increase the price per kilogram by approximately 5 Kroner.

Herring

Herring have been one of the most important pelagic species for live storage in Norway. In the early days, up to 10 000 t of Norwegian spring spawning herring could be stored alive in a single

beach seine. Herring are still stored on the Norwegian coast, but today only in net pens.

In 1994, the Institute of Marine Research in Bergen started trials of harvesting herring roe-on-kelp (Kazunoko-kombu). Purse seine caught herring are transferred to the net pens just before spawning. The net pen bottom is covered with kelp which is harvested when it is covered with sufficient roe. Preliminary trials have shown that Norwegian spring spawning herring spawn on kelp in almost the same way as the Pacific herring *(Clupea harengus pallasi)* in British Columbia and Alaska (Hanson 1992). The product has been tested on the Japanese market with good results (Beltestad 1996; Wray 1995).

Sprat

In about 1880, sprat and small herring began to be canned in Norway. These high quality products were marketed as "Norwegian brisling sardines" and "Norwegian silde sardines" and exported all over the world. One of the fundamental issues when canning whole fish of top quality, is that the stomach contents must be digested before canning. When the fish are stored alive in beach seines or net pens, the stomach usually is empty after two to three days. The sheltered coastline and highly developed technology of storing live fish enabled Norway, almost alone in the world, to produce this high quality canned product.

Mackerel

On the west coast of Norway, mackerel are only available in the summer and autumn, with the largest catches taken between August and October. During this period the catches are much higher than the fresh fish market can absorb. This leads to dramatic seasonal falls in prices. To extend the season for fresh mackerel, and to increase the value of the catch, some pioneer fishermen started long-term storage of live mackerel in 1989. The fish were stored in net pens from autumn until spring the next year. During the main fishing season, the fishermen can obtain about 2 Kroner/kg. In the spring, before the new season starts, they may get more than 20 Kroner/kg (Beltestad & Misund 1993). Today the total quantity of mackerel in long-term storage varies between 150 and 200 t a year.

The mackerel are normally fed for weight maintenance (Juell *et al.* 1996), but one *ad. lib.* feeding experiment carried out in 1991/92 showed that the mackerel could increase its weight from 300 to more than 600 g from January to August (Beltestad & Misund 1993). It is therefore possible to produce a "super" mackerel with an average weight far above 1 kg.

CONCLUSIONS

Today's livefish technology, even if it covers a large number of species, is still on a rather experimental scale. The activity is largely influenced by factors as quotas in the traditional fishery, and obviously by the fresh fish prices. Nevertheless, we strongly believe that the technology developed in the course of these experiments will be of increasing importance in a future where quality and availability becomes more important. However, some further development and technology transfer to the industry still remain to be done before this activity can have a substantial influence on the fresh fish market.

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WATER MOTION

Stress effect during live transport of Silver bream

By Louis Evans and Jane Fewtrell[1]

Abstract

Water motion during live transport of fish may be a significant factor influencing stress levels, and therefore, survival of the harvested fish. The effect of water motion during live transport on the stress response of silver bream (*Rhabdosargus sarba*) was investigated using a range of stress parameters. Fish were placed in 11 L test containers and were subjected to 30 min of water motion, similar to that likely to be experienced in on-board holding tanks. Stress responses were assessed by measuring differential blood cell counts, spleen somatic index, serum cortisol levels and nuclear diameter of interrenal cells. Thirty minutes of simulated water motion resulted in a significant increase in thrombocyte count, serum cortisol levels and nuclear diameter of interrenal cells. A significant decrease in lymphocyte count was also observed. Spleen somatic index results were inconclusive. A stress response in the silver bream due to confinement of the test containers was also observed. It was concluded that water motion, similar to that likely to be experienced during live transport, induces a stress response in silver bream, and may be a factor in fish survival.

Keywords: Live transport; Silver bream; *Rhabdosargus sarba*; Stress; Holding tanks; Water motion.

INTRODUCTION

The Australian live finfish market has increased from approximately $A1.8m in 1990 to $A8.5m in 1994 (Steffens 1995). The live finfish market in both South-East Asia and within the Asian ethnic communities of Australia is the major source of this growth. One example of the premium available on live finfish is the coral trout (*Plectropomus maculatus*) which is fetching between $A200 and $A300/kg on the Hong Kong market (Grant 1993; Steffens 1995).

For any venture involving live fish export to be successful mortalities and disease should be kept to a minimum. Evidence from extensive research has shown that minimising stress induced by the various procedures involved in the harvest, handling and storage techniques used in live export is important in controlling mortalities and poor health (Flos *et al.* 1988; Foo & Lam 1993; Schreck *et al.* 1989; Waring *et al.* 1992).

For convenience, the responses to stress in fish have been classified into primary, secondary and tertiary, depending on the level of organisation of the response (Mazeaud *et al.* 1977; Barton *et al.* 1986; Barton & Iwama 1991). The primary response to stress involves the stimulation of the hypothalymic-pituitary-interrenal axis and the sympathico-chromaffin system (Mazeaud *et al.* 1977; Mazeaud & Mazeaud 1981; Ungell *et al.* 1984) resulting in an increase in the level of circulating corticosteroids and catecholamines. These neuroendocrine reactions stimulate secondary responses and manifest as changes in a range of biochemical, physiological, haematological, immunological and morphological parameters (Barton & Iwama 1991). If the stressor is severe or prolonged, tertiary responses follow. These include alterations in disease resistance, growth performance, reproductive capacity overall health and condition and market quality (Wedemeyer & McLeay 1981; Goodrick 1987).

Quantitative measurement of primary and secondary physiological responses to stressors are used by many researchers to evaluate the intensity of a given stressor and hence, the likely effect of that stressor on subsequent health and survival. Significant stressors can then be modified, or eliminated, in order to minimise the stress response of the fish.

After capture, fish intended for live export are usually stored in on-board holding tanks for a period of days. A potential stressor is the unnatural

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motion of the water in the holding tanks that the fish are exposed to as a result of the boat rolling and pitching.

The aim of this study was to investigate the stress response of a marine teleost, silver bream, to water motion, similar to the levels likely to be experienced during live transport.

MATERIALS AND METHODS

Preliminary investigation

A preliminary investigation was conducted to identify methods that would detect a stress response in silver bream. Silver bream were exposed to air for two minutes and various documented techniques were used to measure the stress response. Methods that were successful in detecting a stress response were utilised in this investigation. It was also determined that providing all fish in each container were sampled within three minutes the stress induced by the sampling methods did not affect the results obtained.

Experimental animals

Forty, six month old silver bream were purchased from the 'Fremantle Ocean Farms', Western Australia, where they had been spawned and reared. The average length and weight was 125.1 ± 15 mm and 20.2 ± 8 g respectively. The fish were maintained in groups of equal numbers in three 350 L fibreglass tanks fitted to a 2.5 t recirculating marine system. Evidence from literature (Swift 1983; Pickering & Stewart 1984) and from previous studies conducted at the Aquatic Science Research Unit indicates that this stocking density should not induce a stress response in the test species. The fish remained in these tanks for 31 days, a period in excess of the acclimation period used by other workers (Thomas & Robertson 1991; Foo & Lam 1993). They were left undisturbed except for once daily feeding of trash fish, at 1300 hours. Artificial temperature control and lighting were not used.

Experimental apparatus design

A see-saw apparatus (Figure 1) was used to create water motion in the 11 L containers. Preliminary observations showed that the water motion produced by the see-saw produced a similar motion in the containers to the rolling and pitching that occurs on fishing boats.

The see-saw was constructed with a 2.5 m plank of wood positioned 150 mm off the ground. It was rocked at a rate of 50 depressions/min and produced a wave height of 3 cm.

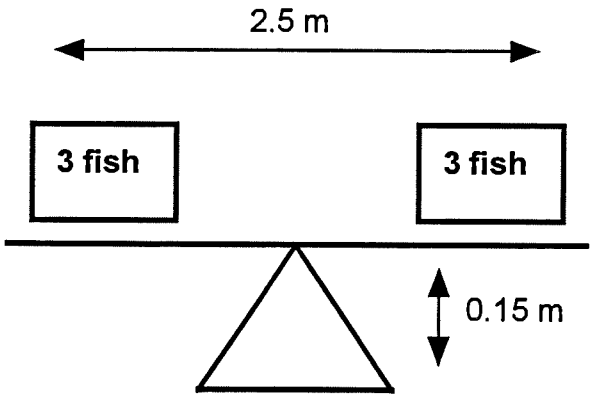

Figure 1: Diagram of the see-saw device used to create water motion.

Experimental design

In order to assess the level of stress induced by the confinement of the silver bream's new environment, a group of fish (unstressed) were sampled from three of the 300 L fibreglass tanks in the hatchery (salinity = 35ppt, ammonia = 0.05ppt, pH = 8.2). Three fish from each tank were sampled. All fish from one tank were sampled within two minutes. Haematological and histological analysis were performed on the samples.

Eight 11 L, rectangular, opaque, dark blue, food grade containers were filled to the same level with sea water (salinity = 35ppt, ammonia = 0.05ppt, pH = 8.2) with each container being supplied equal amounts of aeration. The containers were set up so that water could be siphoned into and out of each one resulting in minimal disturbance to the fish. Three fish were placed into each of the containers (previous trials have shown that more then three fish in each container resulted in death due to high ammonia levels). The fish were fed daily at 0800 hours and were subjected to twice daily 70% water changes to prevent ammonia accumulation. After a 7 day acclimation period the sampling began.

Four of the eight containers were randomly selected as controls. The other four containers were designated as the treatment group and were rocked on the 'sea-saw' device, two at a time. Aeration was maintained throughout the rocking process. Each container was then placed on a bench. One container from both the control and motion group were sampled immediately after the treatment group were exposed to motion. Sampling was then repeated at 30 mins, 10 h and 24 h subsequent to the exposure to water motion. At each sampling point, all three fish in each container were sampled within two minutes. Haematological and histological analysis were conducted on the samples taken from all fish.

Interrenal cell nuclear diameter

After dissection, the head kidney tissue was immediately fixed in Bouins solution, embedded in paraffin wax and sectioned at 5 μm thickness using a microtome. Sections of the head kidney were prepared and one in every 10 sections was stained using the haematoxylin-eosin method .

The interrenal cells of the head kidney were identified under a microscope at 1000 x magnification. The nuclear diameter of 30 cells from each of the three fish at each time point after the applied water motion were measured, using an ocular graticule. The cells were counted in three different regions of the head kidney (selected at random), 10 cells being counted in each region (giving a total of 30 cells).

Serum cortisol

Blood was collected from each fish in non-heparinised capillary tubes. The blood was then transferred from the tube into 2 mL capped plastic sample tubes where it was left, undisturbed until a blood clot formed in the bottom. The serum was then immediately removed with a Pasteur pipette and placed into a clean sample tube. The serum sample was immediately frozen and remained so until the cortisol analysis could be performed using a standard radioimmunoassay cortisol kit (Cat. No.:P2687) supplied by Sorin Biomedica.

Blood smears and differential cell counts

Four blood smears were made with whole blood immediately after it had been sampled from each fish. Each slide was then fixed in methanol and stained using May-Grunwald and Giesma. Once dry three smears from each fish were examined under a compound light microscope at 400 x magnification. A total of 300 blood cells were counted (i.e. 100 cells in each of three different sections of each slide). Differentiation was made between erythrocytes, lymphocytes, neutrophils and thrombocytes (Ellsaesser & Clem 1986). Total lymphocyte count and thrombocyte numbers were recorded and expressed as percentages.

Spleen somatic index

As fish were removed from the containers they were weighed, sacrificed and blood samples were removed. Immediately after all fish from one treatment group had been sampled for blood, the spleen was removed, weighed in a petri dish and then placed in Bouin's fluid. The spleen somatic index was calculated and the spleen weight expressed as a percentage of the body weight of the fish.

Statistical analysis

Statistical analyses were performed with the use of one and two-way ANOVA's and Fisher's LSD tests.

RESULTS

Interrenal cell nuclear diameter

The diameter of the interrenal cells of the control groups showed no significant difference between groups, however there was a slight increase in the control group sampled at 30 mins after the treatment group were subjected to motion (Figure 2).

The treatment group sampled immediately subsequent to the application of the stressor was significantly ($P<0.05$) different from the control. By 10 h after the stressor was applied and also at 24 h there was no significant difference between the treatment and control groups.

The nuclear diameter of the interrenal cells of the fish that were not handled (unstressed) were significantly ($P<0.05$) different to the values obtained for both the treatment and control groups (Figure 2).

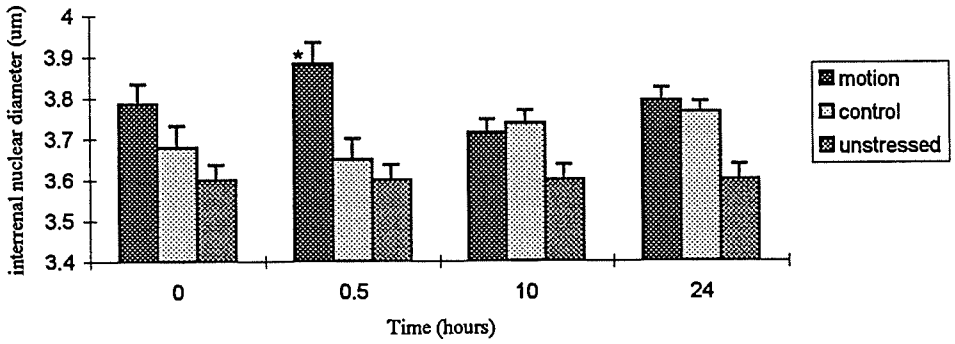

Figure 2: Nuclear diameter of the interrenal cells of silver bream after exposure to 30 min water motion in 11 L containers (motion), fish in 11 L containers only (control) and fish sampled from 350 L tanks (unstressed). Each point represents the mean (±SEM) of three determinations. Asterix denotes mean values significantly different ($P<0.05$) from control values.

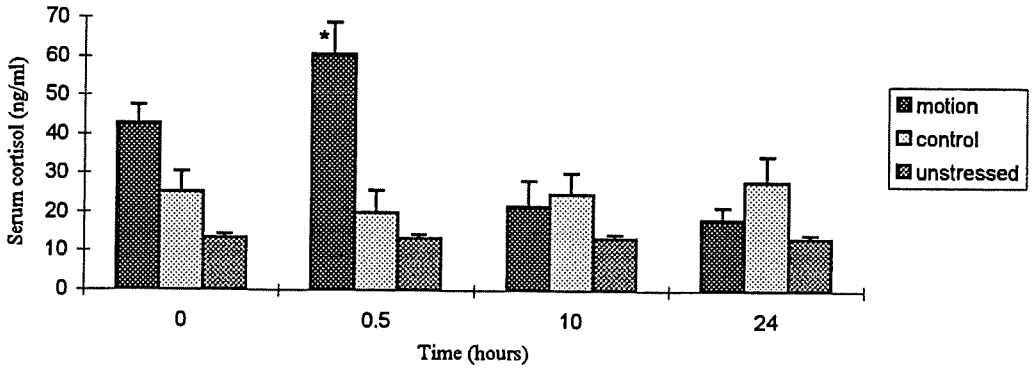

Figure 3: Serum cortisol levels of silver bream after exposure to 30 min water motion in 11 L containers (motion), fish in 11 L containers only (control) and fish sampled from 350 L tanks (unstressed). Each point represents the mean (±SEM) of three determinations. Asterix denotes mean values significantly different ($P<0.05$) from control values.

Comparing the nuclear diameter of the interrenal cells and the cortisol levels at the corresponding sample times gave a correlation coefficient of 0.8.

Cortisol

Cortisol levels increased until 30 min subsequent to the simulated motion where the cortisol level was significantly ($P<0.05$) higher than the control (Figure 3). By 10 h after the simulated motion cortisol levels had decreased significantly ($P<0.05$) from the previous time point. A continued decrease was observed at 24 h. No significant difference was observed between the control containers and although the fish in the control buckets had a higher cortisol level than the fish that had had no exposure to handling, the difference was not significant ($P<0.05$).

The fish that were confined to the 11 L containers had a significantly ($P<0.05$) higher circulating cortisol level than the fish that were not exposed to any handling (unstressed) (Figure 3).

Lymphocyte counts

At 10 h subsequent to being exposed to water motion, the percentage lymphocytes in the blood had decreased significantly ($P<0.05$) from the control group (Figure 4). By 24 h after the water motion, the number of lymphocytes in the blood had significantly ($P<0.05$) increased from the previous sampling point, but were still significantly ($P<0.05$) lower than the control groups lymphocyte numbers.

Lymphocyte numbers of the fish in the control buckets indicated no significant difference ($P>0.05$) between different time points.

The fish that were held in the 350 L fibreglass tanks had a significantly ($P<0.05$) higher percentage of lymphocytes contained within the blood that the fish confined to the 11 L buckets, with or without exposure to water motion (Figure 4).

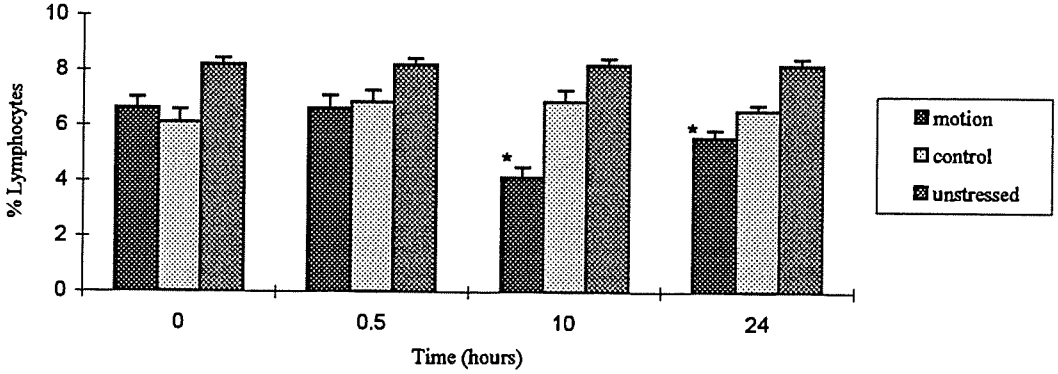

Figure 4: Percentage of lymphocytes in the blood of silver bream after exposure to 30 min water motion in 11 L containers (motion), fish in 11 L containers only (control) and fish sampled from 350 L tanks (unstressed). Each point represents the mean (±SEM) of three determinations. Asterix denotes mean values significantly different ($P<0.05$) from control values.

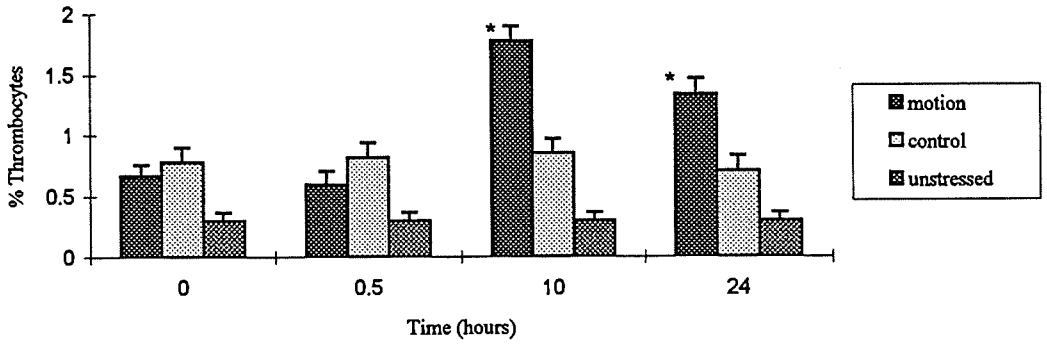

Figure 5: Percentage of thrombocytes in the blood of silver bream after exposure to 30 min water motion in 11 L containers (motion), fish in 11 L containers only (control) and fish sampled from 350 L tanks (unstressed). Each point represents the mean (±SEM) of three determinations. Asterix denotes mean values significantly different ($P < 0.05$) from control values.

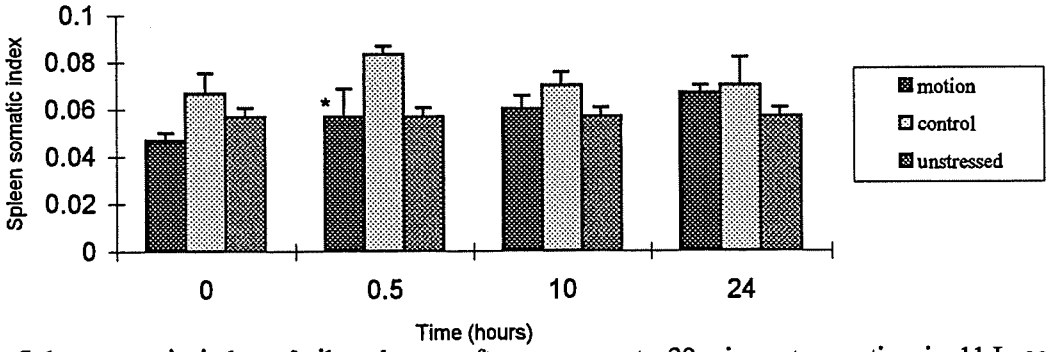

Figure 6: Spleen somatic index of silver bream after exposure to 30 min water motion in 11 L containers (motion), fish in 11 L containers only (control) and fish sampled from 350 L tanks (unstressed). Each point represents the mean (±SEM) of three determinations. Asterix denote mean values significantly ($P < 0.05$) different from control values.

Thrombocyte count

Within 10 h of being subjected to the water motion, thrombocyte numbers in the blood had increased significantly ($P < 0.01$) from the control values. At 24 h after the exposure to motion, thrombocyte numbers had decreased but were still significantly ($P < 0.05$) higher than the control values.

There was no significant ($P < 0.05$) differences in the thrombocyte numbers between the control tanks.

Thrombocytes contained within the blood of the unstressed fish in the 350 L tanks were significantly lower than that of the percentage thrombocytes contained in the blood of the fish confined to the 11 L containers (Figure 5).

Spleen somatic index

The spleen weights from the fish contained in the control tanks did not vary significantly except at the 30 min after the treatment buckets treatment group was exposed to motion where a significant ($P < 0.05$) increase in spleen somatic index (SSI) occurred (Figure 6).

The lowest SSI was recorded immediately subsequent to the treatment groups exposure to motion. No significant difference from the control was observed, except at 30 min after exposure to simulated water motion exposure, where a significantly ($P < 0.05$) lower SSI was observed in the group exposed to motion. SSI in the control group were always higher than in the treatment group.

The fish that were not exposed to handling had a significantly ($P < 0.05$) lower SSI than the fish that were confined to the 11 L containers.

DISCUSSION

It is apparent from the results that water motion of the nature produced in these trials a marked physiological stress response in silver bream. Further, the results suggest that the confinement of the 11 L containers used in the trial also results in an increase of stress levels. Large standard errors in the data were observed, particularly in the fish exposed to motion. This suggests that some of the fish in this treatment group may have been more tolerant than the other fish to stressful situations. Similar cases have been previously reported by other researchers (Pickering 1992; Fevolden *et al.* 1994). The variation is so consistent in some

species that research effort is presently being directed at selecting fish from within a population that have a genetically related high tolerance to stressors (Fevolden *et al.* 1991; Fevolden *et al.* 1994). As stress can be detrimental to the growth rate, reproductive rate and to the survival of the fish, a fish that would tolerate more severe stressors would have high potential in aquaculture.

Despite the high variability observed in the results, all parameters measured in this investigation provided evidence of the occurrence of a stress response resulting from exposure to motion. Control fish, held in the 11 L containers all showed evidence of a stress response, in that the measured parameters all differed from those measured in the fish that were not disturbed prior to sampling. Chronic elevation or depression of the basal levels of stress parameters is a common finding in instances of exposure to prolonged, sublethal stressors (Donaldson 1981). Whether the elevation in stress levels results from the confinement in the 11 L containers or a response to handling is not known.

A decrease in SSI was expected in fish that were stressed. Pulsford *et al.* (1994) reported results of a decrease in SSI of 50% in dab (*Limanda limanda)* when exposed to an acute stressor. In the present investigation the lowest SSI was recorded immediately after the motion ceased (Figure 6). This was expected as the spleenic contractions which cause the spleen to expel red blood cells (erythrocytes) and therefore decrease in weight are induced by increased levels of circulating adrenalin. Adrenalin is stored in the chromaffin cells ready to be released when the fish are exposed to stressors. The adaptational significance of this is that the increase in numbers of oxygen carrying erythrocytes results in more oxygen being available for use by the fish. This increases the probability of the fish either escaping or coping with the stressor and therefore enhances the chance of survival. The quick recovery of the spleen indicates that adrenalin was quickly cleared from the circulation which other researchers have also reported (Mazeaud & Mazeaud 1981).

Unexpectantly the SSI in the 'unstressed' fish was lower than the control fish which may be an indication of adaptation to a new environment. That is, the confined environment of the 11 L containers is more stressful than the environment of the 350 L tank so, therefore, the spleen is storing more blood cells in preparation for release. However, it is more likely that as there was only three fish in each bucket outliers could not be rejected. This is reflected in the large variability of the results obtained within the same treatment group. Interestingly, the increase in SSI that occurred in the control group at the 30 min time point coincided with a decrease (not significant) in cortisol (Figure 3) which suggests that the fish in this container may have been exposed to a minor stressor that the others were not.

Cortisol plays an important role in osmoregulation and increasing the level of glucose available for utilisation by the fish. The concentration of circulating cortisol increases with the increasing severity of the stressor (Barton *et al.* 1986). This was the case in this investigation with a significant increase in the circulating cortisol levels being measured in the fish exposed to motion, with the maximum cortisol concentration recorded at 30 min subsequent to the exposure of motion. Cortisol is not stored, but rather must be synthesised and then released from the interrenal cells of the fish when stimulated by stressors. Therefore, unlike the effects of adrenalin, the effects of cortisol are not instantaneous.

The cortisol levels in the control group were not significantly higher than the levels obtained from the 'unstressed' fish, suggesting that, like the results for the nuclear diameter of the interrenal cells, a significant increase in the circulating cortisol is not necessary for the fish to function normally in the confinement of 11 L containers.

It is generally accepted that the nuclear size of any cell secreting a hormone will increase in size (Scott & Rennie 1980). It was expected that, as the cortisol levels increased so to would the nuclear diameter of the interrenal cells. The results supported this expectation with the actual relationship between the increase in size of the nuclear diameter and the increase in the level of cortisol being directly proportional, with a correlation co-efficient of 0.8. However, Scott and Rennie (1980) reported that in a similar investigation the correlation between cortisol levels and the size of the interrenal cells nuclear diameter was not significant. This may be due to the type of stressor utilised or the different species of fish used.

The largest cell diameter was recorded at the sample point 30 min after the applied stressor, which coincides with the highest level of cortisol (Figure 2). This and the high correlation co-efficient suggests that a stress response was detected by an increase in the size of the interrenal cells nuclear diameter and that the increase in nuclear diameter of the interrenal cells was due to the increase in level of cortisol that they were producing and secreting.

The differences observed in nuclear diameter in the interrenal cells were very small (1μm). Since the maximum resolving power of a light microscope is approximately 0.25μm, measurements are close to the limits of the optical system (Scott & Rennie 1980). Any slight variation in histological methods or slight inclination of the nuclei from the vertical in the section, may have introduced errors in this range of dimensions. This probably explains the large variation obtained in these measurements.

Lymphocyte numbers in the blood of silver bream that had been subjected to motion had significantly decreased from fish that had been only confined to buckets (Figure 4). However, the decline in lymphocyte numbers was not significant until 10 h subsequent to the applied stressor. Other workers have reported time lapses of similar length between increase in cortisol levels and decrease in lymphocytes and suggest that the increase in the level of cortisol during a stress response is the cause of this decrease in lymphocytes (Donaldson 1981; Wedemeyer & McLeay 1981; Pulsford *et al.* 1994). This could certainly be the case in this investigation as cortisol values more than doubled just prior to the recorded decrease in lymphocytes. Further in support of this theory, by 24 h subsequent to motion lymphocyte numbers had increased significantly while cortisol levels had decreased.

The fate of the circulating lymphocytes that 'disappear' from the circulation of the silver bream is unknown. However, evidence from the brown trout (*Salma trutta*) indicates that the cortisol induced lymphopenia is also accompanied by a loss of lymphocytes from other tissues, suggesting that the lymphocytes are being lysed rather than being distributed from the circulation to various tissues (Pickering 1984).

Ellsasesser and Clem (1986) found that in channel catfish (*Ictalurus puncatus*) both the T and B lymphocytes were, in some way, damaged or functionally impaired such that cells remaining in the circulation were no longer capable of responding to antigens and mitogens. This, and the decrease in the number of lymphocytes, would assuredly result in a significantly enhanced susceptibility to infectious agents (Ellis 1977; Ellsaesser & Clem 1986).

An increase in circulating thrombocytes, as detected in this investigation, should be expected during a stress response because of their involvement in the blood clotting mechanism in fish. When an increase in the levels of circulating catecholamines (due to stress) is detected by the appropriate receptors the number of circulating thrombocytes increase in preparation for blood loss, which commonly occurs in 'stressful' situations, e.g. wounds from a predator (Casillas & Smith 1977). Fujikata and Ikeda (1985) observed that the blood from tilapia (*Oreochromis mosambicas)* exposed to handling contains higher numbers of thrombocytes and coagulates more rapidly than blood from fish not exposed to handling. Casillas and Smith (1977) reported similar findings in rainbow trout (*Salmo gairdneri*) exposed to stressors. In contradiction to these results Pulsford *et al.* (1994) recorded a decrease in circulating thromboctes in *Limanda limanda* in response to acute stressors. These contradictions in results may be due to the various difficulties in interpretation of thrombocyte counts such as distinguishing between thrombocytes and lymphocytes without specific markers and the extreme fragility of the thrombocytes which makes them susceptible to damage (Pulsford *et al.* 1994).

There are many potential stressful procedures involved in the live export of fish other than water motion in the holding tanks. However, as each applied stressor will have a cumulative effect on the stress response of fish, it is important to keep each stressor to a minimum (Barton *et al.* 1986). Results from our indicative study may apply to other teleosts as other authors have reported similarities in the stress response of different species of fish exposed to identical stressors (Schreck *et al.* 1989; Steffans 1995). Therefore, reducing the intensity of the water motion during live holding in fishing vessels that the fish are exposed to could increase the survival rate and general health of harvested fish.

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DRUGS IN CULTURED FISH
A rapid chromatographic method

By Ryuji Ueno[1]

Abstract
The author has developed a rapid and sensitive analysis for Oxytetracycline (OTC), sulfamonomethoxine (SMM), miloxacin (MLX) and oxolinic acid (OA) in muscle of cultured fish by High Performance Liquid Chromatograph (HPLC). A Hisep shielded hydrophobic phase column (15 cm x 4.6 mm I.D.) with UV detection was used. For OTC, the mobile phase was methanol/0.05 M oxalic acid (1:9), pH 7.0, and OA, the mobile phase was 0.05 M citric acid/0.2M disodium hydrogen phosphate buffer, pH 2.5/10 mM tetra-*n*-butyl ammonium bromide:acetonitrile (85:15) and detection was at 265 nm. Both methods used samples that require simple pretreatment for muscle. The recoveries of OTC, SMM, MLX and OA were 72-81%. The detection limits of the 4 drugs were 0.02-0.04 μg/g of sample.

Keywords: Drugs; Cultured fish; High Performance Liquid Chromatography; HPLC; Antibiotics; Oxytetracycline; OTC; Sulfamonomethoxine; SMM; Miloxacin; MLX; Oxolinic acid; OA.

INTRODUCTION

As fish culture has developed, various kinds of fish drugs have been used for the control of fish diseases. As a result, the drugs remaining in the tissues of fish have raised questions about not only the quality but also the safety of cultured fish as food. According to the Law of the Slaughterhouse and Food Hygiene for domestic animals in Japan, the safety of cultured fish as food has been checked by a microbiological assay (Jinbo *et al.* 1990; Kiritani *et al.* 1987; Ueno *et al.* 1995a) for residual antibacterial drugs. However, very little attention has been paid to the residual drugs in cultured fish compared with the numerous studies of residual drugs in domestic animals.

OTC, SMM, MLX, and OA are typical synthetic antibacterial agents widely used in fish culture. Although many papers have been published concerning the assay of these drugs, there are few methods for their simultaneous determination. Moreover, these methods are not adequate for the rapid detection of drug residues: microbiological assays (Curl *et al.* 1988; Jinbo *et al.* 1990; Kiritani *et al.* 1987; Mercer *et al.* 1987; Mevius *et al.* 1986; Skeeles *et al.* 1984; Ueno *et al.* 1995b) and fluorometry (Ashworth 1985; Hara & Inoue 1967; Ryan & Dupont 1974) lack sensitivity and specificity, and HPLC, although sensitive, requires long pretreatments. (Bjorklund 1988; Dyer 1989; Groudel *et al.* 1987; Horie *et al.* 1991; Hoshino *et al.* 1984; Kasuga *et al.* 1981, 1982; Kido *et al.* 1985; McElroy *et al.* 1987; Murray *et al.* 1987; Oka *et al.* 1983, 1984; Onji *et al.* 1984; Ueno & Aoki 1996, 1995; Ueno *et al.* 1985a, 1985b, 1988a, 1988b, 1992, 1994, 1995a, 1995b; Uno *et al.* 1993; Yoneda *et al.* 1989). Therefore, a rapid and sensitive method for the determination of these drugs in fish muscle is still needed. In order to remedy this situation, my colleagues and I have been developing an HPLC method for the rapid determination of residual antibacterial fish drugs (Ueno & Aoki 1996; Ueno & Aoki 1995; Ueno *et al.* 1992).

The present paper reviews with this method and demonstrates it with a rapid analysis for oxytetracycline, sulfamonomethoxine, miloxacin, and oxolinic acid in muscle of cultured fish.

CHEMICALS

Oxytetracycline hydrochloride was purchased from Sigma (St. Louis, MO., USA). SMM, MLX, and OA were generously supplied by Sumitomo Seiyaku (Osaka, Japan), Daiichi Seiyaku (Tokyo, Japan) and Tanabe Seiyaku (Osaka, Japan), respectively. All reagents were of analytical grade (Wako, Osaka, Japan).

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Oxytetracycline (OTC)

The chemical structure of OTC is shown in Figure 1. OTC has been effectively used against various cultured fish diseases such as vibriosis, furunculosis, and red pest disease.

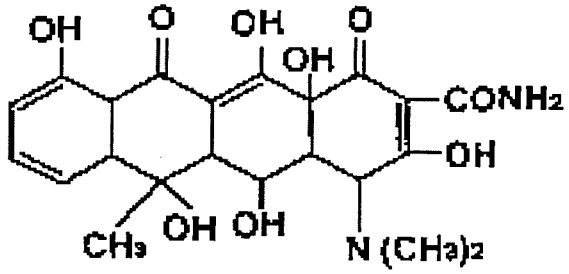

Figure 1: Chemical structure of oxytetracycline

The analytical method (Ueno & Aoki 1995) was modified slightly as follows; muscle (1 g) was put into a 10 mL centrifuge tube, 5 mL of cold 30% methanol containing 0.5% EDTA was added, and the sample was homogenised with a Pencil Mixer (Iuchi, Osaka, Japan) for 2 min. After centrifugation at 4 000 rpm for 5 min, the supernatant was filtered through a syringe filter unit (cellulose acetate membrane, 0.20 mm, Adventec, Tokyo, Japan).

The HPLC system consisted of a Jasco 880-PC pump (Japan Spectroscopic, Tokyo, Japan), a Rheodyne 715 injector (Rheodyne, Cotati, CA, USA) with 100 mL sample loop and a Gilson 311A variable-wavelength UV detector (Gilson, Villiers-le-Bel, France). The analytical column was a Hisep shielded hydrophobic phase column, 15 cm x 4.6 mm I.D., 5 mm particle size (Supelco, Bellefonte, PA, USA), protected with a guard column, 2 cm x 4.6 mm I.D., packed with the same material. Peak areas were quantified using a Chromatopac C-R3A integrator (Shimadzu, Kyoto, Japan). The mobile phase was methanol/0.05 M OA (1:9, v/v). The pH of the mobile phase was adjusted to 7.0 with 25% aqueous ammonia. The flow rate was 1.0 mL/min, and the UV detector was set at 360 nm and 0.02 aufs. The sample volume injected on the column was 100 mL. The analysis was performed at ambient temperature.

The standard solution of OTC was 100 mg/mL in distilled water and kept at -20°C. The solution was diluted to the required concentration with water before use.

Figure 2 shows typical chromatograms of eel muscle both unspiked and spiked with OTC (2.0 mg/g). The retention time of OTC was 3.8 min.

The recovery and the coefficient of variation of OTC determined at a concentration (2.0 mg/g) were 80.5% and 6.3%, respectively. The detection limit of the method was 0.1 mg/g for the muscle samples.

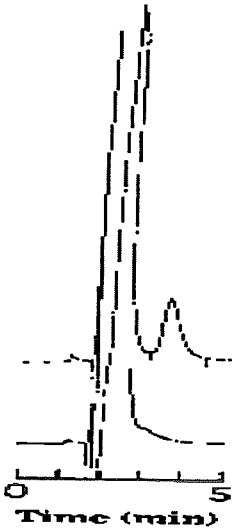

Figure 2: Typical chromatograms of fish muscle sample spiked with 2.0 mg/g OTC and its blank sample. (Ueno & Aoki 1995)

Sulfamonomethoxine (SMM), miloxacin (MLX), and oxolinic acid (OA)

Figure 3 shows the chemical structures of SMM, MLX, and OA.

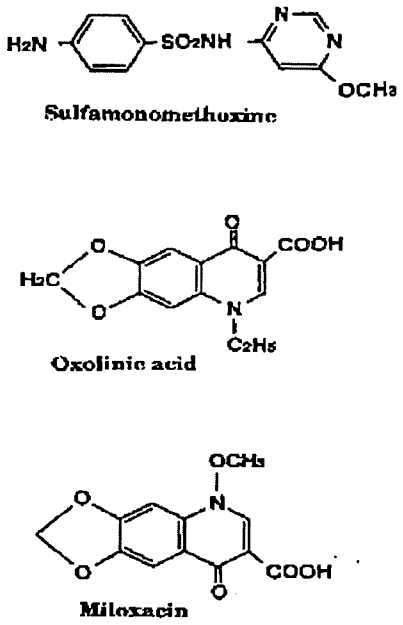

Figure 3: Chemical structures of SMM, OA and MLX

SMM has been used in fish farming as a therapeutic and/or as a prophylactic agent against various fish diseases such as vibriosis, furunculosis, and red pest disease because of its broad-spectrum activity against gram-positive cocci and gram-negative bacilli. OA is a synthetic antibacterial agent used in many countries for the treatment of fish diseases. The compound has been used successfully for the control of furunculosis, vibriosis and enteric redmouth disease. MLX, whose structure is closely related to that of oxolinic acid, has exhibited a broad spectrum of antibacterial activity and is especially active against gram-negative bacteria.

Muscle samples (1 g) were put into 10 mL centrifuge tubes, 1 mL of acetonitrile-tetrahydrofuran (95:5) was added, and the samples were homogenised with a Pencil Mixer for 2 min. After centrifugation at 4 000 rpm for 5 min, the supernatants were filtered through a syringe filter unit (PTFE, 0.20 mm, Adventec, Tokyo, Japan).

The HPLC system was a Waters 625 LC system (Waters, Milford, MA, U.S.A.) The analytical column was a Hisep shielded hydrophobic phase column, 15 cm x 4.6 mm I.D., 5 mm particle size (Supelco, Bellefonte, PA, USA), protected with a guard column, 2 cm x 4.6 mm I.D., packed with the same material. Peak areas were quantified with a Waters 741 data module (Waters, Milford, MA, U.S.A.). The mobile phase consisted of 0.05 M citric acid/0.2 M disodium hydrogen phosphate buffer, pH 2.5 in 10 mM tetra-*n*-butyl ammonium bromide/acetonitrile (85:15). The flow-rate was 1.0 mL/min, and the UV detector was set at 265 nm and 0.01 aufs. The sample volume injected on the column was 20 mL. The analysis was performed at ambient temperature.

Standard solutions were 1 mg/mL SMM in methanol, 1 mg/mL MLX in 1% sodium carbonate, and 1 mg/mL OA in 0.1 M borate buffer, pH 10.0. The solutions were kept at -20°C. Each solution was diluted to the required concentration with the solution before use.

Figure 4 shows typical chromatograms of fish muscle, both unspiked and spiked with SMM, MLX, and OA (2.0 mg/g). The proteins eluted with the void volume, and no interfering peaks were observed in the blank chromatograms. The retention times were 9.5 min for sulfamonomethoxine, 11.5 min for miloxacin and 14 min for oxolinic acid.

Figure 4: Typical chromatograms of fish muscle samples spiked with 2.0 mg/g SMM, OA and MLX and their blank samples (Ueno & Aoki 1996)

Correlation coefficients for the muscle standard calibration curves of SMM, MLX , and OA were 0.999 or higher; thus, the linearities were good. Standard calibration curves for the three drugs in the muscle sample tested were linear at least over the range 0.25 to 50 mg/mL.

Satisfactory recoveries of sulfamonomethoxine, miloxacin , and oxolinic acid were obtained from all samples tested (Table 1). For all three drugs, the limits of detection (signal to noise ratio of 3) were 0.05 - 0.1 mg/g for muscle samples.

Table 1: Recovery of SMM, OA and MLS from spiked muscle of cultured fish

Drugs	Muscle (Recovery %)
Sulfamonomethoxine	72.7 (3.4)
Oxolinic acid	79.5 (6.0)
Miloxacin	71.6 (6.8)

Values in parenthesis are co-efficients of variation (%). (Ueno & Aoki 1996).

The detection limits of OTC, SMM, MLX and OA were decreased to 0.02-0.04 mg/g using a new HPLC system that consisted of a PU-980 Pump, a UV-970 UV detector and a LCSS-905 System Station (Japan Spectroscopic, Tokyo, Japan).

CONCLUSION

These HPLC methods did not require time-consuming and complex extraction procedures and, moreover, did not cause column clogging, peak broadening or variation of retention time throughout the analysis.

Therefore, these methods are suitable for rapid detection of drug residues in muscle of cultured fish and are practical for on-the spot inspections by food inspectors and fish farmers.

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SOLAR DRIED FISH FEED
Development from Catfish by-product

By Mike Hoxey[1] and Richard Stevens[2]

Abstract
An experiment at Lake Argyle has successfully produced a water-stable fish feed from a by-product of catfish (*Arius midgleyi*) processing. The food was produced in a solar drier, the efficiency of which was enhanced by a solar powered fan. The feed was produced mainly from processing by-product from catfish caught on the Lake, by-catch from the same fishery and agricultural by-products from Ord River Irrigation Scheme farms. When fed to Barramundi (*Lates calcarifer*) and Grunter Bream (*Pomadasys sp.*) in a farm on the Lake, the fish demonstrated growth rates that compared favourably to fish fed a commercially prepared diet, at a fraction of the cost. The technique is thus ideal for high volume applications in remote regions, where alternative power sources are both expensive and unreliable, and where, as at Lake Argyle, the cost of freight makes imported fish feed prohibitively expensive. Incidental to the experiment has been the production of feeds that exhibit remarkable stability, even when immersed in water for extended periods, (i.e. for up to seven weeks).

Keywords: Solar dried fish feed; By-products; Catfish; *Arius midgleyi*; Barramundi; *Lates calcarifer*; Grunter bream; *Pomadasys sp*; Lake Argyle.

BACKGROUND

Lake Argyle is a body of fresh water approximately thirteen times the size of Sydney Harbour and containing about 9^3km of water.

This water is exchanged at an average rate of 6^3km/yr making the lake entirely suitable for large scale aquaculture.

Aquaculture of barramundi (*Lates calcarifer*) started in 1991 and augments a wild capture fishery for catfish. The catfish fishery produces 100 t/yr (whole weight) all of which is processed to fillets, plus approximately 60 t of by-catch. This produces 130 t/yr of by-product some of which was fed directly to farmed barramundi.

This project investigated the use of appropriate low technology to convert the by-product into a dry palletised feed for barramundi and other fish species.

Major constraints to the development of barramundi farming in Lake Argyle were removed in December 1993. Research by Keenan (FRDC 89/33) has shown that Western Australian and Northern Territory stocks of *Lates calcarifer* are not genetically diverse. Research by the Western Australian Department of Agriculture Risk Pathology Laboratory has resulted in the removal of the requirement for farmers to use PICORNA virus free stock.

This means that fingerlings (subject only to routine disease screening) can be brought from established farms in the Northern Territory, in large quantities, on a regular basis and at a reasonable cost. This source replaces the current South Australian source which is restricted in production and, with freight costs, prohibitively expensive.

The major expense for barramundi farmers in Lake Argyle is the cost of feed. Currently (June 1996), feed bought from Queensland lands at Lake Argyle at $A1.90/kg of which $A0.70 is freight.

If production of barramundi improves as expected and supply increases, there is a real possibility of a fall in its price, in which case the cost of feed could severely limit the expansion of the fishery. This project sought to produce an endogenous feed that would produce cost benefits over the commercial feed used. During the one year life of the project the following outcomes were achieved.

a) The production of a dried cat-fish by-product using a solar drier.

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b) Formulation of feeds for barramundi using the dried by-product and locally available agricultural products.

c) Manufacture of the formulated feeds to determine their acceptability to caged barramundi.

d) In the course of trials to improve solar drying, a moist pellet was produced that had all the positive characteristics of traditionally manufactured pellets, but which also exhibited exceptional water stability.

During the second year of the project, it is proposed to carry out cage feeding trials to compare the by-product based feed with commercial feeds. Both biological and economic performance will be compared.

METHODOLOGY

Solar drying

Following designs published in various papers by researchers in the solar drying of agricultural and fish products, a series of three solar driers was constructed and tested (Brenndorfer *et al.* 1987). In each case the design was based on a solar collector connected to a drying tower or tent.

The first model consisted of a black polythene covered solar collector with a drying tower at one end and again constructed of black polythene on a metal frame. The system was naturally vented, air entering via the end of the solar collector and exiting by convection from the top of the drying tower.

This design was only partially successful as the air temperature within the drying tower never exceeded the ambient air temperature by more than 15°C. A literature survey suggested that this limit was probably due to the single skin construction of the solar collector.

A second drier was then constructed, again with a black polythene covered collector but this time a double skin was used. The drying chamber was tent shaped and positioned in the centre of the collector. The drying chamber was constructed of sheet metal with a wooden access door and provision was made to fit a solar powered extraction fan. This design was far more successful with regard to achieving suitable drying temperatures as shown in Table 1.

A major problem encountered after a short period of use related to the construction materials used. The polythene sheeting expanded with heat, causing it to sag and partially block the flow of air through the collector. Also the adhesive tape used to join the polythene sheets rapidly lost its adhesion at the working temperatures encountered.

Table 1: Solar dried evaluation

Run 1: 10th September 1994 (Fan off)

Time	Shade Temperature	Sun Temperature	Bottom Thermometer	Top Thermometer	Temperature Difference	
	A	**B**	**C**	**D**	**C-A**	**D-A**
8.30 am	27	32	40	43	13	16
9.30 am	30	37	45	52	15	22
10.30 am	31	39	45	50	14	19
11.30 am	31	41	46	54	15	23
12.30 pm	33	41	47	57	14	24
1.30 pm	35	39	45	55	10	20
2.30 pm	35	38	45	51	10	16
3.30 pm	34	35	40	45	6	11
4.30 pm	30	30	29	30	-1	0

Run 2: 11th September 1994 (Fan on)

Time	Shade Temp	Sun Temp	Bottom Thermometer	Top Thermometer	Product Temp	Temperature Difference		
	A	**B**	**C**	**D**	**E**	**C-A**	**D-A**	**E-A**
6.30 am	24	24	36	28		2	4	
7.30 am	26	30	35	40	22	9	14	-4
8.30 am	28	36	42	48	31	14	20	3
9.30 am	30	40	43	53	35	13	23	5
10.30 am	34	44	48	58	35	14	24	1
11.30 am	33	42	48	58	38	15	25	5
12.30 pm	34	44	49	58	38	15	24	4
1.30 pm	33	42	46	55	38	13	22	5
2.30 pm	35	40	42	50	32	7	15	-3
3.30 pm	33	36	38	45	31	5	12	-2
4.30 pm	30	30	27	28	26	-3	-2	-4

A third drier was constructed, this time of galvanised sheet metal painted black. The design was also slightly modified so that the drying chamber was at one end of the collector and not centrally positioned as in the second design. Tests have proved this to be a satisfactory drier although further potential improvements are planned. One major area of study concerns the recycling of the exhaust air as the relative humidity of this has never exceeded 50% and is usually between 25% and 32%. As this is also the hottest air in the system, methods will be studied for feeding it back until such time as the difference between the relative humidity of the air and the water activity of the product restricts the rate of drying. To optimise this, a sophisticated control system would be required, however, some progress could be made using a simple method of bleeding off a proportion of the saturated air.

This drier is capable of drying >60 kg of wet by-product per 24 h and three such driers will cope with current requirements of the farm.

Product analysis

Various samples of the wet by-product have been tested for dry matter content by heating to constant weight in a microwave oven on site. Whilst this is not a normally accepted method of carrying out dry matter determinations, it appears to be sufficiently accurate for determination of the total quantity of dried by-product potentially available. The average dry matter content of the by-product is 34%.

A sample of the solar dried catfish waste material was sent to Dr Kevin Williams at the Bribie Island Aquaculture Research Centre for chemical analysis and digestibility tests. To date the following results have been received.

Dry Matter	84.7%
Ash	27.7%
Crude Protein	53.0%
Fat	18.0%
Calcium	9.13%
Phosphorus	4.49%
Gross Energy	22.1 MJ/KG

This analysis is fairly typical of a fish meal produced from waste fish although the calcium and phosphorus content are rather higher than with other species. The fat content is high and an analysis of the fatty acid composition carried out by the CSIRO Marine Laboratories shows an unusually low level of EPA (C20:5) and DHA (C22:6) for a fish oil. A copy of the analysis is attached (Table 2).

Table 2: Fatty acid composition of freshwater catfish oil supplied by Argyle Barramunti Farm

Fatty Acid	Percentage composition
Saturates	36.7
Branched	5.1
Monounsaturates	33.5
PUFA	21.8
Other	2.9
TOTAL	**100**

The moisture content of the solar dried material of about 15% is consistent with that achieved by other researchers. No chemical determinations have been made, however storage for up to two (2) months does not appear to cause any problems in the low humidity atmosphere at the Lake.

Product processing

An initial problem was encountered with the solar dried by-product. The solar dried by-product was both pliable and high in fat. This made the production of a fine meal, suitable for inclusion in pellets, very difficult to achieve. A series of diets was formulated using grain, grain by-products and legumes as the major constituents together with various levels of the dried product. These were mixed in an unground state and the whole mixture processed through a hammer-mill. When handled in this way the dried mix was successfully ground through a 2 mm screen and the final meal proved to be quite suitable for pelletising.

Pellets of 4.5 mm, 8 mm and 11 mm diameter were made using the Lister Junior pellet press on site. Pellets of a suitable hardness were produced and, although they sank rapidly when fed in the cages, were accepted by both barramundi and sooty grunter. The level of dried fish used was 30% and 40% and the diets were balanced for protein, amino acids, major minerals and energy. The amino acid levels were based on estimates of the amino acid content of the dried product using published data of levels in other fish meals and adjusted for overall protein content. Formulations used together with their calculated analyses are shown in Table 3.

Table 3: Formulations for pellets **Trial Diet: 30% Argyle Fish - No added oil**

Ingredients	Include (%)	Minimum (%)	Maximum (%)	Amount (kg)	($)	($/t)
Fish Meal (Argyle)	30.00	30.00	30.00	6.00	3.00	500.00
Fish Premix	0.30	0.30	0.30	0.06	0.57	9,500.00
Lupinseed Meal	25.00	25.00	25.00	5.00	0.97	195.00
Mill Run	1..00	10.00	10.00	2.00	0.38	190.00
Soyabean Meal 44	15.00	15.00	15.00	3.00	1.92	640.00
Wheat 11	19.70			3.94	0.77	195.00
TOTAL MIX				0.02t	7.61	380.66

Trial Diet: 40% Argyle Fish - No added oil

Ingredients	Include (%)	Minimum (%)	Maximum (%)	Amount (kg)	($)	($/t)
Fish Meal (Argyle)	40.00	40.00	40.00	8.00	4.00	500.00
Fish Premix	0.30	0.30	0.30	0.06	0.57	9,500.00
Lupinseed Meal	20.00	20.00	20.00	4.00	0.78	195.00
Mill Run	10.00	10.00	10.00	2.00	.038	190.00
Soyabean Meal 44	10.00	10.00	10.00	2.00	1.28	640.00
Wheat 11	19.70			3.94	0.77	195.00
TOTAL MIX				0.02t	7.78	388.91

An alternative method of handling, discovered during the project, involved mixing the wet, minced by-product, with the other ingredients, to the same formulation on a dry matter basis as used in the pellets. This mixture was then passed through the mincer to give a coarse pasta type product which was then solar dried. The final dried pellet proved to be very stable both in air and in water. Also, by manipulating the moisture content, a floating or a slowly sinking feed was produced. Results to date suggest that further work in this area could lead to the development of low cost alternatives to extruded feeds, particularly where limited quantities of waste fish are available.

Based on the known cost of production of the dried by-product together with the cost of suitable agricultural by-products. It was calculated that a product with a similar protein content to the commercial barramundi feed currently being used could be produced for $A200 to $A400/t. This compares with the landed price for the barramundi feed at $A1,900/t (June 1996 price). The largest component of the endogenous feed cost was labour, frequently discounted by the owner of the farm;. The only cash cost being for vitamin supplements.

SUMMARY

A fish feed produced from fish and agricultural by-products has been successfully manufactured at Lake Argyle, a remote location in the North of Western Australia.

By using enhanced solar drying techniques, with no external power source, a low cost fish meal was produced.

Additionally, a highly water stable pellet was produced using simple and low cost equipment.

The technique enables a nutritionally balanced feed to be produced commercially in highly variable quantities (from 1 kg upwards).

The development has staggering implications for fish farmers everywhere, but particularly in remote locations where freight, energy and capital costs make the import or production of fish feeds uneconomic.

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LIVE SPANNER CRABS
Alternative handling methods

By Brian Paterson, Bruce Goodrick, Paul Exley and Ross Smith[1]

Abstract

The way that Spanner crabs (*Ranina ranina*) are treated on boats may explain why commercial operators have difficulty keeping these crabs alive in storage tanks on shore. We stored crabs on boats using three different methods, in baskets (the established industry practice), in cool air and in an aerated flow-through seawater tank. The condition of the crabs was assessed by taking haemolymph samples and measuring lactic acid and ion concentrations and then by recording the mortality of crab's from different treatments during subsequent storage in land-based tanks. If dehydration occurred, it was not reflected in the haemolymph ionic composition. On landing, the crabs held in baskets (25-28°C) had high levels of lactate in the haemolymph (about 40 mmol/L). Road transport prior to tanking saw no further lactate accumulate but many crabs died subsequently. Crabs stored in cool air (20°C) accumulated less lactate and lasted a few days longer before they too began to die. The crabs previously held on the boat in seawater (27-28°C) showed unexpectedly high mortality soon afterwards.

The counter-intuitive result from submerged crabs led us to the option of using cooled seawater sprays on the crabs. In the laboratory, the cool spray (19°C) improved the crab's ability to control haemolymph pH and delayed accumulation of lactate. We recommend that if spanner crabs are stored out of water then they should be kept cool (e.g. 20°C). Use of cooled seawater sprays may further improve physiological condition but this method is yet to be studied on catching boats. While these improvements are probably necessary, none of the parameters we measured adequately predicted onshore mortality. We suggest that the problem with long-term storage may be related to the fact that the claws are not immobilised and that submerged crabs may struggle and injure each other.

Keywords: Spanner crabs; *Ranina ranina*; Handling methods; Storage methods; Haemolymph; Lactic acid; Live transport; pH; Temperatures.

INTRODUCTION

Aquatic crabs and lobsters generally asphyxiate and desiccate when stored out of water. Carbon dioxide excretion and oxygen uptake is impaired and if the animal cannot satisfy its oxygen demand then lactic acid will accumulate in the haemolymph (Vermeer 1987; deFur *et al.* 1988; Uglow *et al.* 1986, Whiteley & Taylor 1992). One way to reduce this problem is to cool the animals down and reduce their metabolic rate (Whiteley *et al.* 1990). Dehydration is another potential problem (Tyler-Jones & Taylor 1986) and Taylor *et al.* (1987) found that dehydration increased the concentration of potassium and chloride in the haemolymph of the freshwater crayfish *Austropotamobius pallipes*. However, the literature is ambivalent about whether survival is improved by keeping the product damp or spraying water on it (Hunt *et al.* 1986; McLeese 1965; Simonson & Hochberg 1986; Vermeer 1987; Witham 1971). Presumably, some species are more susceptible than others and different circumstances may influence the rate of desiccation.

The Australian fishery for spanner crabs *Ranina ranina,* is one of the largest fishery for this species in the world, with a landed catch in 1994 of about 3000 t, of which most was caught in Queensland and the rest in New South Wales. Most of the crabs are now exported live to Taiwan but the crabs are still held out of water on boats, using practice that developed when the crabs were kept "alive" for cooking and freezing on shore. Spanner crabs handled this way, sometimes with an intervening period of transport by road, often die after a couple of days storage in seawater tanks. This means that they must be exported before the typical "purging" process used on other live products and also means that the crabs cannot be held over in tanks if the price is poor.

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In order to establish a link between handling on the boat and later mortality, we kept spanner crabs at sea under a variety of conditions, then returned them to shore and stored them for several days in a recirculating seawater tank. At the same time, we examined the effects of an intervening period of road transport between landing the catch and actually placing it in a storage tank as well as the efficacy of using cool seawater sprays. Measurements of lactate and inorganic ion concentrations in the haemolymph of the crabs were made to shed some light on the stresses they were experiencing.

METHODS AND MATERIALS

Effect of storage method on haemolymph lactic acid and ion concentration

- *On the boat*

Crabs were harvested off the coast of Bundaberg in southern Queensland in a commercial crab boat. Crabs taken from the net were distributed randomly amongst three experimental treatments. Sixty crabs were stored in each treatment. Each treatment could be accommodated in two of the plastic baskets normally used in the fishery for keeping crabs.

One treatment involved storing crabs in water and the other two treatments involved crabs stored out of water. The wet treatment (WET) used a 180 L tank which seawater entered from the vessel's deck hose. The water in the tank was aerated using a battery powered air pump and an array of air stones tied to a grid on the tank bottom. The tank had baffles to prevent surging. The two dry treatments were crabs stored in plastic baskets and covered with a damp towel (DRY) which is similar to the methods currently using in this fishery and a second treatment (DRY/COLD) where crabs were placed in insulated boxes and a polystyrene sheet placed over them along with 1 kg of frozen gel-ice.

The required number of crabs for each treatment were gathered over 19 shots (a shot involves harvesting a long line with 10 tangle nets (each 1 m^2) attached). Within each treatment the crabs were held in air for varying periods depending on the time of day that they were caught. The crabs from each net were distributed between the treatments in such a way that time spent out of water was independent of treatment.

After all crabs required for these three treatments were captured, the remaining crabs harvested were kept as surplus in baskets, covered with a wet piece of polyurethane foam and 1 kg of frozen gel ice, (the method used by this particular fisher) and returned to shore for the road transport experiment.

- *Sorting on shore*

The crabs from the storage experiment were unloaded from the boat and crabs that were not in baskets at this stage (WET and DRY/COLD) were each transferred to a pair of baskets. The crabs caught after those used in the storage experiment were then randomly distributed amongst 6 baskets (i.e. 30 crabs/basket). These crabs were destined for the road transport experiment.

At this stage, 1 mL samples of haemolymph were taken from four crabs chosen at random from each basket of crabs from the storage experiment and from two baskets of surplus crabs. Each sample was injected into a 1 mL microcentrifuge tube and a 0.4 mL sub-sample was immediately mixed into an equal volume of 0.6 mol/L perchloric acid in a second 1 mL microcentrifuge tube. Both vials (whole haemolymph and perchlorate extraction) were then frozen in dry ice and returned to the laboratory in Brisbane for further extraction and analysis.

After completing sorting and haemolymph sampling, the crabs from the storage experiment (WET, DRY and DRY/COLD) were placed in a recirculating seawater aquarium (18.9°C). At this stage these crabs had been in air for between 7 and 13 h. This aquarium was cooled to 17.7°C overnight.

Effect of road transport on haemolymph lactic acid and ion concentration

At the same time, two baskets of the randomly sorted, surplus crabs (the baskets from which crabs had haemolymph samples taken) were also placed in the aquarium. These crabs were the controls for the road experiment (CONTROL) and had been in air for between 4 and 7 h. A further two baskets of the surplus crabs were placed on the floor beside the aquarium and surrounded with cardboard. These were the blanks for the truck experiment (AIR). The remaining two baskets of crabs (ROAD/AIR) were tied onto the back tray of a four-wheel drive vehicle, covered with a tarpaulin and driven to and from the Town of 1770. This is the same road normally used when trucking crabs from the Town of 1770 to Bundaberg (124 km) and thence to Brisbane (a further 368 km south). On arriving back at the recirculating seawater aquarium, about 6 h later, haemolymph samples were taken from 8 crabs in each of the AIR and ROAD/AIR treatments. These samples were partitioned into whole haemolymph and perchlorate extracted haemolymph as before. and the remaining crabs from both of these treatments (which at this stage had been out of water for between 10.5 to 13.5 h) were then placed in the aquarium beside the CONTROLS.

Recording survival of crabs during subsequent storage

The number of dead crabs in each treatment in both experiments was counted twice on the following day (morning and afternoon) and then again twice daily for the following four days.

Effectiveness of cooled seawater sprays

Live spanner crabs were purchased from a commercial supplier (Mooloolaba Fisheries, Mooloolaba, Southern Queensland) and stored in a recirculating sea-water holding tank (temperature 19°C) at our Hamilton laboratory. The experiment began 4 days after the crabs arrived.

A group of 40 crabs (430.4±134.2 g, range 332-1088 g) were taken from the tank using a scoop net and placed in plastic tubs, 10 crabs per tub. Two tubs of crabs were placed under the spray (Spray) and two tubs (No spray) were placed floating on the top of the water, covered and held in position by the lid of the tank (temperature 19°C, and >90% humidity). The remaining crabs in the tank were used as controls. For the spray treatment, water from the holding tank was sprayed over the crabs using a submersible pump connected to a manifold fitted with garden micro-irrigation sprays. The excess flow from the pump was released back into the tank using a tap and bypass.

After 3 h, haemolymph samples were taken from 8 crabs in each treatment (No spray and Spray) and from 4 submerged crabs. This process was repeated again 12 h after the start of the experiment.

Samples of haemolymph (about 0.8 mL) were taken from the crabs using an ice-cold glass Hamilton syringe and 22 gauge hypodermic needle. A hole was carefully punched through the carapace above the pericardium to allow easy penetration of the sampling needle.

The pH of each haemolymph sample was determined anaerobically using a Radiometer G299A microcapillary electrode connected to a Radiometer BMS3 Mk2 thermostated to the experimental temperature (19°C) and calibrated using precision buffers. After measuring the pH, a 400 mL sample of the haemolymph was mixed with an equal volume of ice-cold perchloric acid (0.6 mmol/L) in a labelled vial and the precipitated haemolymph was stored in a freezer (-29°C) until completing the experiment and the extraction was continued determination of lactic acid concentration (Boehringer-Mannheim cat. 139084).

Measuring haemolymph lactate and ion concentration

The frozen partially-extracted haemolymph samples were thawed and the supernatant was removed by centrifuge and then neutralised with 3 mol/L KOH in order to remove the resulting precipitate. The extracts were frozen prior to determination of L-Lactic acid using a commercially available kit (Boehringer-Mannheim cat no: 139 084) and a UV-visible spectrophotometer at a wavelength of 340 nm. Appropriate dilutions of the raw extract, or modifications to the total reagent volume, were made to bring the sample values within the standard curve.

The concentrations of sodium (Na^+), magnesium (Mg^{2+}), potassium (K^+) and calcium (Ca^{2+}) were measured in whole haemolymph by inductively-coupled plasma mass spectrometry (ICP-MS). The coagulated sample (200 to 400 mg) was digested in 2.5 mL of nitric acid in low pressure teflon bombs, placed in a microwave oven for 40 min at 280 watts. Each digested sample was then diluted to 50 mL with distilled water and analysed by ICP-MS, with standards.

RESULTS

Haemolymph lactic acid and ion concentration at the factory

- *Storage method*

Table 1 shows the effect of different treatments on the lactic acid concentration in the haemolymph of spanner crabs.

Table 1: Effect of different treatments on the boat on mean concentrations (±SC) of lactic acid (mmol/L) and ion concentrations (mmol/kg) in the haemolymph of spanner crabs *Ranina ranina* arriving at a factory. Eight crabs sampled per treatment *ns* indicates no significant difference between treatments. In each column, means assigned different letters are significantly different

	Temp (°C)	Time in air (h)	Lactic acid	Na	Mg	Ca^{ns}	K^{ns}
WET	27-28	4-5	22.5±5.38*a*	441±8.1*a*	45±0.0*a*	16.2±1.20	12.5±1.45
DRY	25-28	7-13	39.6±14.70*b*	479±21.2*b*	43±2.0*b*	16.1±2.77	13.9±2.11
DRY/COLD	19-21	7-13	23.4±11.84*a*	461±24.4*a*	45±2.1*a*	14.6±2.27	12.1±0.90

Table 2: Effect of road transport on mean concentrations (±SD) of lactic acid (mmol/L) and ion concentrations (mmol/kg) in the haemolymph of spanner crabs *Ranina ranina* arriving at a factory. Eight crabs sampled per treatment. *ns* indicates no significant difference between treatments. In each column, means assigned different letters are significantly different

	Time in air (h)	Lactic acid^{ns}	Na	Mg	Ca^{ns}	K^{ns}
CONTROL	4-7	27.1±8.75	483±20.6*ab*	42±1.8*a*	14.2±2.65	13.4±0.85
AIR	10-13	35.1±11.41	498±46.4*a*	47±2.9*b*	17.2±2.61	12.5±0.76
ROAD/AIR	10-13	38.5±11.07	451±25.9*b*	44±2.7*ab*	15.3±2.87	12.3±1.85

The lowest concentrations were seen in the live well (WET) and when crabs were stored at low temperature (DRY/COLD). The highest concentration was seen in crabs stored in air on deck (DRY). The highest Na^+ and lowest Mg^{2+} concentrations were also seen in this treatment. Treatment on the boat had no significant effect on haemolymph Ca^{2+} and K^+ concentration.

- *Road transport*

Unexpectedly, driving crabs to the Town of 1770 and back to the factory had no significant effect on the haemolymph lactic acid concentration of spanner crabs (Table 2). However, significant differences where seen in haemolymph Na^+ and Mg^{2+} concentration. Haemolymph Na^+ concentration of crabs after the road trip (ROAD/AIR) was significantly lower than that of crabs that remain undisturbed beside the storage tank (AIR). Haemolymph Mg^{2+} concentration increased significantly during the period in crabs that were not transported (AIR), although there was no significant difference between the concentrations of the air and ROAD/AIR crabs in Table 2. This reversed the trend seen above when Mg^{2+} concentration fell in the DRY treatment on the boat.

Survival at the factory

- *Storage method*

Crabs were stored on the boat using different treatments (60 crabs/treatment) and delivered to a recirculating seawater storage tank on shore, where their mortality was followed for several days (Figure 1). Crabs from the DRY/COLD treatment on the boat showed the best results. Mortality was quite low in this treatment for the first 3 days but afterwards, mortality rate increased. About half of the crabs in the other treatments had died after 5 days of storage.

- *Road transport*

These crabs had only been in air (primarily on the boat) from 4 to 7 h when the first group was placed without delay in the storage tank (CONTROL on Figure 2). Mortality in this group was negligible during the first day but thereafter increased dramatically. Initially, mortality rate was highest in crabs that had been transported by truck for 6 h between being landed and being placed in the holding tank (ROAD/AIR). Crabs that spent this period undisturbed in air (AIR) showed a cumulative mortality profile that was not significantly different from that of the crabs that were placed in the tank without the 6 h delay.

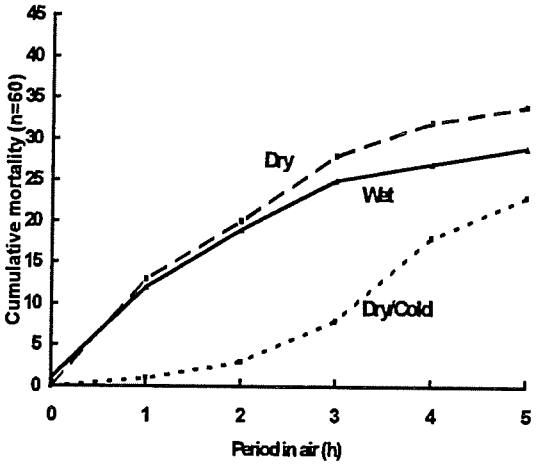

Figure 1: Effect of on-board handling method on the subsequent survival of spanner crabs in a seawater storage tank.

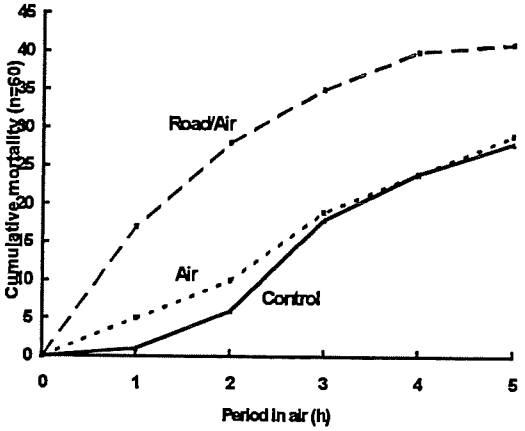

Figure 2: Effect of road transport on the subsequent survival of spanner crabs in a seawater storage tank.

Effectiveness of seawater sprays

- *Haemolymph pH*

The crabs in the No spray treatment were more acidotic (pH fell lower) than the crabs in the spray (Figure 3). Haemolymph pH of crabs resting in the aquarium at 19°C was 7.77±0.05 (mean±SD, n=8).

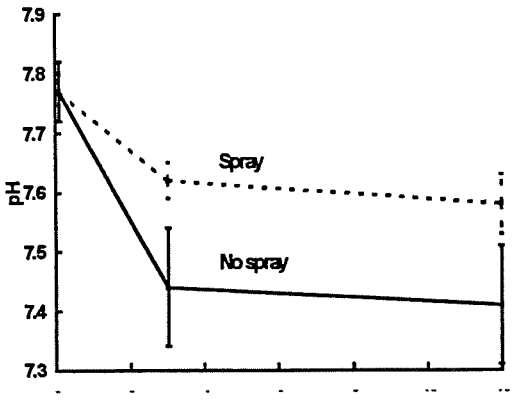

Figure 3: Effects of spraying seawater on the mean pH (±SD) in the haemolymph of spanner crabs stored out of water. Each point represents 8 crabs.

When crabs were stored in humid air or a seawater spray at that temperature the haemolymph pH fell significantly in both treatments during the first 3 h but thereafter did not change significantly (Figure 3). The haemolymph pH of 8 crabs stored for 3 h in the spray treatment was 7.62±0.03, significantly higher than 8 crabs in the air treatment, 7.44±0.10.

- *Haemolymph lactic acid concentration*

Lactic acid accumulated more rapidly in the No spray treatment, particularly in the first 3 h of the experiment (Figure 3). The concentration of lactic acid in the haemolymph of submerged crabs was 0.08±0.03 mmol/L, rising rapidly to 2.84±1.36 mmol/L after 3 h. Lactic acid accumulated more slowly in the sprayed crabs (0.48±0.20 mmol/L after 3 h) but because the data shows heterogeneity of variances it is necessary to transform the raw data using log transformation and the log means were then compared using an LSD (t) pairwise comparison (Table 3). This showed that the rise in lactate concentration in the haemolymph was significantly slower in the sprayed crabs, though it was apparently only delayed since lactate concentration rose later in the experiment.

DISCUSSION

You would expect that storing the crabs in water would be considerably better than any kind of storage out of water. This proved not to be the case. The best survival in this experiment was found when crabs were stored in cold air rather than stored in a tank of continually refreshed sea-water. However, before we go looking for spanner crabs on beaches it is worthwhile acknowledging that crowding unrestrained crabs in a "live well" is probably not a good idea.

Storage on boats

The crabs struggle actively when lifted from the water and continue to scramble about for a short period when placed in the baskets (which accomodate about 30 kg of crabs). After this, the crabs become relatively quiescent. Judging by the lactic acid levels in the haemolymph that immobility is not surprising.

When haemolymph samples were taken from the crabs on arrival at the factory and analysed, they had very high concentrations of lactic acid in the haemolymph. Anything done to the crabs after that had a relatively small impact on the amount of lactic acid in the haemolymph. The lowest values on "arrival" (about 20 mmol/L), were seen in crabs sampled from the WET and DRY/COLD treatments. Much of this lactate may have accumulated in the "cold" crabs while they were being weighed and sorted into baskets, loaded onto a truck and driven next door at ambient temperature. Similarly, the WET tank was drained to reduce weight prior to the vessel returning to shore.

The lactate concentration was higher in the crabs that remained in the baskets at ambient temperature. These are extraordinarily high values, and evidence that there is probably something seriously wrong with the way that this crab is routinely handled. European and Norway lobsters *Homarus gammarus* and *Nephrops norvegicus* only accumulate about 8 to 10 mmol/L of lactic acid in their haemolymph during post-harvest handling (Spicer *et al.* 1990; Whiteley & Taylor 1992).

Table 3. Comparison of mean lactate concentration (mmol/L) in the blood of crabs in the spray and no spray treatments after log transformation. Log means sharing the same letter are not significantly different at 1%

	Submerged	Treatment			
		Spray		No spray	
		3 h	12 h	3 h	12 h
Log means	-1.164*a*	-0.3649*b*	0.4594*c*	0.3907*c*	0.6585*c*
Back transformed means	0.076	0.432	2.880	2.459	4.555

To some extent, the extraordinarily high lactic acid concentrations in spanner crabs may reflect a complete failure in respiratory gas exchange during long periods out of water. Lowery and Tate (1986) associated levels of lactate at around 40 mmol/L with "morbidity" when blue crabs *Callinectes sapidus* were deprived of oxygen underwater. Crabs that sustain moderate levels oxygen uptake in air, such as *C. sapidus* and *S. serrata* show only a small rise in lactate concentration or no change at all (deFur *et al.* 1988; Varley & Greenaway 1992).

Surprisingly, the haemolymph showed no changes in ionic concentration that were consistent with dehydration. Perhaps the ions were redistributing within the crab's body compartments rather than concentrating in the haemolymph. The concentrations of some ions changed as a function of the time they spent out of water and significant differences were demonstrated between handling treatments. Transporting the crabs by truck reduced the sodium concentration relative to crabs left undisturbed in air for the same period (Table 2). There was also an non-significant decrease in the haemolymph sodium concentration of dehydrated crayfish *A. pallipes*, apparently as this ion entered the muscles (Taylor *et al.* 1987).

Rising calcium concentration often, but not always, accompanies acidosis in crustacean haemolymph (Taylor & Innes 1988; Varley & Greenaway 1992). However, haemolymph calcium concentration was similar in all treatments. Either it does not change or it has already risen and plateaud very soon after capture.

Road transport

In this study, the factory was located near the dock and it was only necessary to load the crabs onto a truck and drive next door. However, spanner crabs are sometimes driven long distances after landing, a practise which lengthens the delay before they are submerged.

We have not attempted to simulate an actual truck loaded with crabs, but rather we wished to demonstrate that transporting crabs by road was capable of killing them. We admit that the stress experienced by these crabs went beyond that you would expect from crabs carried over the same road in a heavily laden truck. The stress experienced by commercial shipments of crabs would presumably lie somewhere within the range of mortality described here. The objective of improving the survival of the crabs would be to bring the mortality closer to that expected if you just held the crabs in air for the same period.

The crabs were still alive when placed in the holding tank in Bundaberg. This emphasises the extraordinary ability of this crab to take punishment of this magnitude without giving any warning signs to the people handling them. However, the crabs became very weak and lethargic soon after they were submerged and the mortality rate the next day speaks for itself. We suspect that the crabs asphyxiated when returned to the water as a similar phenomenon has been reported from work on mud crabs (Varley & Greenaway 1992).

Contrary to our expectations, even a "worst case" attempt at road transport like that conducted here did not cause a significant increase in the haemolymph lactic acid concentration in spanner crabs above that you would expect from leaving them in air for the same time. Disturbance increases the haemolymph lactic acid concentration of *H. gammarus*, apparently by increasing locomotor activity and metabolic rate (Taylor & Whiteley 1989; Whiteley *et al.* 1990) however, disturbance may not increase the activity and the haemolymph lactic acid concentration of a crab that has already fatigued (Burke 1979).

- *Mortality during storage on shore*

Spanner crabs are usually packed for export about 12 h after arriving at the factory. They accumulate such high levels of lactic acid in their haemolymph during routine post-harvest handling that it will probably take them several hours to recover (Bridges & Brand 1980) and this time may not be much less than the "recovery" period that the crabs currently receive before they are exported (Paterson *et al.* in prep.).

The crabs need to be exported promptly because a large proportion tend to die if they are left in storage tanks for several days to "purge." As shown in this study, regardless of the method used to store spanner crabs on the boat, a large percentage of the catch still succumbs within 5 days of capture. All that keeping the crabs cold on the boat did was to delay the onset of mortality by 3 days.

The high mortality in the live well treatment was unexpected. It suggests that low temperature per se rather than submersion in water has a beneficial effect on the crabs. Certainly, the lactic acid content of the haemolymph was not a good indicator of subsequent survival results. Aquatic crustaceans survive better out of water anyway if they are cooled down (deFur *et al.* 1988) but there may be a further benefit here from reducing activity and physical injury. Spanner crabs are not "banded" or "tied" after harvest.

The crabs are not as dangerous to people as mud crabs (*Scylla serrata*) but when you try to pick a spanner crab out of a basket, you very often get that crab and several others attached! This cannot be good. When the crabs are crowded, they will injure each other regardless of whether or not they are underwater. Perhaps with spanner crabs, the cooled crabs were less

active in storage and less likely to injure each other, and thus promote fewer opportunities for bacterial infections to take hold.

Effectiveness of cooled seawater sprays

Storing in spanner crabs in air at low temperature alleviates the physiological effects of emersion. The amount of lactic acid that accumulates when spanner crabs are stored in air at 19°C is similar to that seen in other commercial species (deFur & McMahon 1984; deFur *et al.* 1988; Spicer *et al.* 1990; Johnson & Uglow 1985) though as we have seen emersion at higher temperatures leads to a more dramatic accumulation of lactate.

Spraying cold seawater over spanner crabs stored in air alleviates to a certain extent the physiological symptoms of asphyxiation, particularly during the first few hours in air when the greatest change in haemolymph pH occurs. The spray allows the crabs to regulate the pH of their haemolymph at a higher level than would otherwise be possible, even to the extent of reducing the rate of lactic acid accumulation in the haemolymph. Given the clear benefit of storing spanner crabs in a spray system, it is interesting that Varley and Greenaway (1992) found elevated total CO_2 concentration and CO_2 tension in the haemolymph of mud crabs *Scylla serrata* stored in a spray system at a fish market. The crabs were apparently using their normal mechanism for buffering acidosis in the absence of contact with water.

The low lactic acid concentration in spanner crabs stored in the spray was not what we expected to happen. Small amounts of water entering the gill chamber may act as an important sink for carbon dioxide excretion during the acidosis at the beginning of emersion but it should not favour oxygen uptake, (deFur *et al.* 1983). However we have only measured haemolymph lactate concentration, we cannot say emphatically the the different lactate levels point to different rates of anaerobic metabolism in the tissues. Perhaps the crabs in the spray treatment retain the lactate in their tissues for longer, so that it passes into the haemolymph at a slower rate. Obviously, this storage technique needs to be studied in greater detail, particularly given the ambivalent reports of spraying or dampening in the literature.

If the lower haemolymph lactate level reflects differences in lactate production and removal then there are several possible factors involved. We can probably rule out extra activity raising the lactate level. If anything, casual observations indicate the the crabs under the spray were more lively. If the two groups of crabs have a similar demand for oxygen, then perhaps the wetting effect of the spray may enhance gas exchange at the gill. But this could just as reasonably retard oxygen uptake, by keeping the gill water-logged and reducing the surface area available to exploit atmospheric oxygen (deFur *et al.* 1988). If oxygen demand at the tissues is equal and the efficiency of the gill uneffected, then perhaps the haemolymph of the crabs in the spray treatment is better able to deliver oxygen to the tissues because the higher pH favours oxygen transport to the tissues (Burnett 1992).

CONCLUSIONS

Spanner crabs can build up extraordinarily high concentrations of lactic acid during routine handling and storage in air after harvest. Cooling the spanner crabs down on the boat reduces this physiological stress and improves the survival of the crabs during the first few days of storage, but the crabs still begin to die after this. Using a cooled sea-water spray appears to further alleviate the physiological stress of storing the crabs in air. However, while these handling improvements are probably necessary, other factors not related to the parameters measured in this study are still preventing the harvested crabs from being purged and stored on shore for long periods. The fact that unrestrained crabs are crowded together in tanks may provide part of the explanation.

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NORTHERN AUSTRALIAN SHARK
Avoiding tough flesh

By Steven Slattery [1]

Abstract

The texture of two species of northern Australian shark is mainly effected by the biology of the fish. One species, *Carcharhinus sorrah*, requires higher energy to shear a sample of its cooked flesh than does the other, *C. tilstoni*. Male shark are firmer than females and shark with a fork length larger than 85 cm were tough. Of the combination of sex and species group, only male *C. sorrah* were tough. Further definition of groupings also identified female *C. sorrah* larger than 85 cm fork length and male *C .tilstoni* larger than 85 cm fork length as being tough. A manual of best practice was drawn up from the results of a range of experiments.

Best practice recommended for processing shark was:

1. kill, bleed and gut immediately after catch
2. keep trunks cool until rigor has set, but not longer
3. store trunks in refrigerated seawater (RSW) for up to 12 hours
4. then freeze trunks or fillets
5. shark should not be frozen prerigor or kept on deck till postrigor.

Keywords: Shark; *Carcharhinus sorrah; Carcharhinus tilstoni;* Flesh; Texture difference; Biological causes; Processing; K-value.

Fillets from two commercial species of shark caught in northern Australian waters, the school or sorrah shark (*Carcharinus sorrah*) and the black spot or black tip shark (C. *tilstoni*) have been found to suffer from textural problems. Shark fillets which are tough after cooking have been identified in shipments originating both from northern and overseas suppliers. The occurrence has been random and the cause difficult to identify. A research project (93/190) was funded by the Fisheries Research and Development Corporation (FRDC) to investigate the problem. As a result of the investigations a manual of best practice has been written which reports the causes of toughness and how tough flesh can be avoided. The manual is reproduced in modified form for these proceedings. A total of 529 shark samples were tested and analysed for differences in texture between season, species, sex, size and rigor stage.

TESTING FOR TEXTURE

The texture of food can be analysed mechanically using an instrument called an Instron Universal Testing Machine. This machine can mimic the action of a bite by a consumer. A piece of fillet is cut by metal blades and the machine measures the amount of resistance there is to cutting. The measurement is called the 'shear force energy'.

The shear force energy of tough shark was almost twice that of soft shark in samples submitted as being tough or soft by industry (Figure 1). The value of 0.435 J for shear force energy was then used as an industry standard and any shark with a shear force energy equal to, or higher than, this value can be said to be tough.

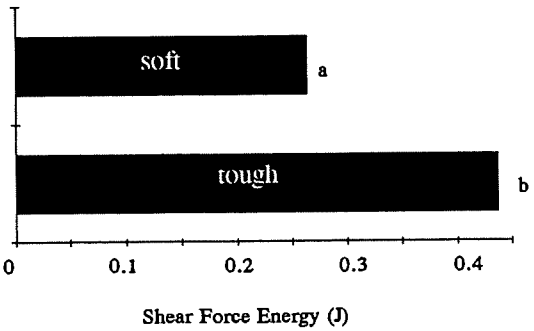

Figure 1: Energy required to shear cooked samples of commercial shark designated as being tough or soft by industry. There is a significant difference between values ($P < 0.01$)

TEXTURE DIFFERENCES

Each species of fish and shark has its own individual textures and flavours. Sometimes these can be quite different from other closely related

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species. Warm-water species of shark have been found to be more coloured, firmer and meaty in texture and tangy in flavour when compared with cold-water species which were whiter, softer and blander. Each consumer has individual preferences for different traits and only when some become extreme does everyone agree that the sample should be rejected.

BIOLOGICAL CAUSES

Often fish with poor texture or taste have been called "mother-in-law" fish and these usually fetch low prices when marketed. The mangrove shark (*C. cautus*) has already been found to have poor consumer acceptability because of dry rubbery texture. The two shark species discussed here have different textures. Overall, the fillets from the sorrah shark (*C. sorrah*) require 25% more energy to shear than fillets from the black spot shark (*C. tilstoni*) (Figure 2) This means that, in general, sorrah shark (*C. sorrah*) are tougher than *C. tilstoni*.

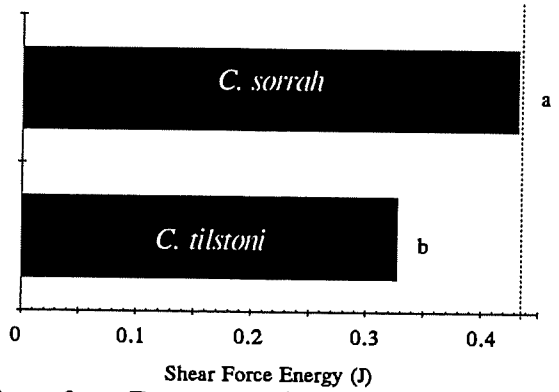

Figure 2: Energy required to shear cooked samples of two species of shark. There is a significant difference between values ($P < 0.01$)

This textural difference is mainly controlled by biological characteristics. Knowing how these shark grow and breed will help understand why tough texture develops.

Sex

Differences in texture can be due to the sex of an individual. These two shark species give birth to live young. The females mate in February and March and ovulation occurs by March-April. The embryos are retained in the uterus and the yolk sac forms a sort of "yolk placenta". As the yolk is used up the relationship between the embryo and mother's tissues becomes complex and close and the young are nourished by the food in the mother's blood in a similar way to mammals. The gestation time is lengthy, taking up to a year before the young are born. The young shark are quite large at birth with *C. sorrah* around 52 cm total length while *C. tilstoni* average 60 cm. The litter size increases with the size of the mother.

This type of reproduction places considerable nutritional strain on females during the maternity period and in times of starvation they use their own body tissue to feed the young. The males do not suffer as much during these times and so are in better condition with the protein component correspondingly firmer. Texture can differ between the sexes (see Figure 3). The average level of shear force energy for all the males in the catch was much higher than the females. This means males are generally tougher and the value is close to the level of the tough samples obtained from industry.

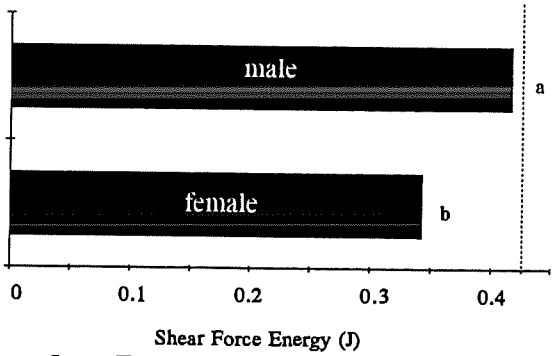

Figure 3: Energy required to shear cooked samples of male and female shark of both species (*C. sorrah* and *C. tilstoni*). There is a significant difference between values ($P < 0.01$).

Size

As an animal grows, its muscle also becomes tougher in texture. The much greater toughness of meat from an old bullock in comparison to veal is a good example of this. The same occurs with shark (see Figure 4). Shark with a fork length greater than 85cm are tough (this is equal to a shark with a total length of one metre).

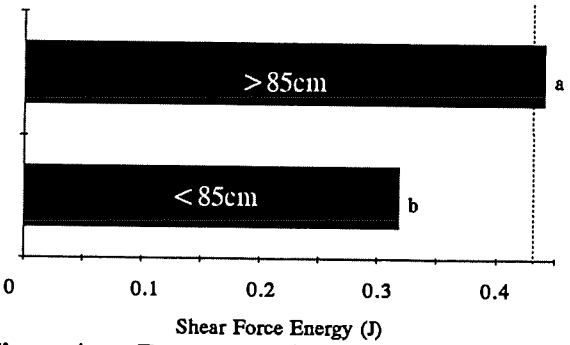

Figure 4: Energy required to shear cooked samples of shark of two different size groups of both species (*C. sorrah* and *C. tilstoni*). There is a significant difference between values ($P < 0.01$).

Growth rate can slow during the life of an animal so that as an individual matures the amount it

increases in length each year becomes smaller. Large individuals that are longer by only a few centimeters can often be several years older than those which are small.

Sex and size

When two aspects which are known to affect texture, such as sex and size, are studied together then the main causes of tough fillets starts to become identifiable. Male shark larger than 85 cm fork length can be seen as the main source of toughness so these should be rejected (see Figure 5).

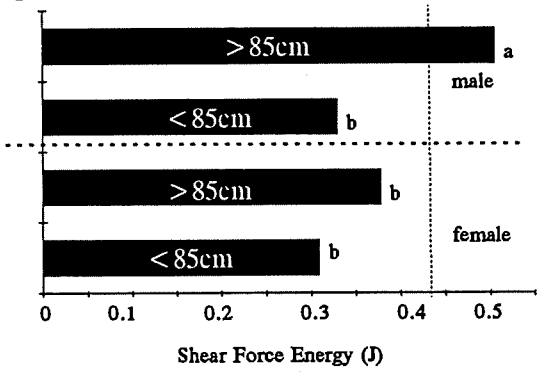

Figure 5: Energy required to shear cooked samples of male and female shark of two different size groups of both species *(C. sorrah* and *C. tilstoni)*. Means followed by a similar letter are not significantly different (P>0.01).

Species and sex

When the effects of species and sex are examined it is obvious that the male sorrah is the main source of tough fillets (see Figure 6). The average texture from a catch of male *C. sorrah* is much higher than the industry rejection level.

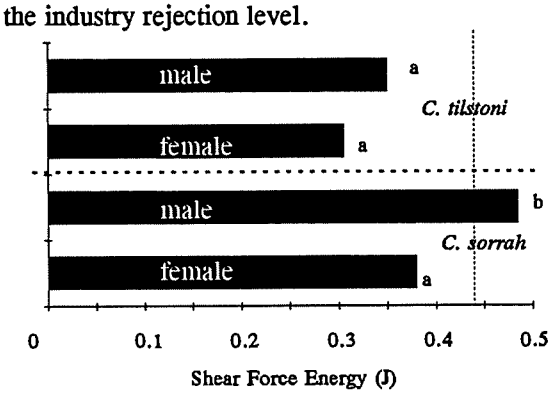

Figure 6: Energy required to shear cooked samples of male and female shark of two different species *(C. sorrah* and *C. tilstoni)*. Means followed by a similar letter are not significantly different (P>0.01).

Thus, help reduce the incidence of tough shark male sorrah (*C. sorrah*) should be separated from the catch and only be processed for purposes which will allow for this toughness.

The separation of the catch into all the possible groups, while identifying the groups responsible, can be misleading because of uneven sample size. The average texture of male sorrah less than 85cm is close to the industry samples of tough shark which means that while there are some tender individuals just as many are tough. As indicated earlier all sorrah males as well as sorrah females and tilstoni males larger than 85cm fork length should be rejected. the n in the graph refers to the number of shark assayed.

PROCESSING FOR THE BEST QUALITY

A number of on-deck aspects were investigated - season of capture, the biological features, the rigor stage when placed in RSW, the temperature of the RSW and the storage period.

The quality attributes of seafood deteriorate with period of storage and elevated temperatures. One chemical measure of this change is the K-value.

The K-value is calculated from the breakdown of ATP, a chemical which is needed for the muscles to work. This method is also used to identify frozen fish which may be submitted illegally during fishing competitions.

When an animal dies the ATP in the muscle begins to break down as rigor mortis commences and K-value increases as rigor progresses (see Figure 7).

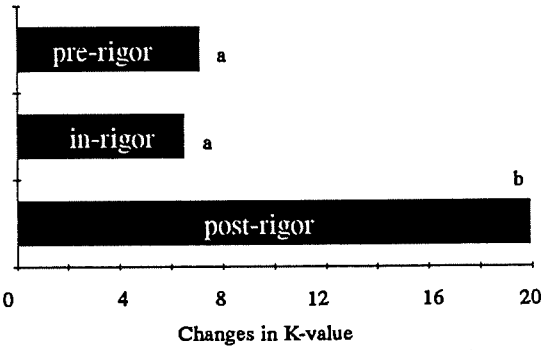

Figure 7: K-values of raw flesh of shark from all sizes, species and sex due to handling and storage at different stages of rigor. Means followed by a similar letter are not significantly different (P>0.01).

It is obviously important to process a catch as quickly as possible but problems of tough texture can occur if a fillet is frozen before rigor develops since the rigor process will occur when the trunk is thawed. This toughening is called thaw rigor. It is known that cold water species of shark need to be kept until the trunks are stiff with rigor before fillets can be cut. In the project shark landed live and killed immediately took from 30 min to 8 h to enter rigor regardless of species or sex.

Another form of toughening can develop because shark or fish are kept at too high temperatures such as being left on deck until rigor subsides before freezing. The deterioration of the flesh leads to the production of formaldehyde during frozen storage. This chemical hardens the protein in the flesh.

The worse the conditions the carcase is kept in, the quicker the K-value increases.

The season can have an impact due to water and deck temperatures as shown in Figure 8.

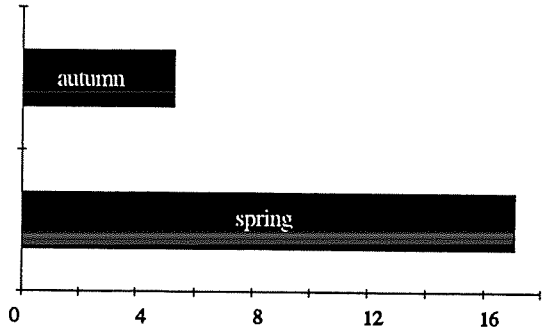

Figure 8: K-values in raw flesh of shark from all treatments (species, sex, size) held in RSW at two different seasons.

During spring and summer temperatures of the water (and on deck) will be higher than in autumn and winter and if shark are not looked after K-values will increase rapidly.

To slow down this increase in K-value, seafood should be chilled quickly and kept at low temperatures if it cannot be frozen straight away.

Storage in RSW is a quick way of reducing core temperatures (see Figure 9).

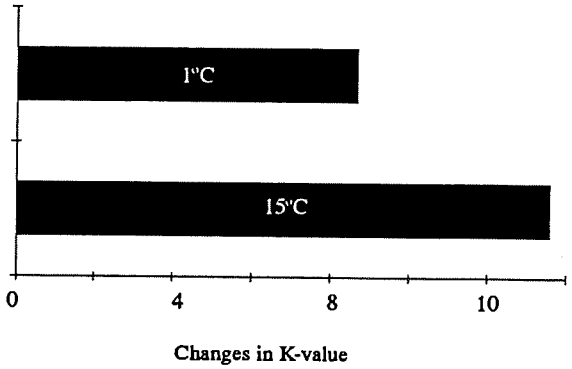

Figure 9: K-values in raw flesh of shark for all treatments (species, sex, size) held in RSW at different temperatures.

When the change in K-value for all of these handling aspects is studied in combination, as seen in the Figures 10 and 11, the best and worst practices can be identified. The worst way to process shark is to keep trunks on deck until postrigor and then store in RSW at 15°C, especially during the spring and summer.

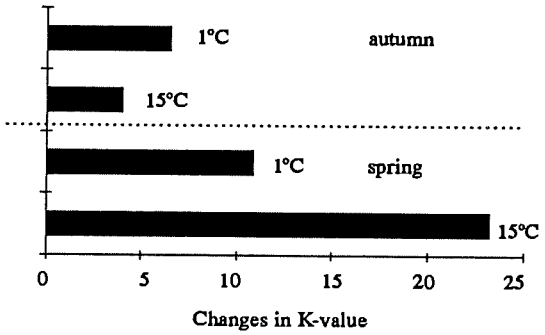

Figure 10: K-values in raw flesh of shark of all treatments (species, sex, size) stored in RSW at two different temperatures over two seasons.

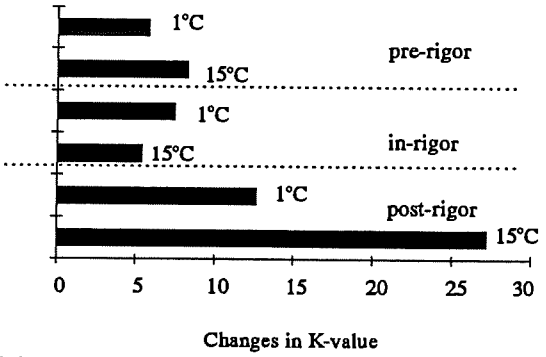

Figure 11: K-values in raw flesh of shark of all treatments (species, size, sex) stored in RSW at two different temperatures at different stages of rigor.

CONCLUSION

The best way to process northern shark is to:

1. kill, bleed and gut immediately;
2. keep the trunks in running seawater until rigor has set, but not longer; then
3. freeze trunks or fillets or store the trunks in RSW at 1°C for up to 12 h then fillet and freeze.

THE NEW ZEALAND SEAFOOD INDUSTRY

Control of *Listeria monocytogenes*

By Philip Bremer, Caroline Osborne[1], Judy Barker, Phil Busby[2], and Graham Fletcher[3]

Abstract

Evidence linking the consumption of seafood products contaminated with *Listeria monocytogenes* to the development of the disease listeriosis has heightened awareness within the New Zealand seafood industry of the challenge that *L. monocytogenes* presents to seafood processors.

In this review, we will present information on the incidence and the sources of *L. monocytogenes* contamination of seafood products and the ability of *L. monocytogenes* to survive processing and packaging. We will then present an overview of the results of our recent research into methods of *L. monocytogenes* control during seafood processing. We will report on the thermal death times of *L. monocytogenes* associated with both raw greenshell mussel (*Perna canaliculus*) meat and mussels prepared for hot smoking and comment on the significance of these results with regard to the design of blanching or hot smoking regimes to eliminate *L. monocytogenes*. Results from research into the effectiveness of organic acids to control *L. monocytogenes* will be presented as will results on the effectiveness of finfish washing regimes to reduce the carriage of bacteria into processing facilities. The *L. monocytogenes* monitoring program jointly developed by the MAF Regulatory Authority and the Fishing Industry Inspection and Certification Council will be described and we will comment on the regulatory aspects of *L. monocytogenes* control.

Keywords: New Zealand; Seafood industry; Salmon; Mussels; Bacteria; Contamination; *Listeria; Listeria monocytogenes*; Z-value; D-value.

THE CHALLENGE OF *L. MONOCYTOGENES*

The bacterium *Listeria monocytogenes* has been recognised as the causative agent of human listeriosis since 1929 (Gray & Killinger 1966; Wehr 1987). While the first reported food-borne outbreak of listeriosis occurred in the early 1980's (Reed 1994), it is only in the last few years that a causal link between the consumption of seafood contaminated with *L. monocytogenes* and the onset of listeriosis has been proven (Misrachi *et al.* 1991; Mitchell 1991; Baker *et al.* 1993; Brett *et al.* 1995).

L. monocytogenes is widespread in the environment (Brackett 1988; Ryser & Marth 1991) and has been isolated from fresh, frozen, smoked and dried-salted products (Weagent *et al.* 1988; Buchanan *et al.* 1989; Caserio *et al.* 1989; Fuchs & Surendran 1989; Farber 1991; Motes 1991; Ben Embarek 1994; Dillon *et al.* 1994; Fletcher *et al.* 1994). However, the question of whether *L. monocytogenes* is a natural part of the bacterial load of fish or shellfish or whether it arises as a contaminant during processing has yet to be resolved (Ben Embarek 1994).

In New Zealand salmon processing facilities there is little evidence to suggest that *L. monocytogenes* associated bacteria is carried into the processing facility with the salmon. For example a recent study failed to find *Listeria* in 18 raw fish samples, while six out of seven (85.7%) samples of salmon that had been processed past the slicing stage were contaminated (Hudson & Avery 1993). However, as Hudson and Avery point out, this does not preclude the possibility of the raw fish being contaminated *by L. monocytogenes* at low levels. If, for example, only one in a hundred or one in a thousand fish was contaminated due to some disturbance in the natural farm environment or to a harvesting error, the possibility of detecting that

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contamination is low, but contaminated fish could bring *L. monocytogenes* into the processing environment. In addition, other recent publications suggest that live salmon may harbour *Listeria*. For example, Eklund *et al.* (1995) report that the primary source *of L. monocytogenes* in salmon processing equipment was the surface areas of frozen or fresh raw fish coming into the plant. Unfortunately the authors of this paper did not state how the fish were treated from the time of harvest to the time of processing, so it is not possible to determine whether the live fish were also contaminated with *L. monocytogenes*. In New Zealand we have reported that *Listeria* cells can be isolated from the gut, but not the skin of salmon, 96 h after adding *Listeria*-contaminated feed to their tanks (Bremer & Cook 1993). Therefore, the potential exists for fish to ingest particles containing *Listeria* at the farm site and during processing, the viscera may act as a source of *Listeria* contamination to the processing environment which may in turn serve as a source of contamination of fish.

With regard to shellfish, *L. monocytogenes* has been isolated from oysters (Soontharanont & Garland 1995), clams (Estela *et al.* 1992), and mussels (Soontharanont & Garland 1995). However, in all cases, *L. monocytogenes* was isolated from the water or the shellfish were collected from areas which were subjected to either coastal run-off or sewage effluent discharge. As bivalve molluscs filter large quantities of water it is reasonable to conclude that the detection of *L. monocytogenes* associated with the bivalve molluscs will be dependent on the water quality. In 1991-92 we carried out a year-long survey of oysters and mussels from three conditionally approved aquaculture sites and one prohibited site in the north of New Zealand (Fletcher *et al.* 1994). Of the 64 oyster and 21 mussel samples collected, only three were contaminated with *L. monocytogenes* with two of these coming from the prohibited site. All three were at most probable numbers of less than 3.0 MPN/100g. However, there was poor correlation between the occurrence of *L. monocytogenes* and either faecal coliforms or rainfall. Over the same period, we tested processed ready-to-eat seafoods purchased from Auckland supermarkets for the presence of *L. monocytogenes*. Of the 52 ready-to-eat samples tested, 35% were contaminated with *L. monocytogenes*. We found *L. monocytogenes* in hot-smoked seafood (squid, eel, mussels and salmon) and cold-smoked foods (salmon and blue cod). *L. monocytogenes* was not found in other hot-smoked foods (salmon, kahawai, snapper or trevally nor in marinated mussels or patés).

As the possibility exists that some aquatic animals may become contaminated through contact with *Listeria* in their natural environment (Ryser & Marth 1991), it seems prudent to assume that all raw shellfish or fish entering a processing facility have the potential to be contaminated with this organism. Procedures must be established to minimise or eliminate the potential for cross-contamination of processing equipment or products.

High risk foods for *L. monocytogenes* are often ready-to-eat, stored at refrigeration temperature for a long period and contaminated with a high number of serovar 4b, *L. monocytogenes* strains (Rocourt 1994). In the seafood industry, products which fit into the category of ready-to-eat, long-life, chilled products include hot-smoked fish and shellfish products and cold-smoked salmon.

L. monocytogenes poses a particular concern for the producers of cold-smoked salmon as the listericidal nature of the cold-smoking step is unclear. Some authors state that the cold-smoke process does not affect *L. monocytogenes* numbers (Guyer & Jemmi 1991; Dillon & Patel 1993) while others have reported a decrease or an absence of *L. monocytogenes* after cold-smoking (Jemmi & Keusch 1994; Rørvik *et al.* 1995). Part of this apparent conflict may be due to differences in temperatures used during cold-smoking. For example, Eklund *et al.* (1995) report that, while populations of L. m*onocytogenes* inoculated onto the surface of brined salmon portions changed very little during a cold-smoke process at 22.2 to 30.6°C for 20 h, lowering the temperature to 17.2 to 21.1°C resulted in a 10- to 25-fold decrease in *L. monocytogenes* numbers.

L. monocytogenes has been reported to be able to survive and even increase in numbers on vacuum-packed smoked seafood products stored at either 4 or 10°C (Guyer & Jemmi 1991; Rørvik *et al.* 1991; Jemmi & Keusch 1992; Leung *et al.* 1992; Peterson *et al.* 1993). Therefore in the interests of public health it is imperative that such products are *Listeria*-free when packed.

Because *L. monocytogenes* can grow at refrigerator temperatures (Ryser & Marth 1991), and as the minimum infective dose has not been determined (Farber & Peterkin 1991; Rocourt 1994), the United States Food and Drug Administration (FDA) and the New Zealand health authorities have taken a conservative approach and recommended that, for ready-to-eat seafood, *L. monocytogenes* should not be present in a 25 g sample (Ministry of Health 1995; Farber 1993). *L. monocytogenes* has, therefore, created a challenge for food processors who, in the interests of public health and for

regulatory reasons, must now ensure that foods which are to be consumed with little or no re-heating (ready-to-eat foods) are free of *L. monocytogenes*. Consequently this organism has become a major concern of the food industry in New Zealand and in many other parts of the world.

RESEARCH ON CONTROLLING *L. MONOCYTOGENES*

In this section we will, with reference to results from our recent research, present an overview of techniques, such as the application of heat or the addition of organic acids, that may be a used as part of a *Listeria* control program to ensure that processed seafood products are *Listeria*-free. In particular, we will report on the thermal death times of *L. monocytogenes* associated with both raw greenshell mussel (*Perna canaliculus*) meat and mussels prepared for hot smoking and comment on the significance of these results with regard to the design of blanching or hot smoking regimes to eliminate *L. monocytogenes*. We will report results from research into the ability of organic acids to kill *L. monocytogenes* cells and discuss the potential of fin fish washing regimes to reduce the carriage of bacteria into processing facilities.

Eliminating L monocytogenes from greenshell mussels by blanching

The New Zealand shellfish industry is recognised as a producer of shellfish of the highest quality. This reputation was gained through strict adherence to industry-agreed standards which involve the classification of growing areas and the regular monitoring of water quality (IAIS 005 1995). *L. monocytogenes* is not often found in samples of mussels collected from approved growing sites in New Zealand (Fletcher *et al.* 1994). Nevertheless, we were interested in determining whether the initial heat process applied to mussels before entering the packaging and "added value" sections of the processing facility had the potential to act as a listericidal step. This would provide an additional safeguard against the introduction of *L. monocytogenes* to the processing facility.

The primary purpose of the initial heating step, known as blanching or conditioning, is to facilitate opening of the mussels and to inhibit enzymes which can reduce the shelf-life of mussel products. Thermal treatments are also known to inhibit *L. monocytogenes* with recent reviews on the thermal death of *L. monocytogenes* suggesting that, for the majority of cases, heating at 70°C for 2 minutes would be sufficient to inactivate any *L. monocytogenes* present in raw meat (Farber & Peterkin 1991; Miles & Mackey 1994). However, as the degree of heat required to kill a given number of *L. monocytogenes* cells in any particular product is dependent on the chemical and physical nature of the product and on the particular strains of *L. monocytogenes* that may be associated with the product, it is desirable to experimentally determine the thermal death point of *L. monocytogenes* cells in association with the product of interest (Brown 1991).

While the application of a certain amount of heat to the mussels during blanchings is desirable, overheating of the mussel flesh causes a decrease in product quality with regard to yield, texture, colour and storage life. In order to predict whether the blanching process is or has the potential to act as an additional safeguard against the introduction of *L. monocytogenes* to the processing facility, accurate information is required on the thermal death point of *L. monocytogenes* cells associated with raw mussels and on the core temperatures of mussels during processing.

The time required to kill 90% of contaminating *L. monocytogenes* cells at a particular temperature is referred to as the D-value or the decimal reduction value. A graph of the logarithm of the D-value against temperature is called a thermal-resistance curve. If a simple least-square regression is fitted to the data, the Z-value estimate is the negative reciprocal of the slope of the fitted line or the degrees of temperature for the D-value to change by a factor of ten (Pflug 1990). We determined that the D-values at 58, 59, 60, 61 and 62°C for seven strains of *L. monocytogenes* in raw greenshell mussels were 17.19, 11.32, 7.46, 4.91, and 3.24 minutes respectively, with a Z-value of 5.52°C (Bremer & Osborne 1997). Using the regression line generated from the data, it was then possible to determine that the D-values at 68 and 72°C were 16 and 3 seconds, respectively.

The core temperatures obtained by greenshell mussels, during passage through a steam injected water blancher (nominal water temperature 94-96°C) in two New Zealand greenshell mussel processing facilities (Factory One and Factory Two) were also determined (Osborne & Bremer 1995). From the mussel core temperature data obtained, the time intervals from the time that the core of each mussel first reached 72°C (or 68°C if 72°C was not achieved) until the time the core temperature showed a significant (greater than 2°C) decrease were determined.

A product is generally considered to be *Listeria*-free when the chances of finding *Listeria* associated with the product are fewer than one in a million, or to put it another way, there is less than 1 *Listeria* cell per million mussels or fewer than 10^{-6} *Listeria* cells per mussel. If we assume that the maximum number of *L. monocytogenes* cells on a mussel

coming into the factory would not exceed 100,000,000 (10^8), the reduction in *L. monocytogenes* numbers necessary to ensure a *Listeria*-free product is from 10^8 to 10^{-6}, which is 14 D-value reductions. At 68 and 72°C, the times required for 14 D-value reductions are 224 and 42 seconds respectively.

Using the D-value data for *L. monocytogenes* and the core temperature data from the mussels, the theoretical number of *L. monocytogenes* D-value reductions obtained during passage of mussels through the blanchers were calculated to range from 22.6 to 97.4 for Factory One and from 0.24 to 29.30 for Factory Two.

The results from the core temperature trials indicated that all mussels undergoing the processing regime employed in Factory One achieved a high enough core temperature to pass the stringent standard of 14 D-value reductions. However, only 33% of the mussels tested (4 out of 12) from Factory Two passed. It can be argued that 14 D-value reductions far exceeds what is realistically required to ensure a *L. monocytogenes*-free product. If, for example, it is assumed that fewer than 1 in 100 mussels are contaminated with *L. monocytogenes* then only 4 D-value reductions are required to reach the standard of fewer than one in a million mussels contaminated with *L. monocytogenes*. In this case, 58% (7 out of 12) of the mussels monitored in Factory Two met the standard.

The time employed as a blanching step in Factory One was significantly longer than the time used in Factory Two (T-value = 35.79 $p<0.001$) and resulted in significantly greater theoretical D-value reductions being achieved (T-value = 6.12 $p<0.001$) by Factory One. At 72°C, the time required for a decimal reduction is only 3 seconds. Therefore small increases in the time the mussels spent in the blancher have a dramatic impact on the effectiveness of the blanching process in ensuring the elimination of *L. monocytogenes* cells. However, the value of increasing run times in order to improve the effectiveness of the blanching process in eliminating *L. monocytogenes*, has to be considered in the light of the possible risks presented by *L. monocytogenes*, the level and frequency of any possible *L. monocytogenes* contamination, the effectiveness of current *L. monocytogenes* control and monitoring regimes and any detrimental effects that increased cooking time may have on "overall" mussel quality. As both companies were satisfied with the quality of the products they were producing, these data suggest that Factory Two may be able to modify their blanching process in order to improve its effectiveness against *L. monocytogenes* without compromising the quality of the mussels they produce.

The results of these studies (Bremer & Osborne 1997; Osborne & Bremer 1995) will allow processors to design blanching regimes that will eliminate the potential for *L. monocytogenes* associated with raw mussels to be carried into the processing facility.

Thermal death of L. monocytogenes in hot-smoked greenshell mussels

From a view point of food safety, the critical steps in the production of hot-smoked greenshell mussels are the heating step associated with the hot-smoking regime and avoiding post smoking contamination during packaging by the enforcement of good personal hygiene and the implementation of sound sanitising regimes.

In order to produce a smoked product that has favourable textural and storage properties, the production of hot-smoked greenshell mussels requires precise temperature control. As the application of heat is effective in killing *L. monocytogenes* (see above), we were interested in determining if the temperatures obtained during hot-smoking were sufficient to ensure a *L. monocytogenes*-free product. Sub samples (25 g) of blended greenshell mussels, that had been soaked in brine in preparation for hot-smoking, were inoculated with *L. monocytogenes*, challenged at 6 different temperatures and *L. monocytogenes* numbers were determined at 5 time intervals for each temperature. The D-values at 56, 58, 59, 60 and 62°C were calculated to be 48.09, 16.25, 9.45, 5.49 and 1.85 minutes respectively, with a Z-value of 4.25°C (Bremer & Osborne 1995a).

This study reinforced the observations of many other researchers, that slight changes (1 - 2°C) in the core temperature obtained in a product during smoking, can have a profound effect on the time required to eliminate a given number of *L. monocytogenes* cells. Therefore, in order to ensure that a proposed thermal treatment will be effective in killing *L. monocytogenes*, it is vital that a processor has a thorough understanding of the spatial and temporal temperature variations that occur within the smokehouse.

A knowledge of the temperature gradients occurring within the smokehouse during hot-smoking of product, coupled with information on the core temperatures obtained by the mussels and data on the thermal death point of *L. monocytogenes* associated with mussels prepared for hot smoking, will enable the development of hot smoking regimes that are effective in killing any possible *L. monocytogenes* contaminates. Such

regimes should ensure the production of *L. monocytogenes*-free hot-smoked mussels.

Using marinades against L. monocytogenes associated with greenshell mussels

Organic acids are a traditional means of improving food safety and shelf-life (Adams & Hall 1988; Ray & Sandine 1992) and, in conjunction with salt, sugar and spices, are used in the production of marinades for greenshell mussels *(Perna canaliculus)*. However, little is known about the survival of *L. monocytogenes* in marinated products. Most of the research on the survival and/or growth of *L. monocytogenes* in low pH environments has been carried out in model broth systems. However, it is difficult to extrapolate results obtained with model systems to the behaviour of bacteria in a food product, as the effects of acids on the growth of *L. monocytogenes* may be influenced not only by pH but by other factors such as salt levels and temperature (Ahamad & Marth 1989; Conner *et al.* 1990; Parrish & Higgins 1989; Sorrells *et al.* 1989). It has also been suggested that natural inhibitors, competing microflora, water activity of the product, presence of other food additives, composition of the product and cell numbers could also affect the efficacy of the organic acids (Ahamad & Marth 1989; Parrish & Higgins 1989).

Knowledge of the D-value of *L. monocytogenes* in a particular product is of importance to the food processor since a marinade with proven listericidal properties will act as an additional safeguard against the sale of product contaminated with *L. monocytogenes*. In our study, three variations of commercially available marinades were prepared and the efficacy of the marinades against *L. monocytogenes* in the presence or absence of green shell mussels was determined by calculating D-values for a mixture of seven strains of *L. monocytogenes* exposed to marinades in the presence or absence of mussels. Using an acetic acid (1.5% w/v) marinade (AA), the calculated D-values in the presence and absence of mussels were 77.3 and 33.3 h, respectively. Likewise, for an acetic acid (0.75%)/lactic acid (0.75%) marinade (AA/LA) and an acetic acid (1.5%)/Gluconic delta lactone (0.2%) based marinade (AA/GDL), the D-values in the presence and absence of mussels were 125.5 and 26.9 h and 86.3 and 19.3 h respectively (Bremer & Osborne 1995b).

The D-value for *L. monocytogenes* was influenced both by the composition of the organic acids in the marinade and by the presence of mussels. In the presence of mussels, the decimal reduction times for *L. monocytogenes* increased by 2.3, 4.4, and 4.6 times for the AA, the AA/GDL and the AA/LA-based marinades respectively compared with the same marinades in the absence of mussels. The variation in increase in D-value indicated there was not a simple relationship between the listericidal nature of the marinades and the presence or absence of mussels.

Ita and Hutkins (1991) found that inhibition of *L. monocytogenes* by acetic acid was greater than could be expected compared with trials carried out with citric, lactic or hydrochloric acids. They, therefore, concluded that inhibition of *L. monocytogenes* by acetic acid is caused by specific effects of the undissociated acid and not by a decrease in the intracellular pH *per se*. In similar experiments, Young and Foegeding (1993) confirmed that there is a specific acid effect in addition to acidification of the cytoplasm and that acetic acid is more inhibitory than lactic acid. As the marinades we tested all contained acetic acid at equilibrium concentrations of either 0.75 or 1.5%, the absence of a lag phase is consistent with death being due to the inhibition of cellular components rather than to a gradual depletion of cellular energy reserves used to maintain intracellular pHs.

This research suggested that storage of marinated product prior to release will be an effective method for decreasing the possibility of *L. monocytogenes* being associated with these products. Further, as the decimal reduction time for *L. monocytogenes* in the presence of marinades appears to be dependent not only on the organic acid composition of the marinade but also on the physical and chemical characteristics of the marinated product, the results from these experiments indicate that care needs to be taken when extrapolating the results from model systems to predict what will occur in a real system. We believe that the only reliable way to determine the listericidal nature of a particular marinade in association with a given product is to test it experimentally under conditions that mirror those under which the product will be distributed and sold.

Washing finfish to restrict the carriage of bacteria into processing facilities

A recent study carried out in North Western USA reported that the external surfaces of frozen and fresh fish were the primary source of *L. monocytogenes* contamination to cold-smoked fish processing plants (Eklund *et al.* 1995). As the listericidal nature of the cold-smoking step is unclear (Guyer & Jemmi 1991; Dillon & Patel 1993; Jemmi & Keusch 1994; Rørvik *et al.* 1995) and as *L. monocytogenes* has been reported to be able to survive and even increase in numbers on vacuum-packed smoked seafood products (Guyer & Jemmi 1991; Rørvik *et al.* 1991; Jemmi & Keusch 1992; Leung *et al.* 1992; Peterson *et al.* 1993), it is

prudent to have in place a control step that can act to eliminate *L. monocytogenes* from the surface of gilled and gutted fish prior to further processing. In addition, with minimally processed products, such as cold smoked or sashimi salmon the limiting factor determining the shelf-life of the product is often related to proliferation of bacteria (total heterotrophic counts). Therefore, in order to enhance the quality and to extend the shelf-life of these products, it is important to keep strict control on total bacterial numbers on the surfaces.

In the production of cold-smoked salmon products, the skin and the belly-cavity linings which come in contact with the wash solutions are removed and discarded during processing. Therefore treatments can be applied to gilled and gutted fish that would reduce the quality of the finished product if they were applied after filleting.

We have carried out preliminary trials on the effectiveness of a chlorinated wash in reducing the numbers of bacteria associated with farmed Pacific salmon (*Oncorhynchus tshawytscha*). Our results indicate that washing with chlorinated water can remove/kill as many as 99.76% of the culturable bacteria associated with the external surface of the salmon. Important parameters in fin-fish washing include: the duration of washing, the level of chlorine, the water flow, and the rate of aeration. As well, as effectiveness in removing bacteria, it is important that the washing regimes do not have a deleterious impact on the organoleptic quality of the finished product. Therefore it is important to determine the rate of change in effectiveness for each parameter. For example, if the duration of washing is considered, it is logical to assume that if washing for one hour removes a certain number of bacteria then washing for two hours will remove more. However, the advantages gained by the extra hour may not off-set the deleterious effects of the longer wash. In addition, as it is likely that the various parameters, such as chlorine concentration, flow rate and duration of washing, will have a synergistic effect on bacterial removal, it is important to plan and implement an experimental design that will allow interactions between these parameters to be measured.

Information gained and techniques developed from this research will result in a decrease in the introduction of bacteria into seafood processing facilities and a decrease in the number of bacteria contaminating the finished product. These techniques will not only enhance the safety of seafood products, they will decrease product recalls and enhance the quality and extend the shelf-life of the finished product.

MONITORING PROGRAM TO CONTROL *L. MONOCYTOGENES*

In this section we will describe the monitoring program that is used for *L. monocytogenes* in the New Zealand seafood industry and how this is helping to ensure that New Zealand ready-to-eat seafoods are free from *L. monocytogenes*.

Regulatory responsibilities

- *Ministry of Health*

On the domestic market in New Zealand the Ministry of Health is responsible for food safety and has a introduced a "zero tolerance" standard for *Listeria monocytogenes* (i.e. 25 g samples, n = 5, c = 0, m = 0) (Ministry of Health 1995). This standard applies to ready-to-eat seafood, e.g. smoked mussels, cold smoked salmon, seafood salad pieces. There are some exemptions to this standard, e.g. seafood with a pH less than 4.6, or a water activity less than 0.9. A number of export markets (e.g. Australia and USA) have similar standards for imported ready-to-eat seafood.

- *Ministry of Agriculture*

The Ministry of Agriculture and Food (MAF) Regulatory Authority (Meat and Seafood) is the controlling authority for export seafood and has accountability and responsibility for food safety standards and certification of fish and fish products.

- *Fishing Industry Inspection and Certification Council*

The Fishing Industry Inspection and Certification Council (FIICC) was established in 1988. It is a cooperative organisation involving MAF, Fishing Industry Board (FIB) and the fishing industry and is established as a subcommittee of the FIB. FIICC provides advice to the Board and MAF on the development and formulation of industry agreed implementation standards relating to the export of fish and fish products.

Legislative requirements

The Fish Export Processing Regulations (1995) which govern the export of seafood from New Zealand enable circulars to be issued which provide a means of achieving the standards in the regulations. These circulars are issued by the Director-General, MAF and are known as Industry Agreed Implementation Standards (IAISs). A number of IAISs have been developed including: premises, certification, operations in fish premises, labelling and shellfish quality assurance.

Each of the IAISs outline the means of achieving the particular standards detailed in the regulations. Companies may, if they wish, make a specific application to have a different method of achieving a standard approved. An example of a program is

the monitoring program for *L. monocytogenes*. The emphasis under this system is for the individual companies to take responsibility for food safety.

History of Listeria in seafood in New Zealand

In the late 1980's and early 1990's, *L. monocytogenes* was found in seafood products both in overseas countries and in New Zealand. In some cases, this resulted in rejection of seafood at the port of entry with the loss of confidence in the export market.

In September 1991, a FIICC Circular outlining a monitoring program for *Listeria* was issued. The program applied to cooked or ready-to-eat seafoods and was based on a program that has been implemented in Canada. It required environmental samples to be taken every month in the processing factory.

At the beginning of 1993, a major review of the program was undertaken. Although still based on environmental montioring, the revised program was more comprehensive. Further modifications were made in 1995 (IAIS 003.9 1995).

Monitoring program for L. monocytogenes

Companies are required to develop a written program detailing the person responsible for the program, the procedures that are to be used, records that will be kept, action to be taken when positive results are found and plans to control contamination in the various as described below. The main features of the current program are given below.

- The premises environment is divided into a number of zones based on potential risk to the product. This ranges from non-processing and outside areas (Zone 1) to product contact surfaces within the critical hygiene area (Zone 4).

- The sampling rate for each zone varies. For example, sampling in Zone 1 is on a voluntary basis. Sampling of Zone 4 is five sample sites per fortnight.

- Flow charts of the actions to be taken when positive results are obtained are provided. Actions include the review of sanitation, manufacturing and product handling, the review of access restrictions, and the resampling of the environment. All actions are required to be carried out within a specified time period.

- Companies must report positive *L. monocytogenes* results either from samples taken in the critical hygiene environment or from product samples to the local Inspector. The Inspector ensures that appropriate follow up action has been taken.

- Adequate records must be maintained by the company so that they can demonstrate they are meeting the requirements of the monitoring program.

- All testing is required to be carried out in an approved laboratory. Both government and private laboratories can be approved.

- Samples of product are to be tested each month as verification for the monitoring program.

A task group will be brought in to assist companies where persistent problems with *L. monocytogenes* are found in their premises. This group includes a technical expert from MAF and will usually include company personnel and the local Inspector. The group reviews the program in the premises and specifies remedial action.

Guidelines

Guidelines on the management of *L. monocytogenes* in Fish Packing Houses (Fishing Industry and Inspecion Council 1994) have been issued to all premises. The intention of the guidelines is to assist industry with the management and control of *Listeria*. The guidelines cover a wide range of subjects including construction and hygiene, process control, sampling and product recall. The document is advisory to premises and is designed to provide a basis of understanding for the New Zealand seafood industry so that effective *Listeria* management control programs can be developed and implemented. They are also designed to complement the mandatory requirements in the IAISs.

Current situation

The monitoring program for *L. monocytogenes* has been operating in export seafood premises in New Zealand for several years now. The use of the task force to deal with situations where persistent problems with *Listeria* occur in a premises has proved invaluable and has enabled individual companies to resolve these problems in a quickly and effective manner.

CONCLUSIONS

While control of *L. monocytogenes* is and will continue to present a challenge to the New Zealand seafood industry, it is a challenge that most seafood processors have reduced to a manageable level.

In order to eliminate *L. monocytogenes* in the final product, it is important to have in place a *L. monocytogenes* control program which encompasses all steps in the production of seafood products from the time of harvest or capture through to the point of sale.

Effective *L. monocytogenes* control also requires an appreciation of the mode of action of the various control points or hurdles employed to either inhibit or kill *L. monocytogenes*. An improved understanding of how processes such as the application of heat or organic acids kill *L. monocytogenes* cells not only results in the development of effective listericidal steps by defining minimal limits at which these processes are effective, it can improve the overall safety, quality and enhance the shelf-life of the finished products.

While efforts by food processors, regulatory authorities and scientists have, in a relatively short period of time, come a long way towards controlling *L. monocytogenes* contamination on seafood products we can not afford to be complacent. For effective, cost-efficient *L. monocytogenes* control, a greater understanding is required on a number of issues such as: the mechanisms by which *L. monocytogenes* attaches to and/or grows on product and processing surfaces and how best to remove/kill the attached cells, how/where the micro-organism survives within the processing environment and how to eliminate it, and the development and validation of effective listericidal regimes for minimally processed products. Scientists, regulatory agencies and seafood processors need to work together in the further development of handling and processing regimes to control *L. monocytogenes*.

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OCCURRENCE OF *Listeria monocytogenes*

In ready-to-eat smoked products of Atlantic salmon farmed in Tasmania, Australia

By Christian Garland and Lyndal Mellefont [1]

Abstract

Since February 1994, we have investigated the occurrence of *Listeria* species, particularly *L. monocytogenes*, in more than 600 samples of various smoked salmonid products. All samples were ready-to-eat foods commercially manufactured from Atlantic Salmon *(Salmo salar)* farmed in south-eastern Tasmanian waters. The major products tested include cold-smoked salmon slices and fillets, and paté made from hot-smoked salmon trimmings.

In the period February 1995 to December 1995, the occurrence rate of *L. monocytogenes* in cold-smoked salmon products was 0.46% (2 positive detections in 433 samples, including 305 samples screened in a factory and found to be negative by ELISA testing). The two positive detections of *L. monocytogenes* were attributed to factory-acquired contamination of product. This result is similar to the occurrence rate of 0.35% (1 in 285 samples) determined in the preceding 12 months (Garland 1995).

In the case of hot-smoked salmon paté, frequent detections of *L. monocytogenes* (18 of 61 samples; occurrence rate of 29.5%) were made in June and July 1995. Contamination of paté by *L. monocytogenes* was found to be due to the presence of the organism in raw salmon trimmings, and its survival during hot smoking. Modifications to the hot smoking process, including increasing the core temperature treatment from >70°C/h to 80°C/0.5h then 85°C/0.5h, greatly reduced the number of positive detections. In the period September 1995 to March 1996, the occurrence rate was 1.0% (1 in 100 samples). The one positive detection in paté was attributed to carotene which had become contaminated with *L. monocytogenes* and was subsequently used in the paté blend.

In our experience, the control of *Listeria* in smoked salmonid products requires stringent application of HACCP (Hazard Analysis and Critical Control Points) in the factory. Known CCPs should be monitored frequently and the potential for new CCPs to occur must be acknowledged and acted on.

Keywords: *Listeria*; *Listeria monocytogenes*; Atlantic salmon; Salmo salar; Paté; Hazard Analysis and Critical Control Point; HACCP; Ready-to-eat foods.

INTRODUCTION

The consumption of commercial ready-to-eat foods is increasing worldwide, together with growing public demands both for foods which are free of chemical preservatives, and foods which are fresh and uncooked. These three risk factors combine to form a major challenge to producers of microbiologically safe ready-to-eat foods. According to these criteria, various ready-to-eat seafood products can be assessed as belonging in the high risk category, including : raw sashimi-style fillets and whole fish; roe; raw molluscs, whole or in the half-shell; cold or hot-smoked pieces, fillets or whole fish and shellfish; marinated fish and shellfish; blended products such as patés, roulades and terrines; and cold salads in which raw or processed fish or shellfish form a component.

The approaches of manufacturers and public health authorities to ensure that ready-to-eat seafoods are microbiologically safe are evolving slowly. HACCP (Huss 1992) is being applied increasingly

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at the factory level; in some instances voluntarily by manufacturers, in other instances because it is mandated by government as part of a food safety plan (e.g. AQIS 1994). Overall however, routine testing of the microbiological status of commercial ready-to-eat seafood products continues to be undertaken infrequently although good hygiene practices (e.g. Sikorski 1992) are being implemented gradually, at least at the manufacturing level.

Various bacterial diseases can be transmitted to the human consumer in seafoods (reviewed by Gibson 1992), including listeriosis which causes effects ranging from diarrhoea and influenza-like symptoms, to septicaemia, meningitis and meningoencephalitis, to abortion (Jones 1990). The most susceptible groups are neonates, the elderly, pregnant women and the immuno-compromised. Listeriosis is a relatively rare disease but of considerable concern due to a mortality rate of 30% and higher (Ryser & Marth 1991). Limited evidence suggests listeriosis may be acquired via contaminated seafoods (Lennon *et al.* 1984; Facinelli *et al.* 1989; see also a case of abortions induced by marinated mussels - Garland 1995)

L. monocytogenes can grow at refrigeration temperatures (Ryser & Marth 1991) and this capability adds a further risk factor to the consumption of ready-to-eat seafoods, most of which are stored chilled at commercial outlets prior to sale. In an earlier paper (Garland 1995), we described a HACCP system to control the occurrence of *L. monocytogenes* in ready-to-eat cold-smoked Atlantic salmon products at the factory level. In the present paper, we report further data on the occurrence of *L. monocytogenes* in cold-smoked Atlantic salmon products and new data on methods to control the organism in paté made from hot-smoked salmon trimmed pieces (trimmings).

MATERIALS AND METHODS

Sample collection

Samples of cold-smoked Atlantic salmon *(Salmo salar)* products and hot-smoked Atlantic salmon paté were obtained from manufacturers in southern Tasmania (Australia) where the fish had been farmed. The ready-to-eat samples were submitted for analysis in chilled condition (4°C) and in their typical packaging : vacuum packaged (cold-smoked products) or in jars with tight-fit lids (patés).

Bacteriology

Composite samples (5 x 5 g) of seafood were tested by the USDA FSIS (1989) method. Primary isolation was undertaken in three stages: 25 g was homogenised in 225 mL UVM broth in a stomacher and incubated at 30°C for 18-24 h; 0.1 mL was transferred to 10 mL Fraser broth and incubated at 35°C; Fraser broths were streaked onto Oxford or MOX agar after incubation for 24 h (only if positive) and 48 h (if positive or negative) which were then incubated at 35°C for 48 h. Suspect *L. monocytogenes* (and other *Listeria* spp.) colonies were characterised according to gram stain and morphology, motility, "umbrella" growth in Bacto motility medium, haemolytic and CAMP reactions, and various biochemical reactions (determined on Biomerieux api *Listeria* strips), as per the USDA FSIS (1989) method.

The selectivity of Oxford and MOX agars as the final bacteriological recovery medium used in primary isolation of *Listeria* was also compared by streaking replicate samples from Fraser broths onto the two media.

Validated recovery

Tests were undertaken to ensure that *L. monocytogenes* (reference culture ACM 98) could be recovered from food products. Low and medium inocula were prepared from appropriate dilutions of brain heart infusion broth cultures which had been incubated at 35°C for 24 h. Inocula (0.1 mL) were pipetted into 25 g composite samples which were then tested by the USDA FSIS (1989) method, as above.

RESULTS AND DISCUSSION

Validated recovery

L. monocytogenes was successfully recovered from low and medium innoculated cold-smoked Atlantic salmon slices on both Oxford and MOX agars by means of the USDA FSIS (1989) method (Table 1).

Occurrence of L. monocytogenes in cold-smoked Atlantic salmon products

In the period February 1995 to December 1995, there were only two positive detections of *L. monocytogenes* in 433 samples of vacuum-packed cold-smoked Atlantic salmon slices and fillets submitted to our laboratory from four different manufacturers in southern Tasmania. The occurrence rate was estimated as 0.46%, which is similar to the previous 12-month rate of 0.35% (Garland 1995), and was regarded as satisfactory. In the case of the two positive detections of *L. monocytogenes* in ready-to-eat products in 1995. Of the two positive instances, *L. monocytogenes* was isolated by swab from the surface of a plastic bin which had been used during product processing in the factory. In the second instance, despite multiple swabs of surfaces in the manufacturing

area the source of *L. monocytogenes* in the factory was not determined.

Of the 433 ready-to-eat samples tested, 305 were screened at one factory by means of a commercial ELISA type kit. As part of their HACCP system, staff at the factory also used this kit to check for the presence of *L. monocytogenes* in the product at various stages during processing, and in swabs of food contact surfaces and secondary surfaces (such as floors, drains and door handles). It is interesting to note that in the period February 1994 to December 1995, 20% of presumptive *Listeria*-positive in-process product samples and 26% of presumptive *Listeria*-positive swab samples, as determined by the ELISA type kit, have subsequently proved to be *Listeria*-negative by the USDA FSIS (1989) method in our laboratory.

We are currently investigating the possible causes of these false-positive results. A range of organisms were cultivated from archived (frozen) primary isolation media (UVM and Fraser broths) in which false-positive results had been obtained. Pure cultures of the organisms were then retested by the commercial ELISA-type kit and one organism has been found to be presumptive *Listeria*-positive. It is a small gram positive non-motile chain-forming coccobacillus, which is non-haemolytic and catalase negative, and does not grow on Oxford or MOX agars but does grow in UVM and Fraser broths. The organism has been tentatively identified as *Aerococcus viridans*. Further testing is planned to determine if the organism shares common antigens with *Listeria*.

A second explanation for our failure by the USDA FSIS (1989) method to detect *Listeria* in the presumptive positive samples submitted to us, is loss of organism viability during storage (archiving) in the frozen state. Accordingly, samples of the food products and UVM and Fraser broths used in the validated recovery tests above (Table 1) were frozen, thawed and retested by the USDA FSIS (1989) method. Positive detections of *L. monocytogenes* were subsequently made in all samples, indicating that freezing did not affect recovery of the target organism.

Occurrence of L monocytogenes in hot-smoked Atlantic salmon paté

A paté manufacturer in southern Tasmania experienced recurring *L. monocytogenes* contamination of their chilled ready-to-eat product over a 7-week period in mid-1995. Eighteen of 61 samples tested positive for *L. monocytogenes*, an occurrence rate of 29.5%. The paté was blended from hot-smoked Atlantic salmon trimmings, cream cheese, carotene, gelatine, cracked pepper, aspic and water. The contamination was surprising in view of the fact that all samples of cold-smoked Atlantic salmon slices submitted to our laboratory from the same factory had proved negative for *L. monocytogenes* in the 40 previous weeks. In addition, hot-smoking at >70°C (the temperature used by the manufacturer) is usually considered listericidal. Accordingly our initial investigations focussed on the non-salmon ingredients and various surfaces in the manufacturing area. *L. monocytogenes* was detected in a distant grease trap and *L. innocua* in a nearby drain but no *Listeria* sp were found in the non-salmon ingredients or on various food contact or other secondary surfaces. Despite thorough cleaning and disinfection of the grease trap and drains, however, *L. monocytogenes* continued to be detected intermittently in the ready-to-eat paté over the next few weeks.

Attention was then focussed on the salmon ingredients. *L. monocytogenes* was detected intermittently in the raw salmon trimmings, and in the hot-smoked trimmings used as an ingredient. Sensitivity of detection of *Listeria* was greatly increased by testing 5 x 5 g samples collected from kilogram quantities of a blended mixture of salmon trimmings. It was clear that *L. monocytogenes* had contaminated the raw salmon trimmings, and was subsequently surviving the hot-smoking process. In contrast, the whole fish received at the factory and cold-smoked, were not contaminated.

Table 1: Validated recovery of *L. monocytogenes* (ACM 98) from cold-smoked Atlantic salmon by the USDA FSIS (1989) method

Final recovery medium	Inoculum (no./25 kg seafood)	*L. monocytogenes* on final recovery medium
MOX Agar*	3.8	Present
	38	Present
	380	Present
	Nil	Absent
Oxford Agar**	2.4	Present
	24	Present
	240	Present
	Nil	Absent

* As manufactured by BBL. ** As manufactured by Oxoid.

Table 2: Hot smoking processes for Atlantic salmon meat (trimmings)

Processing Stage	Non-Listericidal Hot-Smoking Process (until July 1996)	Listericidal Hot-Smoking Process (until August 1995)
Raw meat (trimmings)	Stored at -20°C to -24°C for several weeks, thawed overnight at 2-3°C	Stored at -20°C to -24°C for several weeks, thawed overnight at 2-3°C
Brining	Up to 10 sec at 3-4°C	Up to 10 sec at 3-4 °C
Size of meat pieces	Up to 15 mm thick	Mostly up to 2 mm thick, occasionally up to 5 mm thick
Racking meat for smoking	10 kg/710 x 950 mm rack	7 kg/710 x 950 mm rack
Gap between edge of racks and internal wall of smoker	5 mm	$\geq$ 2 cm
Initial meat temperature on loading racks to smoker	~10°C, with smoker at 12°C to 18°C	~10 °C, with smoker at 75°C
Preliminary cold-smoking	Up to 10 h at 26-28°C	Nil
Hot-smoking	Estimated $\geq$ 70°C/1 h	Measured 80°C/0.5 h, then measured 85°C/0.5 h
Rotation of racks during hot-smoking	No	Yes
Weight loss of meat after hot-smoking	25%	30%

A series of trials was then undertaken to develop a listericidal hot-smoking process; the successful modifications are outlined in the right hand column of Table 2.

In the period August 1995 to March 1996, 100 samples of ready-to-eat paté prepared by the modified hot-smoking process were tested but only one sample was found to contain *L. monocytogenes*. The occurrence rate of 1.0% indicated that the modified hot-smoking process shown in Table 2 dramatically improved the microbiological status of the product, given the previous occurrence rate of *L. monocytogenes* contamination of 29.5%. In view of this result, the increase in weight loss from 25% to 30% was considered an acceptable economic loss. In the one instance of positive *L. monocytogenes* detection, from anecdotal information this was attributed to contamination by the carotene ingredient. The carotene was usually prepared in boiling water and used quickly in the paté blend. However in this instance it was removed from the paté-making area to another part of the factory, where it was used and then returned, without the supervisor's knowledge. Presumably it was contaminated with *L. monocytogenes* when out of the controlled manufacturing area.

The main modifications listed in Table 2 which are considered responsible for successful listericidal treatment are :

- minimal thickness of meat pieces to ensure adequate heat penetration;
- reduced total load of meat on racks;
- adequate gap between smoker wall and edges of rack to ensure adequate ;
- fan-forced heat circulation;
- hot-smoking at 80°C/0.5 h then 85°C/0.5 h, rather than at >70°C/1 h;
- measurement of temperature by accurate (calibrated) thermometer;
- rotation of racks during hot-smoking.

Loncarevic *et al.* (1996) isolated *L. monocytogenes* from a whole rainbow trout *(Onchorhynchus mykiss)* which had been hot-smoked at >60°C for 3-4 h whereas Jemmi and Keusch (1992) found that hot-smoking at 65°C for 30 min was listericidal for *L. monocytogenes* contaminated whole trout. In both these instances, *L. monocytogenes* contamination prior to smoking would be expected to have occurred on the surface of the fish. In our case, *L. monocytogenes* contamination prior to smoking would be expected to have occurred throughout the depth of racked fish meat, including the core. Our results suggest that for hot-smoking to be listericidal for deeply contaminated meat, a higher temperature/time regime is required, namely 80°C/0.5 h followed by 85°C/0.5 h. Further tests are currently being planned in our laboratory to determine the most effective listericidal temperature/time regime.

Comparison of selectivity of Oxford and MOX agars for Listeria

The bacterial biota on seafoods is diverse (Liston 1992) and bacteriological techniques to detect a specific organism need to be highly selective. In the case of USDA FSIS (1989) method, selectivity for *Listeria* is achieved by means of primary enrichment, secondary enrichment, and selective agar; all three stages use two or more antibiotics as selective agents.

In our experience with testing seafoods, several non-*Listeria* colony types can grow on Oxford or MOX agars after 48 h at 35°C but four are more common than others, characteristically :

1. rough brown colony with uneven margin, aesculin hydrolysis, humic odour; the organism is a slender chain-forming gram positive rod, non- motile and catalase positive;

2. circular shiney golden-brown colony, aesculin hydrolysis; the organism is a slender gram positive rod, motile by spiralling and catalase positive;

3. dull golden-brown colony with irregular margin, aesculin hydrolysis; the organism is a slender gram positive rod, non-motile and catalase positive;

4. shiney yellow raised colony, no aesculin hydrolysis; the organism is a gram positive coccobacillus, motile and catalase positive.

In a comparison of replicate samples of seafood innoculated onto Oxford and MOX agars, we have found MOX agar to be marginally more selective than Oxford agar. Colony types 1 and 4 above usually grow respectively more slowly and not at all on MOX agar compared to Oxford agar. With regard to swabs of relatively dirty areas in the manufacturing area (such as floors, drains and palettes), MOX agar is much more selective than Oxford agar. In a few instances, *Listeria* has been overgrown by other colonies on Oxford agar and has been undetectable.

CONCLUSIONS

1. The implementation of HACCP can achieve acceptable low occurrence rates of *L. monocytogenes* contamination of ready-to-eat seafood products made from smoked Atlantic salmon.

2. For HACCP to be successful, constant surveillance of all activities in the manufacturing area is needed. This does not necessitate constant microbiological testing but it does require that all personnel entering the high-risk manufacturing area are aware of possible sources of *L. monocytogenes* contamination, including any material which is removed and then returned to it.

3. Implementation of HACCP does not guarantee that *L. monocytogenes* contamination of final product will not occur. Routine processes (such as hot-smoking) which are based on literature methods may not succeed as planned, and may require modification. Product testing should be undertaken regularly to check that the manufacturing process is not failing.

4. MOX and Oxford agars are both acceptable selective media for detection of *Listeria* in seafood samples, with MOX agar marginally better than Oxford agar. In the case of detection of *Listeria* in swabs of surfaces in the manufacturing area, MOX agar is an acceptable selective medium but Oxford agar can occasionally fail to demonstrate the presence of the target organism.

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COMMERCIAL ABALONE CANNING

Temperature patterns and heating rates using pressurised saturated steam retorts

By Dean Bottrill[1]

Abstract

Lower yields of canned abalone (*Haliotis* spp.) were obtained in commercial thermal processing compared with laboratory trials or small scale production runs using commercial equipment. This led to a study of the commercial process, based on 20 years observations.

Temperatures were measured using 20 probes and data logging equipment. The large number of probes together with almost instantaneous reading of the probes allowed observation of the temperature pattern throughout the retort at any time during a thermal process and changes in the pattern with time. The retort used was a standard horizontal retort with bottom steam injection and top venting. The retorts used in most trials were fitted with electronic controls with PID control and automatic come-up to remove operator variability in process control. Cans were stacked into baskets for loading into the retort.

Steam distribution was found to follow standard fluid flow principles. The original assumption was that once process temperature (and pressure) was reached, the temperature throughout the retort was uniform. This assumption was found to be erroneous due to high steam demand and flows, resulting in pressure (and temperature) differences throughout the retort. The effect of can stacking patterns, steam spreader design and method of use of the equipment were investigated to determine their effect on the temperature patterns.

Uniform temperatures were achieved throughout the retort during the thermal process, however, yield variations persisted, although to a lesser degree. Heating rates of product in the cans showed similar heating patterns previously observed temperature patterns, despite temperatures adjacent to the cans being uniform. Manipulation of the process resulted in much greater uniformity in heating, together with much more uniform F_0's and drained weights.

Keywords: Abalone; Canning; F_0; Retort; Temperature; Steam; Pressure.

INTRODUCTION

This paper is a summary of observations on abalone canning over the last 20 years. The aim of the work was to enable uniform and predictable drained weights to be produced in canned abalone. Abalone were packed commercially to give a drained weight that was 50% of the stated net weight. The standard abalone can (74 x 118.5 mm) had a drained weight of 213 g and to achieve this fill weights of between 230 g and greater than 310 g were required. Some of this variation was found to be due to quality problems, handling procedures and precanning processing procedures. The work with commercial canning was done in parallel with laboratory trials. Variation in drained weight attributable to quality problems and preprocessing handling and precanning processing procedures could be readily reproduced and demonstrated in the laboratory. This allowed the problems to be defined and solved. Accurate predictions of drained weight could be achieved in the laboratory and in very small production. In large production runs there were large variations in drained weight within a cook and between cooks, despite achieving uniform quality, optimising processing conditions and ensuring uniform pack weights. It was suspected that the variation was a result of non-uniform cooking of the abalone and this phase of the process was studied.

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Large variation in drained weights between cooks and within cooks, together with a minimum drained weight requirement, meant that cans had to be over-packed to ensure the minimum drained weight requirement was met. Overpacking of expensive product meant a very large give away (and large yield losses) and the risk of under processing.

Retort temperature studies had been conducted using a multi-probe analogue electronic thermometer with manual reading and switching between probes. However, during periods of rapid temperature change it took the full 1 minute interval between readings to read 6 probes, resulting in a continual cycle of reading and no exact comparison between probes since probe 6 was read 50 seconds after probe 1 until such time as the temperatures were relatively constant. Exceptionally high or low readings were attributed to thermocouple error and were discarded as being due to damaged thermocouples or poor electrical contact.

EXPERIMENTAL

Effect of abalone quality on yield

Live abalone were shucked and the shucked weight of the individual abalone was measured. The shucked meat was placed in a refrigerator and stored at approximately 7°C. Abalone pieces were cleaned and canned at intervals over a 13 day period by the standard procedure in the laboratory. Before cleaning and canning, measurements were made of the pH, weight changes and the appearance and texture of the meat.

Effect of F_o on drained weights

Abalone of uniform quality were retorted at 113°C for 50 min to achieve an F_o of 2.5 min (as calculated from measurements with thermocouples inserted at the centre of the abalone) and at 116°C for 75 min (to achieve an F_o of 5.3 min).

Trials with commercial retorts

Retorts used in the trials were usually fitted with Taylor Microscan 500 indicating process controllers with automatic ramp soak and proportional, integral and derivative (PID) control in operation to automatically and accurately control the come up and process conditions. Independent chart recorders recorded the process temperatures within the retort. The retorts were standard commercial horizontal retorts as found throughout the canning industry, holding two baskets of approximately 500 cans each. The retorts had a bottom steam spreader, top venting and top water sprays, with manual pressure control during the cooling cycle with compressed air. Both the water spray spreader and the steam spreader extended the length of the retort and the steam spreader was designed according to the National Canners' Association recommendation with vent holes 1.5 to 2 times the area of the smallest constriction in the steam pipe. The retorts were fitted with a standard mercury in glass thermometer and a pressure gauge.

- *Temperature variations within retorts*

Temperatures were measured using a Datataker F100 automatic recording data logger capable of reading 20 probes per second to 0.1°C, connected to copper constantin thermocouples via an isothermal block. Probes were welded and the welded end insulated with a thin layer of araldite. Twenty probes were used per experiment and probes were placed within baskets with different stacking arrangements. Probes were placed adjacent to retort control sensors and remaining probes were placed between layers of cans, starting at the bottom layer at the centre of the basket and progressing up through the basket. The position of probes was identified by the code 1/2, 2/3, 3/4, etc, where the numbers identified the layer of cans in the baskets (with the lower number being the lower layer in the basket). Thus, 3/4 identifies the probe between the third and fourth layers of cans up from the bottom of the basket. Baskets held 6 to 8 layers of cans when laid on their sides, with 6 cans end to end across the basket and 11 rows of such cans side by side along the basket. Baskets could be packed with 6 cans end to end across the basket, with a gap between the last can and the side of the basket, or packed with the gap in the middle of the basket, with 3 cans end to end either side of the gap. In most trials baskets were packed with 3 cans end to end at each side of the basket and a gap of approximately 100 mm between cans in the middle of the basket. Probes were placed in the centre of the row between layers (midway over the second can from the side if a central gap were present or at the centre of the basket when no central gap was present). Layers were tightly packed, with the upper layer sitting in the groove between rows in the lower layer, or were separated by placing a rigid steel mesh between layers. Alternatively layers of cans were stood on end in the basket (4 layers high), stacked with adjacent rows displaced to minimise the space between cans, or stacked with adjacent cans in line to maximise the space between cans.

- *Heating rates of abalone within cans within the retort*

Abalone of identical quality were carefully selected to be of similar weight and thickness. Probes were carefully inserted at the centre of the abalone meat and such test cans were brined, closed and placed in the basket as the second can from the side of the basket (in all cases cans were laid on their sides,

with a space in the centre of the basket and rigid steel mesh between layers). Test cans were placed in the bottom, middle and top layers in the basket, with test probes outside and adjacent to the test can to measure the temperature of the environment surrounding the can. Thus, two probes were associated with each test can, one in the centre of an abalone meat within the can and another adjacent to the outside of the can). At the completion of the trial the Fo received by the abalone meat was calculated, the drained weight measured the following day and the probe position checked to see that it was positioned correctly within the abalone.

RESULTS AND DISCUSSION

Effect of meat quality on yield

Freshly shucked abalone were initially soft (pre-rigor) to touch while cold but on stimulation with handling the muscle contracted resulting in the meat becoming hard. The meat pH was 6.3 and 5.98 kg of shucked meat was required to yield a carton of finished product (24 x .213 or 5.112 kg for a 24 can carton). As the meat went into rigor (became hard before cleaning) the pH decreased, with little effect on the yield per carton. After day 6 the pH commenced to rise, the meat became soft (post-rigor) and the yield per carton increased. By day 13, the meat was of marginally acceptable quality and the quantity required to produce a carton had increased to approximately 7.4 kg. In view of the effect of quality on yield all trials were conducted using good quality abalone meat.

Effect of F_o on yield

A linear relationship was observed between yield (expressed as drained weight as a percent of fill weight) and Fo for identical quality abalone. Under laboratory conditions it was found that consistent drained weights could be achieved if processing and canning conditions were uniform. In commercial equipment similar uniform drained weights were obtained when only a few cans were retorted but when larger numbers of cans were processed there were large variations in drained weight throughout the baskets. There appeared to be no consistent pattern with different retorts, for instance, in some retorts cans at the top of the basket had low drained weights while in other retorts, of apparent similar design, cans at the bottom of the basket consistently had the lower drained weights.

Temperature studies using commercial retorts

The initial trials used the standard packing procedure where cans were layed on their sides, packed end to end across the basket, with the pattern replicated in subsequent layers up the basket. Probes were inserted between the layers of cans across the basket so that a pattern of heating thoughout the basket could be followed. The temperatures reached throughout the basket, together with the retort temperature, against time. The retort temperature is the upper line and indicated retort temperature was reached in 16 min, corresponding with the electronic controller measurement, the pressure gauge, the mercury in glass and the independent chart recorder. In this case temperatures were lowest at the centre of the basket between layers 4/5 and 5/6. It is clear from these results that although the normal external measurements indicated process temperature was reached at 16 min and constant throughout the process, temperatures between cans were far from uniform. The process called for the cans to be exposed to saturated steam at retort temperature for the duration of the process. It was clear cans at the centre and top of the basket were not exposed to retort temperature even at the end of the cycle and would therefore be grossly underprocessed while cans at the bottom of the basket were exposed to temperatures higher than the retort temperature for a large part of the process.

In this retort there were twin steam spreaders below the basket positioned below the second can from the edge of the basket. There were 3 rows of jets in the spreader, with the central one facing upwards and the other two rows approximately 20°C from the centre of the pipe to either side of the central row. The steam in this case was therefore directed at the bottom layer of cans which experienced the highest temperatures and had the lowest drained weights.

In another retort there was a single steam spreader at the bottom of the retort with jets on opposite sides of the spreader resulting in the steam moving horizontally from the steam spreader. The heating characteristics for this retort are completely different. The slowest heating point was then at the bottom of the basket (1/2), although some cans at the bottom were in the steam path and heated rapidly. Cans near the top of the basket (5/6) were subjected to much higher temperatures than were indicated on the external instruments (and confirmed by adjacent thermocouples). In this case the retort contained 2 baskets of cans, one stacked with a space between cans at the centre of the retort (SB) and one basket without the space (PB). There was little difference in the temperature patterns in the two baskets under the same heating conditions. In comparison of the heating patterns with the two steam spreader designs it is apparent that small modifications can have a dramatic effect on steam distributions and hence on temperature patterns.

It would appear from this comparison that in the first case the steam was being forced up through the basket, while in the second it was mainly bypassing the basket and rising to the top of the retort.

Returning to the initial retort, the can configuration was altered in order to allow steam to pass through the basket. Cans were stood on end with different configurations. The most even temperature distribution was achieved with the open stacking configuration, allowing the steam to pass up the vents between the cans. Again the lowest temperatures were observed at the top of the basket. With this stacking arrangement water collected on the tops of the cans in the cooling cycle and it was difficult to dry the cans. Also the stacking arrangement was very susceptible to operator error and cans tended to move when the baskets were wheeled to the retorts, upsetting the arrangement.

In order to open the basket up for the free movement of steam through the cans and allow draining of the water, cans were laid on their sides and rigid steel mesh was placed between layers of cans. Again relatively uniform temperatures between cans resulted, with the upper layers being marginally slower to reach temperature.

The expectation was that as temperatures between cans were uniform throughout the process then heating of the cans would be even and drained weights would be uniform. However, substantial drained weight variation persisted.

Heating rates of abalone in cans in commercial retorts: Since the drained weight of abalone meat had been found to be dependent on the F_o of the process it had received it was decided to measure the F_o of abalone in cans throughout the basket. Temperatures between cans were uniform throughout the basket once retort temperature was reached, however, the rates of heating of the abalone were greatly different, with the abalone in the bottom layer heating much faster than abalone in the middle and top layers of cans. During the cooling cycle, since cooling was effected by a top water spray and submersion from the bottom, the top cans cooled quickest.

It was found that by manipulating the come up cycle it was possible to bring the heating curves of the abalone in the different layers together. Improvement in uniformity of heating was reflected in the uniformity of the F_o values and the drained weights. Table 1 shows a progression in improvement in uniformity of F_o and yield as the come up cycle was modified. In Trial 1 a 24 min come up cycle was used, while in subsequent trials the come up cycle was maintained at 15 min with manipulation of temperatures and venting within that time frame. In all cases temperatures adjacent to the cans were uniform during most of the come up cycle and all the process cycle of the cook but F_o's for that process varied greatly, depending on the operation of the come up cycle. Thus although cans were experiencing the same time-temperature treatment their F_o values were markedly different. The easy explanation is that the probes were not all placed at the centre of the abalone but abalone were checked after each trial to confirm correct positioning of the probes. In addition drained weights corresponded with the F_o patterns.

These trials created a number of dilemmas. Firstly, after the retort had reached process temperature and pressure (as indicated by the standard thermometer and pressure gauge) temperatures greatly in excess of retort temperature were measured adjacent to cans. How could this occur? Text books say that in pressure heating with saturated steam the applicable equation relating pressure and temperature is $PV = RT$ where V (the retort volume) and R (the gas constant) are constant therefore the temperature is proportional to the retort pressure, and hence standard tables of pressure versus temperature are applicable.

Since the pressure gauge is constant once the retort has reached process temperature one could argue in the sealed retort pressure must be equal, however, this argument is fallacious. Examination of the steam valve at the start of the process cycle will show that it is fully open and there is a great deal of steam rushing into the retort at this stage of the cycle (an idea of the volume of steam flow can be assessed by opening the steam valve the same distance with the door of the retort open).

Table 1: Progression in improvement in uniformity of F_o and yield

	1	2	3	4	5
Process F_o (min)					
Top	2.01	1.48	2.04	2.07	2.48
Middle	2.87	1.98	1.67	2.44	2.42
Bottom	3.45	2.41	2.40	2.41	2.69
Drained Weight*					
Top	76.4%	80.0%	75.6%	75.9%	205g
Middle	73.3%	77.0%	77.5%	73.6%	213g
Bottom	72.1%	77.6%	75.4%	73.9%	211g

* Drained weight expressed as a percentage of fill weight for trails 1 to 4 and as a drained weight obtained from a constant fill weight in trial 5.

If there is a flow of steam there has to be a pressure difference to create the flow, with a corresponding temperature difference.

Higher temperatures are observed near cans adjacent to ports in the steam spreader. If steam at pressure is impinged on cans then the temperature of that steam becomes the temperature to which that particular can is exposed, not the temperature shown by the standard thermometer.

Secondly, if conditions are set up in the retort so that temperatures between cans in the basket are uniform, how can the F_o's be so different? With correctly designed steam spreaders, if we study the patterns of F_o it is apparent that those cans closest to the steam inlet have highest F_o values and those furthest from the steam inlet have the lowest F_o values. If we close the retort after loading the baskets of cans and only open the steam inlet and the vent it will be fairly apparent that the steam is not passing out the vent. In fact, the flow from the vent is very low until some time after opening the steam valve. During this time steam is striking cold cans and condensing. In condensing it is dropping its latent heat at the point of condensation. Condensation of 1 g of steam deposits approximately 540 calories of heat on the can in converting from steam to water with no change in temperature, while the 1 gram of water formed only supplies 1 calorie per gram for each 1°C fall in temperature after the steam condenses. Steam condensation therefore results in very intense point of contact heating. In condensing, the steam reduces in volume dramatically, for example, that 1 gram of steam would have occupied approximately 1.4 L but only 1 mL as condensed water, a 1400 times reduction in volume. Thus, in condensing, more steam is drawn to that point and steam will not pass that point until such time as the point is up to steam temperature and no more condensation occurs. Cans above that point are only exposed to moist air at steam temperature, which has very low rates of heat transfer, resulting in very low rates of heating of those cans.

Let us now look at heat requirements to bring the first layer of cans up to steam temperature. Abalone is packed as intact abalone meat in approximately an equal weight of brine. There are 1 to 3 pieces of meat per can, depending on the size of the abalone being packed. A comparison of heating rates of brine in a can and large solids in a can under identical heating conditions shows that liquids, with free convection (as in the case of brine in an abalone can), heat at about the same rate as the retort, with approximately a 2°C lag at the cold spot, whereas the cold spot in a solid product may hardly have started heating when the retort is up to process temperature. Thus, where a can is exposed to steam the liquid very rapidly reaches steam temperature. Free liquid in the can therefore acts as a large heat sink, utilising available steam until the liquid is up to steam temperature. The free liquid in the can bathes the surface of the abalone in the can but the rate of heat absorption by the solids is via conductive heating and the rate of heating is much slower, resulting in a much lower heat sink effect. Once the brine in the first layer of cans the steam contacts reaches steam temperature, the surface of the abalone in those cans is bathed by brine at steam temperature and heating of the abalone is optimal, only being restricted by the rate of conductive heating through the solid meat. It is only once these conditions are set up that steam can move to the next layer of cans. Hence, there is a range of times taken to bring abalone in cans at different positions to temperature, resulting in a range of heat treatments given to the abalone and a range of F_o values observed throughout the basket, despite cans being exposed to environments of similar temperature.

CONCLUSIONS

Canning in batch retorts requires a great deal of care in can stacking and retort design to obtain uniform temperatures between cans. Even with uniform temperatures between cans the rate of heating is not dependent on the temperature the cans are exposed to but rather on the exposure of the cans to steam. Since steam is consumed in heating the cans steam consumption and supply rates must be carefully controlled in a batch retort to obtain uniform steam treatments.

Understanding these phenomena does not solve the commercial problem of drained weight variation (nor of F_o variation, which in itself presents an extreme safety risk if minimum F_o's are below 2.4 min) due to underprocessing and the survival of spores of *Clostridium botulinum*, which produces a lethal toxin. However, an understanding of the causes of drained weight variation allows one to manipulate the process so that the constraints imposed by nature do not restrict the canner from achieving his goal. There are many constraints to take into account in redesigning the equipment and process to achieve uniform drained weights and F_o's but there is inadequate time to cover these. Suffice to say, uniform drained weights and F_o's can be achieved, thereby optimising yield while maintaining throughputs and safety as shown in Table 1 trial 5.

STORAGE CONDITIONS
Effect on the protein content of the Northern shrimp

By Iciar Martinez and Kristin Lauritzsen[1]

Abstract

In spite of being amongst the fastest perishable foodstuffs, the post-mortem changes in muscles of crustaceans have not been studied in as much detail as those of other marine species. This work characterises the changes that occur after death in the muscles of *Pandalus borealis* and the influence of the storage conditions.

The muscle proteins of some newly killed shrimps were extracted with water, a low-salt and a high-salt containing buffer successively. The remaining animals were divided into two groups: (a) stored in seawater at about 2-4°C (to simulate natural conditions); OR (b) stored on ice.

After 4, 12, 28 and 53 h, the muscles were submitted to the same three-step extraction procedure mentioned above. The changes that occurred in the protein patterns of the extracts were visualised by sodium dodecyl sulphate-polyacrylamide-gel electrophoresis (SDS-PAGE) and immuno-blotting using an antibody to the myosin heavy chain of the Arctic charr.

Storage in seawater increased the spoilage rate in all three extracts: the composition of muscle extracts obtained after 12, 28 and 53 h of ice storage was comparable to that of seawater-stored shrimp muscles after 4, 12 and 28 h respectively. Shrimps stored in seawater looked rather appealing up to the 12 h sampling and acceptable after 28 h. At the 53 h sampling, the seawater was turbid and the characteristic malodour of rotting shellfish was strongly noticeable. Shrimps stored on ice looked drier than those in seawater and therefore less appealing after the first 12 h. They did not, however, develop manifest malodour even after 53 h of storage. In both cases, one of the most evident effects of aging was the decrease in the relative amount of the 200 kDa band following SDA-PAGE identified as the myosin heavy chain. A concomitant increase in the number and intensity of bands of molecular size slightly superior to 94 kDa, crossreacting with the antibody anti-myosin heavy chain was also noted. Another prominent feature was the disappearance of a 67 kDa band which has not yet been identified.

These results support the general attitude towards "dead" shellfish and confirm that shrimps are dead at the time they are taken out of the seawater (to be submitted either to ice storage, freezing or cooking), should be rejected. They also indicate that preservation of shrimps on ice better maintains the integrity of the muscle proteins than storage in seawater, and should therefore be the recommended method for storage immediately after capture.

Keywords: Shrimp; *Pandalus borealis;* Muscle; Post-mortem; Storage; Protein content.

INTRODUCTION

Pandalus borealis is a valuable fishery resource for Norway. In 1995 38,800 t were caught and that constituted 1.54% of the total landings (Anon. 1996a). Its value at landing, however, was 9.34% of the total. The export value of *P. borealis* for the same year was 877m Norwegian Kroner (4.4% of the total), although shrimp products were only 1% of the total volume (including cultured species) of exported seafood products (Anon. 1996b). A small amount of the landings are caught off the Norwegian coast, but the main bulk comes from the Barents Sea and around Spitsbergen. It is therefore extremely important for this high-price fishery to obtain a better knowledge of the early changes occurring in shrimp muscle that can affect their quality and price at landing.

Flick and Lovell (1972) reported that ATP, ADP, AMP and IMP decreased with post-mortem time in the muscle of the brown shrimp, while the pH value increased from 7.4 to 8.2 after 10 days of ice storage. In the same species, Lightner (1973) observed the

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development of a rigor-like stiffening of the abdominal musculature whose time of appearance and duration was temperature-dependent: at 30°C it appeared 2 h post-mortem and disappeared by 12 h. The same work showed that the hepatopancreas was the first structure to undergo autolytic degradation, while muscle and connective and cuticular tissues were the most resistant (Lightner 1973). Muscle texture degradation and development of mushiness started in the proximal section of the tail in freshwater prawns stored whole which has been attributed to the proteolytic and collagenolytic enzymes released from the hepatopancreas upon disintegration (Baranowski *et al.* 1984; Nip *et al.* 1985). Nip and Moy (1988) showed the gradual disintegration of the perimysium, endomysium and eventually, the separation of muscle fibres with the corresponding changes in the microstructure of the myofilaments, including the disappearance of sarcoplasma and the myofilament structure in the H-zone during ice storage.

The ionic strength of the muscle has also been shown to influence the deterioration of texture in freshwater prawns (Papadopoulos *et al.* 1989) and beef (Wu & Smith 1987). Elevated ionic strengths (0.3M KCl) *in vitro* increased the solubilization of myofibrillar proteins in iced stored freshwater prawns (Papadopoulos *et al.* 1989), especially in prawns stored whole, and proteolysis was shown by SDS-polyacrylamide gel electrophoresis by the appearance of a series of protein bands in the 65 kDa to 180 kDa molecular size range.

Astier *et al.* (1991) studied the changes in fish myofibrillar proteins affected by proteolysis during the post-mortem process. The alterations started to occur during the rigor mortis and, as in shrimps, they were temperature dependent and more pronounced in the high ionic strength extracts. The changes included proteolysis of myosin, nebulin and of the Z-line proteins, leading to protein degradation or delocalization. In the same work, titin and a-actinin seemed to be resistant to proteolysis (Astier *et al.* 1991).

Yu and Lee (1986) found a relationship between the pH of the muscles and the post-mortem structural changes. With high pH values, there was extensive degradation of the Z-line, whereas in muscle with low pH the myosin heavy chain and structures of the M-line were preferentially affected (Yu & Lee 1986). A difference to fish, the post-mortem pH value in shrimp muscles seems to be high, as reported by Flick and Lovell (1972) in the brown shrimp (from 7.4 to 8.2 after 10 days of ice storage) and by Viggoson (1988) in the Northern shrimp, who found pH values between 7.1-7.7.

Due to the lack of work documenting post-mortem changes in the muscle of *P. borealis* and the importance of this resource, the present work was undertaken.

MATERIALS & METHODS

Animal samples

Pandalus borealis (carapace length 15 mm, 2-3 developmental stage), had been caught off Tromsø in October and kept alive in tanks with seawater until the time beginning of the experiment. At zero time, the abdominal cuticle of six individuals were removed and a piece of the abdominal muscle was cut, as shown in Figure 1 and extracted. Twenty individuals were put into a glass bottle containing seawater, sealed and kept in a cold room at 4°C. Other twenty were stored in ice on a net (to allow draining of water from the melting ice) in a cold room at about 10°C. In addition, one individual was left in seawater at 10°C for 12 h and extracted as indicated below.

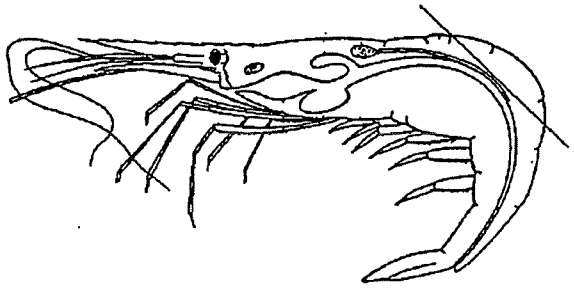

Figure 1: Schematic representation of *Pandalus borealis* showing the area where the samples were taken.

Extraction of muscle proteins

At zero time and after 4 h, 12 h, 28 h and 53 h of storage, the muscles of three individuals from each group were extracted as follows. The whole procedure was carried out on ice. The shell was removed and about 100 mg of the dorsal muscle were excised and finely minced in an Eppendorf tube with 500 µL of double distilled H_2O. The contents were stirred for 10 min, and after a centrifugation for 5 min at 14,000 rpm the water extracts were transferred to new tubes, an equal volume of ice-cold 100% glycerol was added and the samples were stored at -20°C. The pH was measured in the three first sampling times by spotting a drop of the water extract, prior to the addition of glycerol, onto pH indicator paper. For the extractions of the two last storage times, the indicator paper was cut in small pieces and one piece was completely immersed into the extract.

The low- and high-salt soluble extracts were obtained following the protocol described by d'Albis *et al.* (1986). To the pellets left in the tubes after the water extraction, 500 µL of a low salt solution (20 mM NaCl, 5 mM sodium phosphate, 1 mM EGTA, 15 mM $MgCl_2$, 5 mM dithiothreitol and 200 mM phenylmethylsulfonyl fluoride, pH 6.5) were added. The contents were stirred for 10 min, centrifuged for

5 min at 14,000 rpm, the extracts were transferred to new tubes and an equal volume of ice-cold 100% glycerol was added. To these new pellets, 500 µL of a high-salt solution (100 mM sodium pyrophosphate, 5 mM EGTA, 15 mM $MgCl_2$, 5 mM dithiothreitol and 200 mM phenylmethylsulfonyl fluoride, pH 8.5) were added. The contents were again stirred for 10 min, centrifuged for 5 min at 14,000 rpm, the extracts transferred to new tubes and an equal volume of ice-cold 100% glycerol was added. All the extracts were stored at -20°C until analysis.

The protein content in the extracts was estimated by their optical density (an OD of 1 is equivalent to 1 mg/mL of protein). The samples were diluted to 200 mg/mL protein in SDS-polyacrylamide gel electrophoresis sample buffer (10% glycerol, 5% 2-mercaptoethanol, 2.3% SDS, 62.5 mM Tris-HCl, pH 6.8) (Laemmli 1970) and frozen stored.

To the insoluble pellets, 500 µL of SDS-polyacrylamide gel electrophoresis sample buffer were added, the contents were stirred for 10 mins, centrifuged, and the supernatants stored at -20°C for electrophoretic analysis.

SDS-Polyacrylamide gel electrophoresis

Five microlitres of the diluted extracts, containing about 1 mg protein, were loaded into the wells of 14x16cm, 0.5 mm thick slab gels containing 15% acrylamide and 0.087% piperazine di-acrylamide (Anderson *et al.* 1973; Hochstrasser *et al.* 1988). SDS-polyacrylamide gel electrophoresis was performed according to Laemmli (1970) at a constant intensity of 20mA per slab for about 3 h. The gels were silver stained (Ansorge 1983). The analyses were made on each individual shrimp as well as on pools of each treatment group for each time.

Immunoblotting

The protein content of the extracts was separated as described above but with the BioRad mini slab gels (7 x 8 cm, 0.5 mm thick) at constant 150V for 1 h. The proteins were transferred onto nitrocellulose according to Towbin *et al.* (1979) using the BioRad mini transfer unit at 100V for 50 min. The nitrocellulose sheets were blocked with phosphate buffer saline (PBS) containing 0.5% powdered skimmed milk for 1 h. The blots were incubated for 1h in about 5 mg/mL of primary antibody anti-Arctic charr fast skeletal myosin heavy chain Martinez and Pettersen (1992). Two polyclonal antisera were used. The antisera were produced as described in (Martinez & Pettersen 1992). One was anti-myosin heavy chain from the white muscle of 2-year-old Arctic charrs and the other anti-myosin heavy chain of skeletal muscle from newly hatched Arctic charr. Secondary antibody was peroxidase labelled goat anti-rabbit IgG (Sigma) and 3,3'-diaminobenzidine was used as substrate.

RESULTS

The pH value of the muscle water extracts increased only slightly during the first 4 h after death (pH about 6.5) and did not seem to vary until after 12 h, subsequently showing a continuous increase up to a pH value of approximately 7.8 (Figure 2a). Since the first three values were measured by spotting a drop onto indicator paper, they are probably more inaccurate than the last two. The pH of the water extracts did not seem to be significantly affected by the method of storage, and only after 28 h did shrimps stored in seawater display a slightly higher pH than ice stored shrimps.

The amount of protein in the water-soluble fraction was independent of the storage method and showed a continuous decrease with time from 20 mg/mL at zero time to 9.5 mg/mL after 53 h of storage (Figure 2b). The protein contents in the low- and high-salt extracts of shrimps stored in seawater were in general higher than in the extracts from ice-stored shrimps (Figures 2c and 2d). In both fractions, the protein contents decreased with storage time except after 12 h and 53 h of storage. After 12 h, the low-salt extract of seawater stored and the high-salt extract of ice-stored shrimps showed a plateau (Figure 2c), while the low-salt extract of ice-stored and the high-salt extract of seawater-stored shrimps showed an increase (Figure 2d). After 53 h of storage, the protein contents in the low-salt extracts of both ice- and seawater-stored shrimps increased slightly as well as in the high-salt extracts of ice-stored shrimps, although in the last case the increase was bigger (Figure 2d).

The water- and low-salt soluble extracts presented very similar protein composition, except for the presence of two bands corresponding to the myosin heavy chain in the low-salt extract and a band of unknown origin and molecular mass slightly higher than 94 kDa present only in the water extract of iced stored shrimps for 28 h and 53 h. The low-salt soluble extracts of shrimps stored in seawater contained proportionally more myosin heavy chain than those ice stored.

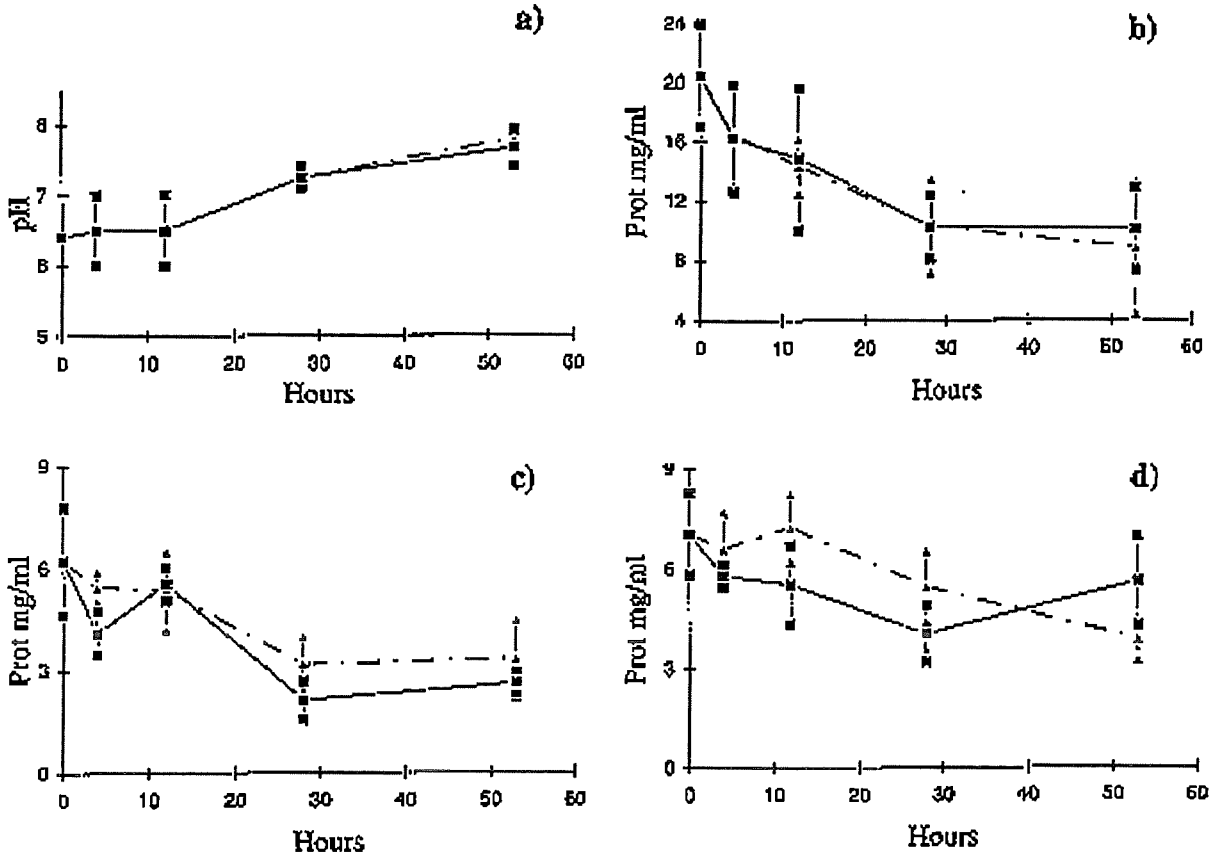

Figure 2: pH value and protein contents (mg/ml) in extracts of shrimp muscle stored on ice (solid line) and seawater (broken line). **a)** pH value in the water extract. **b)** Protein content in water extracts. **c)** low-salt extracts. **d)** high-salt extracts. Hours are hours after death. Indicated values are average + standard deviation.

Two closely migrating protein bands of about 67 kDa, present at the time of death in all the fractions (water-, low-salt and high-salt soluble and in the pellet) progressively disappeared with increasing storage time. Both bands disappeared more rapidly from shrimps stored in seawater than from ice-stored shrimps, and the upper band of the two disappeared faster than the lower band.

The faster migrating 67 kDa band was clearly noticeable in extracts of shrimps stored in ice for 12 h and weak in the same extracts after 28 h of storage, but it was hardly noticeable in extracts of seawater stored shrimps for 12 h and absent after 28 h. A protein band of about 50 kDa, was present in very low levels at zero time in all extracts. Its amount in the water and high-salt soluble extracts increased during the first 12 h of ice storage and decreased later on, but it disappeared faster from seawater stored shrimps. It was still clearly noticeable after 28 h of ice-storage, but not in seawater-stored shrimps after the same time. Concomitantly with the disappearance of this band, another band was first noticeable in the water and high-salt soluble extracts after 12h of storage. It reached a maximum at 28 h and decreased in the 53 h extracts. Extracts from seawater-stored shrimps were similar to ice-stored ones, but they were about 16 h "older". Other changes were the progressive disappearance of protein from the high-salt extracts and the appearance of small size fragments after 53 h of storage.

A series of bands of molecular size about 100 kDa were present in all the high-salt soluble extracts and in the insoluble pellets even in newly killed shrimps. They gave a positive reaction with the two anti-myosin antisera although the reactivities were different. These bands may represent fragments of the myosin heavy chain and/or paramyosin. They seemed to be more intense in samples in which the myosin heavy chain band was weaker.

The immunoblots confirmed that the myosin molecule of "fresh" or newly killed *P. borealis* can be solubilized by the low-salt containing buffer of pH 6.5 used in this work. After 1 day at 10°C, however, only fragments of low molecular size remained.

DISCUSSION

Rigor mortis is the stiffening of muscles that occurs after death. The main cause of rigor mortis is the disappearance of ATP from the muscle (Amlacher 1961), together with high levels of Ca^{2+} in the cytosol

due to the inability of the sarcoplasmic reticulum ATPase to sequester it (Stryer 1981). This phenomenon is very easy to record in animals with exposed musculature, such as vertebrates, but it is difficult to notice in animals whose muscles are protected by a hard exoskeleton, as crustaceans. Lightner (1973) observed the development of a rigor-like stiffening in the brown shrimp. As in any other species, the time of onset of the rigidity and its duration was temperature-dependent, occurring earlier at higher than at lower temperatures. After death, the glycolytic metabolism continues but, due to the lack of oxygen, glycogen metabolizes only to lactic acid, which accumulates in the muscle causing a decrease in pH value (Love 1979). The post-mortem pH values of the muscle reported here (pH 6.5 to 7.9) are within the range (pH 7.1-7.7) reported by Viggoson (1988) for *P. borealis*, and slighter lower than the values (pH 7.4-8.2) for the tropical shrimp *Panaeus aztecus* (Flick & Lovell 1972). The post-mortem pH is usually higher in shrimp than in fish muscle, which seldom reach values over 7.0 (Dunasjsk, 1979; Martinez *et al.* 1991; Rustad 1992) during rigor. In addition, neither this work, nor the other two works on shrimp muscle, noticed a drop in the pH value. The pH closer to neutrality at the time of death and only increased afterwards. The pH therefore does not seem to be a parameter which can be used to indicate rigor-mortis in shrimps.

During rigor-mortis as well, the solubility of the myofibrillar proteins is usually low and increases after its resolution (Martinez *et al.* 1987). The fact that the high-salt soluble proteins measured after 4 h had a lower value than at the time of death, may indicate that they were in rigor at this time, while the increased solubility registered at 12 h may manifest that rigor had already started to resolve. This result contrasts with that of the tropical shrimp *Panaeus aztecus* which took 24 h to go into rigor at 10°C and after 72 h was still in rigor (Lightner 1973).

The water and low-salt soluble extracts showed almost identical protein composition regardless of storage conditions. As shown for several fish species (Astier *et al.* 1991; Stefansson & Hultin 1994; Wu *et al.* 1991), the myosin heavy chain could be solubilized by water and low-salt buffers. In the present work, the low-salt solution was more efficient to extract myosin than water alone. In most of the extracts, there were two bands corresponding to myosin heavy chain. Our work does not clarify whether they represent different isoforms (Sakurai *et al.* 1996) or one main form and one degradation fragment. The other unidentified proteins also seem to be subject to proteolysis during cold storage, as indicated by the disappearance of the high molecular size band concomitant with the increase of the lower band which also disappears with time.

The high-salt extract showed the same composition than the insoluble pellet. In all the samples, there were a series of bands of molecular size approximately between 80 kDa and 100 kDa that can be either proteolytic fragments of the myosin heavy chain or paramyosin. Paramyosin is a rod-shaped α-helical molecule that forms the central core of the thick filament in most invertebrate muscles (Bullard *et al.* 1973; Cohen *et al.* 1971; Schmitz *et al.* 1994), including crustaceans (Maroto *et al.* 1995; Mykles 1985; Sakurai *et al.* 1996). In crustaceans, its molecular size may be 105 kDa, 110 kDa or 130 kDa, depending on the isoform (Maroto *et al.* 1995; Sakurai *et al.* 1996). In the worm *Caenorhabditis elegans,* two of the regions in the paramyosin molecule important for assembly have been reported to be homologous to regions of the myosin heavy chain (Hoppe & Waterson 1996). Therefore, cross-reactivity with anti-myosin chain antibodies is a possibility. However, the great abundance of these bands, together with the simultaneous decrease in intensity of the myosin heavy chain band, suggests that they are mainly degradation fragments of the myosin heavy chain. Papadopoulos *et al.* (1989) reported as well the appearance and increase with storage time of fragments of the same molecular size (68 kDa to 180 kDa) found in this work, and they also attributed it to increased solubilization and degradation of myofibrillar proteins.

Ca^{2+}-activated proteases are known to exist in crustacean muscle (Beyette *et al.* 1993; Mykles & Skinner 1986) some of which, in addition, specifically degrade myofibrillar proteins (Mykles & Skinner 1982). These proteases are usually active within the pH range measured in the water extracts. Since both the low-and high-salt extracts contained 1mM and 5 mM EGTA respectively, which inhibits the Ca^{2+}-activated proteases (Astier *et al.* 1991; Mykles & Skinner 1982), it is likely that most of the degradation observed in the zero time samples occurred during the 10 min necessary to carry out the water extraction. The hepatopancreas and digestive tract of crustaceans is very rich in proteolytic and collagenolytic enzymes (Gates & Travis 1969; Kimoto *et al.* 1983; Klimova *et al.* 1990; Tsai *et al.* 1986). Therefore, the extent of proteolytic degradation may have been due to contamination from intestinal contents and digestive enzymes, since the area used for sampling was very close to this organ. It cannot be explained by assuming the shrimps were preparing to undergo molting, since the sampling took place in October and molting occurs in the spring. An alternative explanation is that the muscles of crustaceans are rich in both Ca^{2+}-dependent (Beyette *et al.* 1993; Mykles & Skinner 1982, 1986) and independent (Doke & Ninjoor 1987; Mykles 1989a, 1989b; Sherekar *et al.* 1986, 1991) proteolytic enzymes, and being those enzymes naturally adapted to the low Arctic temperatures, proteolytic degradation can take place at

a faster rate during cold storage of Arctic species than during cold storage of temperate or tropical species. The same would apply to their associated bacterial flora. The size of the shrimps may also have influenced their susceptibility to degradation: the different isoforms of myofibrillar proteins, in particular myosin, expressed in different tissues (Li & Mykles 1990; Mykles 1985) and during ontogenesis (Costello & Govind 1984; Martinez *et al.* 1991), have different susceptibilities to proteases and in addition, smaller animals have smaller skeletal muscle fibres and usually weaker collagen layers. Therefore, the small size of the shrimps may have accentuated their perishability.

Storage in seawater was at all times the most detrimental procedure. This can be explained by the higher temperature at which these shrimps were kept (4°C versus 0°C), by the activity of the bacteria carried by the shrimps and the seawater and by the effect of the salt contained in the seawater. The salt contained in the seawater may have induced an increase in the solubilization of the myofibrillar proteins already during the time of storage, thus the increased intensity of the myosin heavy chain band in the low-salt soluble fraction of these samples compared with the ice-stored. The effect of NaCl on the increased solubility and susceptibility to proteolysis of shrimp myofibrillar proteins has already been reported by Papadopoulos *et al.* (1989) and is confirmed in the present work.

In summary *P. borealis* seems to be a more perishable species than tropical shrimps, with a very high susceptibility to proteolytic degradation of myofibrillar proteins. Storage in seawater after death worsen their condition and decreased the shelflife in this species. It is therefore recommended to handle with extreme care *P. borealis* and store them in a cool and humid but not soaked environment, as soon as possible after capture.

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FISH AND SHELLFISH
Differentiation between frozen-thawed and unfrozen

By Morihiko Sakaguchi, Takashi Hirata[1], Changhu Xue[2] and Woo Jun Kim[3]

Abstract
Freezing is the most prevalent technique in the world used to minimise the change in seafood quality. During freezing, some organoleptically undetectable deteriorations occur so that consumers do not always recognise the raw materials as frozen-thawed or unfrozen. The Torrymeter has been proved to differentiate frozen-thawed from unfrozen fish fillets. It aids in the discrimination of frozen-thawed from unfrozen and aged fillets. The Torrymeter, however, was unable to discriminate shellfish meat such as oyster, spear and common squid and kuruma prawn. The chromameter which measures L*a*b*, allowed differentiation between frozen-thawed spear squid meat and unfrozen. An impedance analyzer which measures the peak frequency could also detect the difference in the squid meat when applied on gut side.

Keywords: Fish; Shellfish; Frozen-thawed; Unfrozen; Storage; Torrymeter; K-value; Yellowtail; *Seriola quinqueradiata*; Pacific saury; *Cololabis saira*; Spotted halibut; *Eopsetta grigorjewi*; Oyster; *Crassostrea gigas*; Spear squid; *Loligo loligo bleekeri*; Common squid; *Todarodes pacificus*; Kuruma prawn; *Penaeus japonicus*.

INTRODUCTION
Frozen storage is the method most commonly used to maintain the flavour and texture of seafood in palatable states for relatively long periods. Recent development of low-temperature storage and concurrent transportation has resulted in approximately 50% of seafoods being frozen. It is not always easy for consumers to distinguish frozen-thawed from unfrozen fish and shellfish using sensory techniques. Consumers thus require information of the materials whether they have been frozen-thawed or unfrozen in their history. The Fisheries Agency of the Japanese Government recently proposed some guidelines for fishery products. One guideline requires the materials to be labelled as frozen-thawed or unfrozen, especially for the following 4 species of fish and shellfish: saury, flatfish, prawn and squid.

The development of rapid and convenient methods for discriminating between frozen-thawed and unfrozen materials of fish and fishery products is required. Numerous papers describing this discrimination have been published so far on the visual observation of change in ocular turbidity and epidermal color and on the measurement of following items: myofibril protein hydrolysis, transparency and cell fragility of muscle, oxidation of lipids, decomposition products of trimethylamine oxide, various enzyme activities, flesh color, rupture of red blood cells, electric resistance (Konagaya 1979; Yuan *et al.* 1988; Kitamikado *et al.* 1988). There are some extreme difficulties for the differentiation of fillets and muscle pieces as well, which lack eyeball, skin and red blood cells. Many of the methods mentioned above involve complicated and time-consuming procedures. We describe here the method for differentiation of frozen-thawed from unfrozen fish and shellfish using Torrymeter, impedance analyzer and chromameter which measures L*a*b* value. The measurement using all these instruments, of course, is nondestructive.

Fish
The intelectron fish tester (Henning 1965) and its developed form, the Torrymeter (Jason *et al.* 1975) are known as instruments which measure the electrical properties of fish surfaces. Previously, freezing of fish was reported to produce a drastic change in the reading of both instruments and to result in an inability to obtain readings for relation

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to the freshness of frozen and thawed fish whatever the freshness before freezing (Cheyne 1975). This phenomenon is mainly attributed to the change in electrical properties of fish tissue structure, which is caused by the disruption of cell membrane upon freezing. In fact, the Torrymeter enabled the differentiation of frozen-thawed from unfrozen fillets of yellowtail *Seriola quinqueradiata* (Kim *et al.* 1987). The fillets frozen at -20°C showed much smaller Torrymeter reading (TMR) than those stored in ice (Table 1).

Table 1: Torrymeter reading (TMR) and K-value (KV) of frozen-thawed and unfrozen yellowtail fillets

Treatment	TMR ± SD	KV (%)
Unfrozen - (before the beginning of storage) (n=6)	10.8 ± 0.4	0.3
Unfrozen - (stored in ice - 18 h) (n=6)	11.2 ± 0.4	6.2
Frozen - (stored at -20°C - 18 h)* (n=6)	0	2.6
Unfrozen - (stored in ice - 18 days) (n=6)	0	54.0

* thawed in ice-water for 6 h
TMR±SD, mean±standard deviation of TMR (Kim *et al.* 1989)

A similar phenomenon was observed for Pacific saury (*Cololabis saira*) (Table 2) and shotted halibut (*Eopsetta grigorjewi*) (Table 3).

Table 2: Torrymeter reading (TMR) of frozen-thawed and unfrozen Pacific saury

Treatment	TMR ± SD
Pacific Saury	
Unfrozen - (before the beginning of storage) (n=12)	4.9 ± 0.7
Unfrozen - (stored in ice - 5 days) (n=6)	3.4 ± 0.5
Frozen-thawed - (stored at -20°C - 3 days and ice - 2 days) (n=6)	0.4 ± 0.7

Table 3: Torrymeter reading (TMR) of frozen-thawed and unfrozen spotted halibut

Treatment	TMR ± SD
Spotted Halibut	
Unfrozen - (before the beginning of storage) (n=12)	13.8 ± 0.6
Unfrozen - (stored in ice - 5 days) (n=6)	11.3 ± 1.0
Frozen-thawed - (stored at -20°C - 3 days and ice - 2 days) (n=6)	0.1 ± 0.3

When fillets of yellowtail were stored in ice, the TMR decreased gradually and reached approximately 0 on the 18th day (Figure 1).

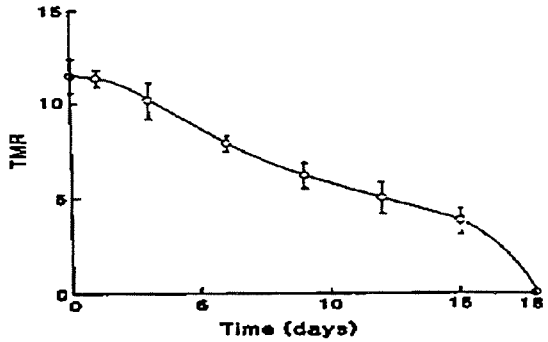

Figure 1: Change in Torrymeater readings (TMR) of yellowtail fillets during ice storage

These lines of evidence suggest that when given samples show lower TMRs, it is required to determine whether the lower readings are due to decreased freshness or to freezing. The freshness of samples was measured using an index of K-value (the proportion of hypoxanthine and inosine in the total amount of ATP and its degradation products). The K-value of the samples stored for 18 days in ice was more than 50%, indicating an unacceptability of the fillets.

In fact, the K-value of fillets increased gradually soon after the beginning of storage (Figure 2); the fillets (white muscle) became unacceptable on the 6th day when the value reached approximately 20% (Murata and Sakaguchi 1986).

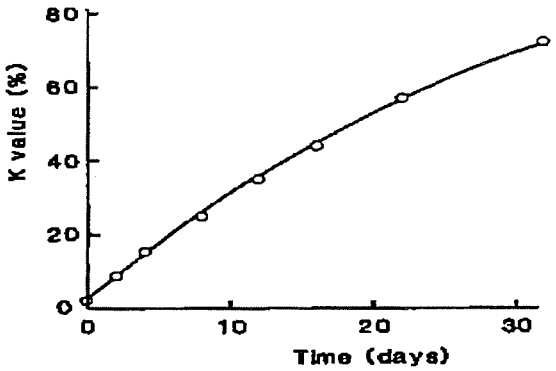

Figure 2: Change in K-value of yellowtail muscle (white muscle) during ice storage

The effect of freeze-thaw on TMR of fillets is different among fishes. Figure 3 shows the change in TMR of fillets which had undergone up to 3 freeze-thaw cycles during ice storage.

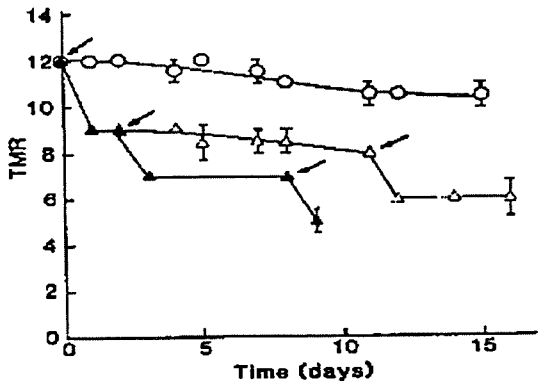

Figure 3: Changes in Torrymeter readings (TMR) of carp subjected to repeated freeze-thaw cycles during ice storage

The fillets subjected to repeated freeze-thaw cycles exhibited a decrease in TMR by about 3 units for the first cycle, followed by 2 units each for the second and third cycles (Sakaguchi *et al.* 1989). The decrement was much smaller than that of yellowtail fillets. One might thus suspect that there is a difficulty in differentiating the frozen-thawed from unfrozen fillets of carp. The differentiation can readily be made because the TMR of fillets without any cycle (unfrozen fillets) decreased very slowly so that the decrement was as low as approximately 1.0 unit even after 15 days in ice. The fillets stored for this period were completely unacceptable.

Partial freezing storage has been reported to prolong the shelf life of some fish and fishery products to a larger extent than ice storage (Uchiyama & Ehira 1986). The torrymeter was tested for the possibility of differentiating partially frozen from unfrozen fish fillets (Razavi-Shirazi *et at.* 1990). Table 4 shows the effects of partial freezing storage at -3°C for approximately 3 days on TMR of yellowtail fillets. The frozen fillets showed a 4-unit lower reading than the fresh fillets (Unfrozen I) and a 2-unit lower than the fillets stored unfrozen (Unfrozen II) for the same period. Little difference in TMR was observed from the unfrozen fillets of prolonged storage period and a significantly greater K-value (Unfrozen III). These lines of evidence suggest that the torrymeter alone is unable to differentiate the partially frozen from unfrozen fillets of yellowtail. The measurement of TMR in combination with K-value, therefore, enables one to discriminate between the frozen-thawed and unfrozen fillets. The K-value determination is generally made in destructive procedures but recently Kohashi *et al.* (1995) reported a rapid and nondestructive method for the measurement.

Table 4: Torrymeter reading (TMR) and K-value (KV) of partially frozen and unfrozen yellowtail fillets

Treatment	TMR ± SD	KV (%)
Unfrozen - (stored in ice - 18hrs)	11.5 ± 0.6	2.9 ± 0.9
Unfrozen - (stored in ice - 3 days and 3°C - 18hrs)	9.2 ± 0.5	14.4 ± 1.6
Unfrozen - (stored in ice - 3 days and 3°C - 18hrs and ice - 3 days)	7.4 ± 0.6	23.0 ± 1.3
Partially frozen - (stored -3°C - 3 days and thawed 3°C - 18hrs)	6.8 ± 0.5	12.3 ± 1.1

n = 5 (Razavi-Shirazi *et al.* 1990).

Shellfish

Shellfish such as molluscs and crustaceans include a large number of industrially important species.

Little information, however, is available on the differentiation of frozen-thawed from unfrozen shellfish samples. The Torrymeter, effective at differentiating frozen-thawed from unfrozen fish fillets, was applied to flesh of Pacific oyster, spear and common squid and kuruma prawn.

Table 5 shows TMRs of frozen-thawed and unfrozen meat of oyster (*Crassostrea gigas*). No significant difference in TMR was observed between them. Similarly, there was no difference in meat (mantle muscle) of spear squid (*Loligo loligo bleekeri*) and common squid (*Todarodes pacificus*).

Table 5: Torrymeter reading (TMR) of frozen-thawed and unfrozen oyster meat

Treatment	TMR ± SD
Unfrozen - (before the beginning of storage) (n=15)	8.6 ± 0.3
Unfrozen - (stored in ice - 6 days) (n=7)	7.9 ± 0.5
Frozen-thawed - (stored at -20°C - 3 days and ice - 3 days) (n=8)	9.3 ± 0.4

Table 6 shows TMRs of frozen-thawed and unfrozen meat (shucked meat) of kuruma prawn (*Penaeus japonicus*). There were also no significant difference observed between the prawn samples. These findings suggest that the Torrymeter is ineffective for such a purpose on all shellfish species tested.

Table 6: Torrymeter reading (TMR) of frozen-thawed and unfrozen kuruma prawn meat

Treatment	TMR ± SD
Unfrozen - (before the beginning of storage) (n=12)	10.3 ± 0.5
Unfrozen - (stored in ice - 5 days) (n=6)	7.8 ± 0.4
Frozen-thawed - (stored at -20°C - 3 days & ice - 2 days) (n=6)	9.3 ± 0.5

It is generally said that the surface of squid meat changes in color after freeze-thaw operation(s). Table 7 shows changes in L*a*b* value of frozen-thawed and unfrozen mantle of squid during ice storage.

The a* value rather the than b* and L* values changed more rapidly during storage. All of the a* values of the unfrozen sample from 5 days to the final day (7 days) were significantly low, compared with the frozen-thawed sample ($p<0.05$). It could be concluded that the color analysis differentiates frozen-thawed squid meat from unfrozen. On tuna meat, a similar color analysis has already been made by Chow *et al.* (1988).

Table 7: Torrymeter reading (TMR) of frozen-thawed and unfrozen squid meats

Treatment	TMR ± SD
Spear Squid	
Unfrozen - (before the beginning of storage) (n=6)	6.0 ± 0
Unfrozen - (stored in ice - 5 days) (n=3)	4.7 ± 0.6
Frozen-thawed - (stored at -20°C - 2 days & ice - 3 days) (n=3)	5.0 ± 0
Common Squid	
Unfrozen - (before the beginning of storage) (n=14)	4.0 ± 0
Unfrozen - (stored in ice - 5 days) (n=7)	3.0 ± 0
Frozen-thawed - (stored at -20°C - 2 days & ice - 3 days) (n=7)	3.7 ± 0.6

Impedance analysis performed on frozen-thawed and unfrozen flesh of spear squid indicated that peak frequency measured on the flesh of the gut side could be a good indicator (Sakaguchi *et al.* 1995). The frequency obtained for very fresh samples was approximately 2500 kHz, while the values for frozen-thawed and stored in ice (unfrozen) were both less than 1000 kHz, when measured on the flesh of the skin side. When measured on the flesh of the gut side, in contrast, the frozen-thawed samples had greater values of 500 to 1000 kHz (Figure 4), suggesting that the peak frequency measurement meets a requirement for the differentiation of squid muscle stored under different conditions.

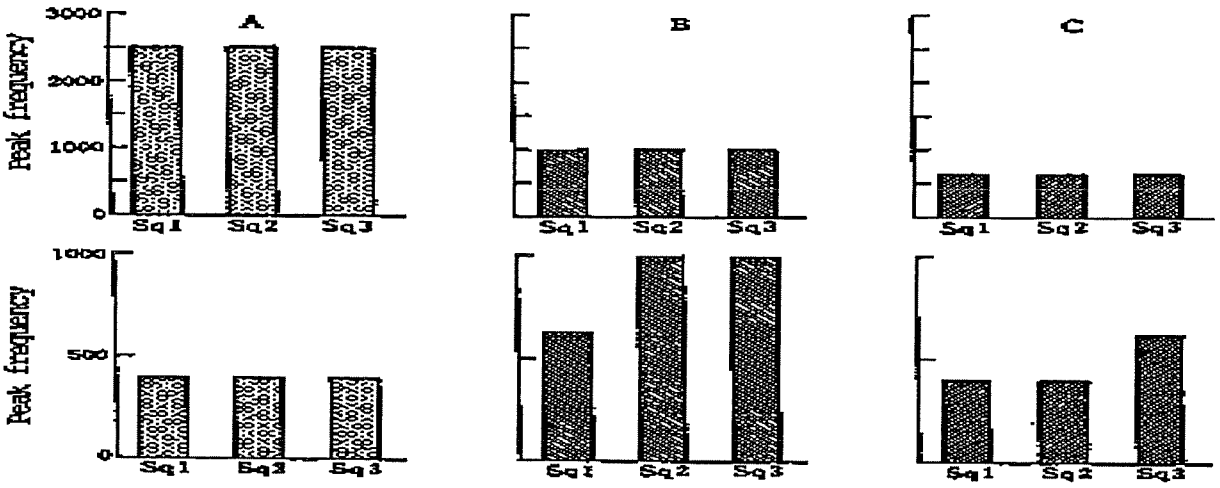

Figure 4: Peak frequency of frozen-thawed and unfrozen spear squid meat measured on skin top and gut bottom sides.

A = Fresh meat before the beginning of storage (upper - skin side; lower - gut side).
B = Aged meat stored at -20°C for 2 days & followed by ice for 3 days (upper - skin side; lower - gut side).
C = Aged meat stored in ice for 5 days (upper - skin side; lower - gut side).

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PRE-RIGOR FISH
Handling and processing

By Nils Sørensen, Jon Gardar Helgason and R. Brataas[1]

Abstract

Freshness is one of the most important parameters of fish quality in most markets. Fresh products often achieve a higher price based on a general attitude among consumers that "fresh is better". The availability of high quality chilled, fresh fish products is increasing as aquaculture and intermediate storage of live fish are gaining more importance in supplying the market.

For the processor, it is desirable to preserve freshness by starting production as early as possible after slaughter, in order to gain time for distribution. Usually, commercial processing of fillets is started after rigor mortis which often delays production for 2-4 days.

The onset of rigor mortis has implications for processing because handling or filleting fish pre-rigor or in-rigor can change the product properties and quality. Also when packing fresh, whole salmon it is important to work quickly to bleed, gut and ice the fish in boxes before rigor mortis starts. We will discuss how poor handling of salmon in rigor mortis can result in bruising and gaping of the flesh.

It may be of interest to extend the pre-rigor period or avoid the onset of rigor, and thus have more time for handling, packaging or processing. Rigor mortis is dependent on the fish species, temperature of pre-rigor storage, handling before slaughter, slaughtering stress and the biological status of the fish. Two methods for assessing the development of rigor mortis are discussed. Use of deflecting index and measurement of fillet length can give some information on the rigor state, but the fish-to-fish variation and the variation between the fillets of fish are high.

In this paper, we have focused on how storage temperature influences the onset and strength of rigor mortis. Effects of frozen storage, salting and smoking fillets from very fresh fish have also been examined.

Keywords: Pre-rigor; Rigor mortis; Storage temperatures; Quality; Processing; Handling.

INTRODUCTION

Fresh products often achieve a higher price based on a general attitude among consumers that "fresh is better". For the processor of fresh, chilled products, it is desirable to preserve freshness by starting production as early as possible after slaughter, in order to gain time for distribution. For the Norwegian fish industry, it is an objective to increase the production of processed products, based on demands from the market, in order to improve profitability. Chilled products are a priority area in this respect. They command understanding of processes related to the onset and resolution of rigor mortis in fish.

The interest in high quality fish products, fresh or lightly preserved, is increasing in many markets. Our experiment shows that slightly different approaches in processing may result in large differences in the quality and yield of the finished product. This is observed by salting cod fillets for up to 3 h in saturated brine, preparing a lightly salted product (ca. 3% NaCl(w/w)) suitable for the kitchen. The differences are smaller when salting Atlantic salmon, being a fatty fish.

Handling and processing before rigor mortis

Processors have found that handling salmon in rigor mortis can result in bruising and gaping of the flesh. Therefore packing fresh, whole salmon must be done rapidly in order to bleed, gut and ice the fish before onset of rigor mortis. Filleting fish while in-rigor is difficult, both by hand and machines, often resulting in reduced yield. Removal of pin-bones which is important in salmon fillets, is also very difficult until 2-3 days after slaughter.

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It is of interest to extend the pre-rigor period or avoid the onset of rigor, and thus have more time for handling, packaging and preferably processing. Rigor mortis is dependent on the fish species, temperature and handling before slaughter, slaughtering stress, the biological status of the fish and temperature of pre-rigor storage (Stroud 1969; Azam *et al.* 1989; Azam & Mackie 1990; Iwamoto *et al.* 1990a; Iwamoto *et al.* 1990b; Love & Haq 1970; Sørensen *et al.* 1995).

In Norway, the processing of pre-rigor fish is well known to the industry, when filleting saithe *(Pollachius virens)*. The factories often keep the fish alive in pens, being able to offer high freshness. The main products are iced, gutted fish for the fresh trade and frozen fillets in different sized blocks for frozen, breaded products.

When saithe is filleted pre-rigor, the frozen blocks may give problems when used for fried products, as the batter and breading can blow off. This is because the fish when heated, goes into rigor mortis and changes shape, and partly because trapped pockets of water give rise to "explosions" when fried in oil. These problems are the result of the fish being too fresh when processed.

This paper presents data from experiments assessing onset of rigor; strength of rigor and how the state of rigor effects salt uptake and texture of fresh and lightly salted fish fillets.

Measurement of rigor mortis

Onset of rigor mortis is caracterised by the whole fish becoming rigid, due to contractions of the muscles. Different methods for assessing aspects of rigor; onset, duration and strength of rigor mortis, can be proposed. Usually methods are related to the degree of rigidity of fish muscle in whole fish, measured as deflection. Also degree of contraction of fillets give information on the state of rigor mortis, as well as evaluation by special rigorometer (Korhonen *et al.* 1990).

Length reduction, whole fish

In theory it should be possible to assess onset and strength of rigor mortis by assessing changes in length of the fish. As long as the fish is whole, the fillets are attached to the backbone, giving small reductions in length. Oehlenschlaeger (1991) reported a reduction of 2.5% in length during storage of 30 cod on ice. Maximum shortening was reached after 12-24 h and further storage reduced the reduction to approximately 1.5%. The method relies heavily on careful measurements of fish length between exact points on the fish. Results presented in this paper for ice storage of cod and salmon gave much smaller reductions in length, no change for salmon, around 0.5% for cod at 9-11°C and 1.5% for saithe (*Pollachius virens*) after 4 days at 3-4°C.

- *Indexes*

In general methods with whole fish are based on the degree of bending the fish experiences when placed on the edge of a table. According to Cutting (1939) and revision by Bito *et al.* (1983) the rigor index is measured in relation to the deflection at the time of the first measurement. It depends on several measurements of the same fish and the time that the first measurement is recorded. A deflection index (DI) that use the degree of deflection in relation to the whole length when the fish is placed exactly half way outside the table have been proposed by Sørensen *et al.* (1995). By using a deflecting index the measure is independent of time. In Figure 1 results from (Sørensen *et al.* 1995) are given for DI, assessing the development of rigor mortis in Atlantic salmon at three different temperatures. The measurements are very dependent on individual fish. In addition, each measurement involves handling of the fish, which in itself can alter rigor development. An objective measurement should preferably involve very large numbers of fish and the measurement should be performed only once on each fish in order not to be biased by handling the fish. The deflecting index method thus gives very useful information on the development, strength and duration of rigor mortis.

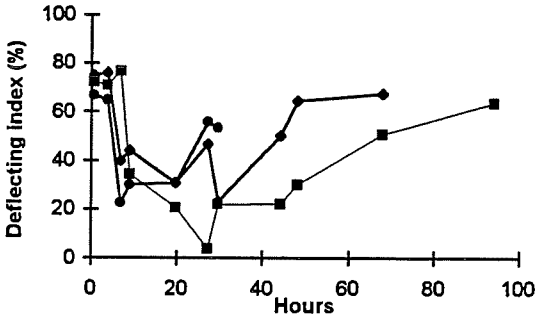

Figure 1: Deflecting index for whole Atlantic salmon during storage at different temperatures, 0°C in ice, 10°C and 20°C. Average of 10 fish at each temperature. (Sørensen *et al.* 1995)

DI values range from 100% for soft fish (either pre- or post-rigor) to 0% indicating high degree of rigor mortis as the fish is rigid.

Length reduction of fillets

A third possibility is to measure changes in length of individual fillets, i.e. cut from the backbone. These fillets do contract significantly due to onset of rigor mortis, the degree of contraction gives information about the process. The fillets should be cut immediately after slaughter. In Figure 2 from (Sørensen *et al.* 1995), the length of fillets were measured during storage at different

temperatures. Assessing contraction of fillets could be regarded as more objective since the fillets are left untouched while rigor lasts, but assessment must be made on a smooth surface, and the fillets must be protected from surface drying. The two latter methods indicate that onset of rigor is more rapid in fish stored at 20°C and it resolves more rapidly. Since the fillets were approximately 50 cm in length, 2% change involves only one cm fillet contraction, then definite conclusions are difficult to make.

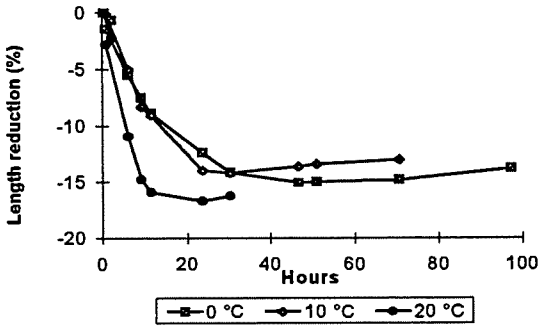

Figure 2: Reduction in length of single fillets of Atlantic salmon stored at different temperatures; 0°C, 10°C and 20°C, as a function of time, Each storage temperature represent an average of 10 fillets. (Sørensen *et al.* 1995)

MATERIALS AND METHODS

Atlantic salmon

Atlantic salmon were obtained from the aquaculture station in Kårvika near Tromsø. The fish had an average weight of approximately 3.5 kg. The salmon were killed by a blow to the head, bled for 20 minutes in a container with seawater, 8°C, before gutting and transport to Fiskeriforskning. 20 starved and 20 non-starved fish were stored in ice and at day 0, 1 ,4, 7 and 11 three fish were filleted and used to assess texture.

For the salting experiments, 45 Atlantic salmon, starved for two weeks, were obtained from a commercial plant near Tromsø. The average round weight was 4 kg. Fillets from 15 salmon were cut pre-rigor, 15 in-rigor and 15 post-rigor, to give a total of 90 fillets, skin on, divided into three groups. Each of the three groups of fillets were salted in saturated NaCl brine immediately after the respective times of filleting, i.e. 2 h, 1 day and 4 days in ice after slaughter. All fillets were salted for 1, 2 or 3 h at 0°C (in total 9 subgroups of 10 fillets each), to prepare a lightly salted product. The same procedure was used when salting cod fillets.

Atlantic cod

Fourteen (14) Atlantic cod were obtained from the aquaculture station in Kårvika near Tromsø, having been fed very small quantities of herring during 3 months. The fish was on average 3-5 kg, round weight. They were killed by a blow to the head and bled for 20 minutes in a container with seawater, 8°C.

For the salting experiments, 45 Atlantic cod were obtained from the aquaculture station in Kårvika near Tromsø where the fish had been kept for 5 months in a net pen. The fish were caught in the wild by Danish seine. The fish were fed whole, thawed herring *ad libitum* for the last period (2 months) before slaughter. They were killed by a blow to the head and bled for 20 minutes in a container with seawater, 8°C. The average round weight was 4- 6 kg.

Salt content

The salt content was measured (w/w-basis) according to Volhard's (1937 and 1949) method, in three separately homogneised fillets after each salting period.

Texture

Two groups of 3 Atlantic salmon, starved and non-starved, were sampled during storage in ice for 11 days, filleted and skinned. All pin-bones were removed before cutting into 6 cm wide, 20 cm long pieces from the thickest section of muscle. Texture was measured using a 20 kg weigh cell in a KGS Materials Testing Machine, texture analyzer, developed at Fiskeriforskning. A 72 mm wide, 1mm thick Warner Bratzler-type shear cell was used. 6 parallel samples from each of the three fillets were measured. A cell speed of 4.88 mm/sec was used and maximum shear force at failure was registered. The results are given as the average for the three fillets.

RESULTS

Evaluation of rigor mortis

Times for onset of rigor mortis were assessed by measuring changes in length of 5 whole Atlantic salmon at two temperatures, 0-3°C and 9-11°C, and of 8 Atlantic cod at 9-11°C, Figure 3. The results show very small changes in length of the fish and compared with the difficulties in measuring accurately, we can conclude that the length of whole cod or salmon changes marginally, 0 to 0.5%, during storage for one day. These results shows that assessment of rigor mortis can not be made by measuring changes in length of whole fish during duration of rigor mortis. Other measurements of saithe showed a change of 1.5% reduction when stored in ice for 4 days.

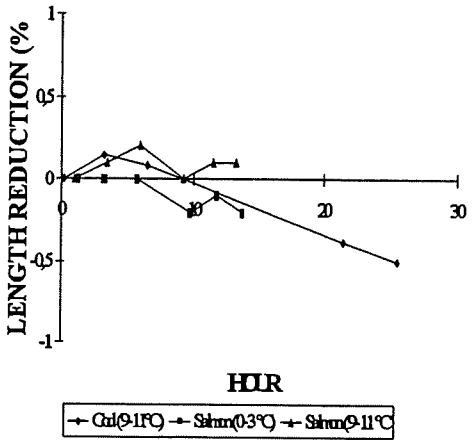

Figure 3: Average reduction in length of whole Atlantic cod (n=8) and Atlantic salmon (n=5) as function of time at different temperatures.

Assessing onset and strength of rigor mortis by measuring the reduction in length of fillets are possible, but results from individual fillets show that they behave quite differently, e.g. cod fillets in (see Figure 4).

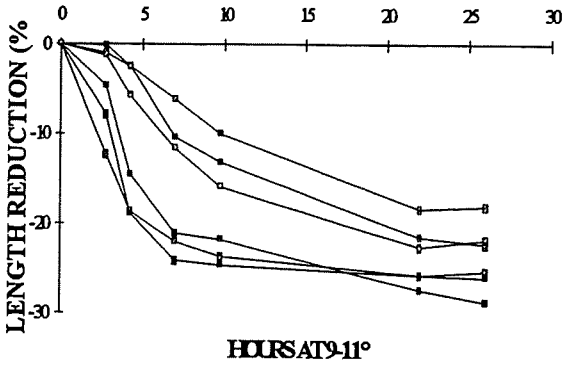

Figure 4: Reduction in length of six cod fillets stored at 9-11°C, as function of time after slaughter. Length reduction is given as percentage of original length.

Still, the development of rigor mortis seem to be smooth for each fillet, although resulting in high standard deviation when presented as averages, due to high individual variation. Maximum rigor is reached after one day storage, ranging from 18 to 28% contraction in fillet length. This is more than observed for salmon (around 15%) but maximum rigor occurs during the same period, 20-40 h after slaughter (see Figures 1, 2 and 4).

The reduction in length of the fillets gave a product with different characteristics of appearance, being more dull, opaque (i.e less shiny), than the normal post-rigor filleted product.

Rigor mortis - effects on texture

The texture, measured as maximum shear force at failure, on whole salmon fillets, had a distinct change from day of slaughter to day one. This fish was starved for two weeks. In the period when the fish was in-rigor to post-rigor only minor changes was measured in texture. The non-starved fish was low in texture from day of slaughter to day 11 in iced storage, having a slight increase during time (see Figure 5).

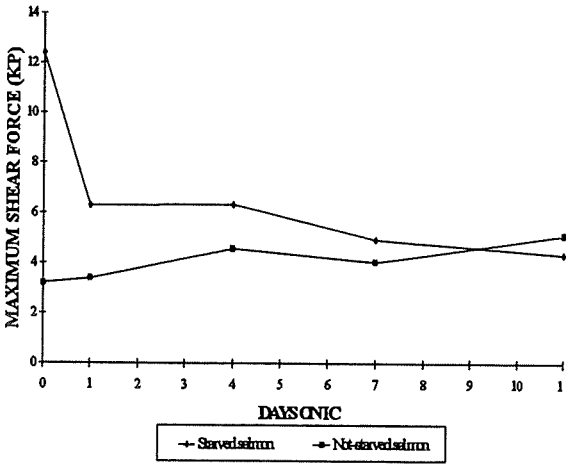

Figure 5: Texture measured as maximum shear force at failure. Results are presented as the mean from 3 fillets of Atlantic salmon, filleted on the day of sampling. Day 0; pre-rigor, day 1; in-rigor and day 4 onwards; post-rigor. Total storage time in ice was 11 days.

Salting

During salting for up to 3 h the salt content increased in all cod and salmon fillets (see Figure 6).

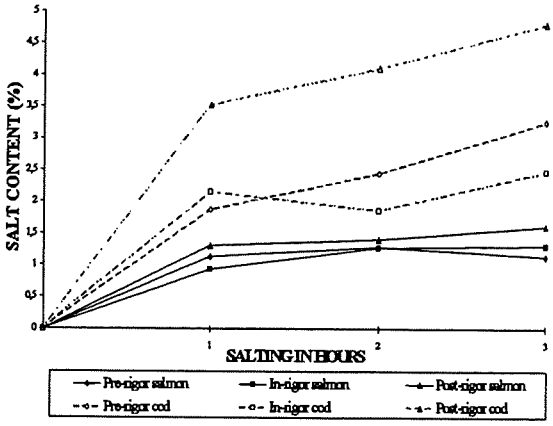

Figure 6: Average salt content in pre-rigor, in-rigor and post-rigor cod and salmon fillets after 1, 2 or 3 h salting in saturated brine

Between pre-rigor, in-rigor and post-rigor fillets of cod the differences in salt uptake was big, while for salmon fillets, reaching only 1% salt, minor differences were recorded. It takes less than 1 h to

reach a salt level of 3% in post-rigor cod fillets and approximately 3 h in pre-rigor fillets. The in-rigor fillets did not reach this level in 3 h. A salt content of 3-3.5% in the fillet (w/w-basis) is regarded suitable for poaching.

All pre-rigor salted fillets did enter rigor during the salting process and the appearance of the fillets changed from being smooth and shiny to having a rough and dry surface. The fillet thickness also increased significantly.

The pre-rigor cod fillets lost weight from the start of the salting process; 7% weight was lost after 3 h. The cod fillets cut while in-rigor and post-rigor, increased in weight during the 3 h salting period, by 3.4 and 4.5 % respectively (see Figure 7). The salmon fillets did not change much in weight during salting, although pre-rigor fillets showed a slight decrease.

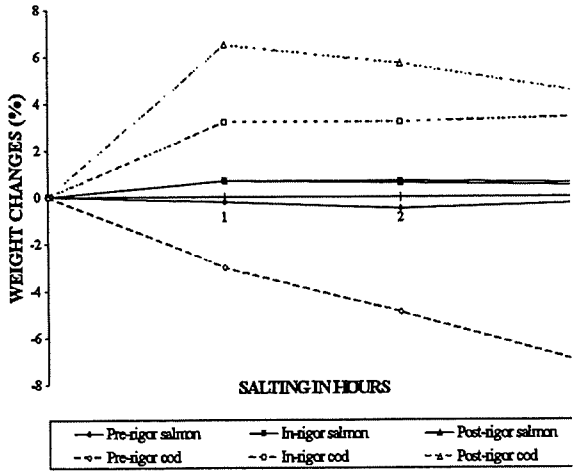

Figure 7: Average weight changes during salting for 1, 2 or 3 h of pre-rigor, in-rigor and post-rigor cod salmon fillets.

DISCUSSION

Commercial processing of fish must take the development of rigor mortis into consideration since it affects yield and fish flesh quality. Boxing of "live fish" should be done before onset of rigor mortis to avoid possibilities of flesh damage. Information is needed to advise the processor on which conditions that can influence onset and duration of rigor mortis. Temperature is one important parameter that can be manipulated. In preliminary experiments we have also found that chilling live salmon will influence both onset and length of the rigor mortis period.

When whole fish or fillets go into rigor, the appearance changes and different levels of shear force can be measured. The standard deviations are high, from 30% in the first measurements to 10% during storage period. The use of shear force as measure for texture can be questioned as itgives little information on elasticity. There is a need to develop objective methods for assessing fish texture.

The large differences between pre-rigor and post-rigor salting of the cod fillets are important findings for the processors when preparing salt cured products that are popular in the market. They must be aware the important relation between freshness and yield. The same results have been reported for full-salting of cod onboard vessels. A lower yield is obtained than for the salting ashore of fish that have been iced for 5-7 days. For these products also other attributes of quality; colour, discoloration and gaping, should be considered.

It is known from practical experience and our previous unpublished experiments, that pre-rigor and in-rigor fish absorb salt more slowly than post-rigor fish. A common explanation of the salting process is that salt is absorbed in the first stage and, at pH above the isoelectric point, the Cl-ions will neutralise positive ions, resulting in repulsion of the proteins. Water is absorbed and the weight increases, due to swelling of the muscle, (Honikel 1989; Offer & Trinick 1983).

The pre-rigor cod fillets in this experiment did not swell and they lost weight. This can be explained by water loss due to contractions squeezing water out when rigor mortis is triggered by salting in brine (Fennema 1990). As the fish is very fresh the cells are more intact and liquid is not easily absorbed into the cells by swelling. The practical result is that it is far more economical to salt a post-rigor fillet than a pre-rigor one, if a lightly salted fillet is the desired product. In this respect it is correct to say that optimal quality is more important than highest degree of freshness.

CONCLUSION

Knowledge of both onset and duration of rigor mortis is important when packaging and processing very fresh fish, either from intermediate storage, onboard factory ships or from aquaculture. Objective methods for assessing the development of rigor is not available. The experiments with deflecting index and contraction of fillets give some information but are hampered by the big individual variation between fishes. Measuring whole fish length is neither a relevant method.

The quality of a fillet that has been prepared pre-rigor, is different from a traditional post-rigor fillet, especially in appearance, colour, shape, texture and technological properties such as salt uptake. The yield of cod fillets are very different: post-rigor fillets increases 6% in weight to reach

3% salt (w/w-basis), while pre-rigor fillets lose 7% weight in 3 h to reach 3% salt in the fillet. A difference of 13% in yield is of great importance to the processor. Such differences were not achieved in a comparable experiment salting salmon fillets.

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LOW SALT KAMABOKO
Heated Fish Meat Paste

By Yasuo Makinodan [1]

Abstract

The addition of NaCl on *kamaboko* (heated fish meat paste) making is indispensable for giving elasticity and salty taste to the product. It is said that myofibrils are not dissolved adequately from muscular tissue when the amount of NaCl added is below 2.0% (final concentration in the paste) and elastic *kamaboko* cannot be prepared. In fact, *kamaboko* available in the markets contains about 2.5% NaCl.

On the other hand, taking NaCl in abundance is not good for human health. NaCl is ingested through various kinds of foods, so it is desirable to reduce the NaCl content if possible. From such standpoint, decreasing the amount of NaCl used in *kamaboko* making seems to be an important problem.

On decreasing the amount of NaCl used in *kamaboko* making, there are some reports that a part of NaCl can be substituted by $MgCl_2$ and so on. Moreover, recently it has been clarified that *kamaboko* with superior elasticity can be made when the fish (white croaker) meat paste is set (or preheated) at 40°C for 30 min before proper heating even if the amount of added NaCl is lowered to 1.5% (1.0% if salty taste is ignored).

Keywords: *Kamaboko;* Fish paste; Low-salt; Quality; Sodium Chloride; Magnesium Chloride

INTRODUCTION

Kamaboko or heated fish meat paste is prepared as follows: minced white-flesh fish meat is ground with a proper quantity of NaCl and other additives. The obtained fish meat paste is shaped, for instance on a board, and heated. The quality of kamaboko is collectively evaluated from external appearance, elasticity, and taste. Among them, the elasticity is the most important factor.

It is considered that the dissolution of myofibrillar proteins from fish meat is indispensable from kamaboko to have an elasticity. Previously Dyer *et al.* (1950) reported that the maximum extraction of soluble protein and myosin from cod muscle is obtained between 3 and 7% salt. In lower concentration than 3% the extracted amount decreases sharply. Shimizu (1961) pointed out that such salt solubility of fish protein is closely connected with the elasticity formation of kamaboko. The elasticity of kamaboko made from flying fish (*Prognichtyhs agoo)* was very weak below 2% NaCl concentration (almost final concentration) and was hardly formed in 1%. NaCl concentration of kamaboko on the market is about 2.5%, coinciding with his report.

At present a recognition fixes that it is undesirable for the human's health to take NaCl abundantly. We take NaCl daily from many kinds of foods, therefore it is desirable that the NaCl content of one food is moderate if possible. According to a recent inquiry in Japan (Anon 1995), people between 30 and 50 especially female, have a belief that kamaboko contains much NaCl. To promote the consumption of kamaboko under thus recognition, decreasing the NaCl content in kamaboko seems to be an important problem.

As already mentioned, there is a common acceptance that we can not make kamaboko if added NaCl content is below 2%, because myofibrillar proteins are not extracted from fish meat. Is this consensus right? The fact does not seem so. I will introduce two possible methods.

SUBSTITUTING ANOTHER SALT FOR A PART OF NaCl

One method is to substitute another salt like $MgCl_2$ for a part of NaCl. Fukuda *et al.* (1989) examined the effect of addition of NaCl and $MgCl_2$ on the gel formation of kamaboko using Alaska pollock (*Theragra chalcogramma*) as material. When only

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NaCl was added, the strength of kamaboko gel was maximum at the final concentration 2.0-2.7%, while $MgCl_2$ did not show such gel forming ability at any concentration. However, when a part of NaCl was substituted by $MgCl_2$, the strength of kamaboko gel containing 1.9% NaCl and 0.6% $MgCl_2$ increased about 16% compared with that of kamaboko containing 2.5% NaCl alone. The NaCl concentration of the kamaboko mentioned above is still about 2%, so it is difficult to regard this as the low salt kamaboko. However, the experiment seems to show the possibility that the low salt kamaboko can be prepared.

USING SETTING (OR PREHEATING)

Another method is the utilisation of so-called setting or preheating. Setting is to preheat fish meat paste at the temperature lower than 50°C before a real-heating at around 85°C. Setting is often used to increase the elasticity in the general kamaboko making. From the common sense that the low salt in kamaboko making is absurd, the technique combining a setting with a low salt have been hardly tried (Yamamoto 1983) seriously in our academic society.

We (Makinodan *et al.* 1996) examined whether the elasticity of the low salt kamaboko is reinforced by a setting, using white croaker (*Argyrosomus argentatus*) as material. When thinking of the low salt kamaboko, the final concentration of added NaCl is lower than 2%. But 1% NaCl seemed to be unsuitable for the white croaker kamaboko making, because the product hardly showed neither salty taste nor umami (or deliciousness). Therefore, we decided NaCl concentration 1.5% and at first investigated the effect of setting temperature on the reinforcement of the elasticity. The gel strength (breaking strength x breaking dent) of the kamaboko with setting at 30 to 50°C for 30 min was all strong compared with that heated directly at 90°C for 30 min, especially at 40°C.

Since a conspicuous setting effect was observed at 40°C, next we examined the effect of NaCl concentration on the setting at 40°C. When the amount of added NaCl was 1.5% and less, the gel strength of kamaboko without setting was surely weak and a kamaboko-like elasticity was not found organoleptically. However, the kamaboko with setting increased the elasticity remarkably, and the gel strength of kamaboko contained 1.5% NaCl became 3 times larger than that of control. Even in 1% NaCl addition, if the fish paste was preheated, the kamaboko produced showed an appreciable elasticity.

QUALITY OF LOW SALT KAMABOKO

Further, it is said that the quality of the elasticity of kamaboko depends upon the balance of a breaking strength and a breaking dent which makes the gel strength (Yamamoto 1986). Therefore, these factors of the low salt kamaboko and kamabokos on the market were compared. In the case of kamaboko without setting, the low salt products showed the very weak breaking strength, but when they were set at 40°C for 30 min their elastic quality became excellent. A similar setting effect is reported by Oka *et al.* (1992) on a fried kamaboko using lantern belly (*Acropama japonicum*) as a starting material.

When the texture of kamaboko containing 1% NaCl was observed on an electron microscope, in case of the kamaboko without setting, the dispersion of protein filaments or aggregates was coarse. It became crowded in the kamaboko with setting and the micrograph was similar to that of a high quality kamaboko on the market. It has been already clarified that the dispersion of protein filaments is crowded in a highly elastic kamaboko (Niwa 1984). Further, judging from this figure, the myofibrillar proteins seem to dissolve even in 1% NaCl, differing from the former report.

As above, at least when white croaker is used as the starting material, even if the amount of added NaCl is 1.5 or 1.0%, we can make a high quality kamaboko by using the setting at 40°C for 30 min.

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USE OF SEAFOOD PROCESSING AID

By Michael Morrissey [1] and Joe Regenstein[2]

Abstract

Seafood Processing Aid (SPA, Cottee Corp., Pymble, New South Wales, Australia) is a proprietary mix (approved by the U.S. Food and Drug Administration (US FDA)) and is a Generally Recognised as Safe (GRAS) food ingredient that has been formulated to provide seafood with similar benefits as polyphosphates. The product has been approved for use with seafood in Australia, Malaysia, New Zealand (although a specific request is required by each company for each application), the European Economic Community (EEC) (where the only labelling requirement is for the salt), and as a processing aid for shrimp peeling in the USA.

In this latter application, SPA has been shown to increase the yield from 24.7% for untreated shrimp to 29.9% with a 15 min dip and 30.4% with a 30 min dip. Phosphate treated shrimp gave a 32.4% post-peeling yield. Moisture content of the raw shrimp was 78.5% for the control, 79.5% for a 15 min SPA dip, and 79.6% for a 30 min dip. The pH of the control was 7.75 and the SPA treated shrimp were 7.85 and 7.80 for the 15 and 30 min dips, respectively. Thus, SPA increased processing yields without significantly increasing moisture or pH.

Current work is examining the potential impact of SPA on gadoid texture changes during frozen storage. Preliminary results suggest that SPA inhibits dimethylamine formation with a concomitant improvement in water retention properties.

Keywords: Seafood; Processing Aid; Shrimp; Crustacea; Finfish; Moisture.

INTRODUCTION

Seafood Processing Aid (SPA) is a proprietary salt mix that is used to assist in the peeling of crustacea in order to obtain optimum yield and minimize waste. SPA is also used with fish fillets for water retention and the prevention of degradative changes during frozen storage. All of the ingredients for this product have been submitted to the US FDA and each ingredient in the mixture has been accepted by FDA as GRAS (generally recognized as safe) when used in seafood processing. The letter to this effect is in the possession of Cottee Corporation. Approval for the use of SPA with seafood has also been obtained in Australia, New Zealand, Malayasia and the EEC.

SPA is being offerred as an alternative to polyphosphates in those situations where for legal or marketing purposes a company cannot or does not want to use polyphosphates. In many cases, for economic or technical reasons, a company may prefer polyphosphates. Both of our research groups have worked extensively with polyphosphate and consider them beneficial for seafood when properly used.

PEELING OF SHRIMP AND OTHER CRUSTACEA

During the processing and peeling of shrimp, particularly Pandalus species, it is observed that a significant amount of edible flesh remains attached to the shell after cooking and peeling. The existing process protocol does not allow for complete breakage of collagen between the meat surface and the shell.

As the impact of SPA in this application is on the connective tissue, a short review of collagen biochemistry may be helpful (Lampila *et al.* 1993), recognizing that much more detailed knowledge in this area has been generated by our conference host, Allan Bremner.

Connective tissue proteins are triple coils of high proline and hydroxyproline containing proteins. The content of stroma or collagen in fish muscle varies with species, and also with the particular muscle, age, season, the type of swimming the fish is doing, and nutritional status along with unexplained variability with a species between individual fish (Sato *et al.*

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1986). Unlike terrestrial animals, whose collagen becomes more highly cross-linked (mature and elastic) with age (Hultin 1983), fish and shellfish collagens seem to regenerate on an annual basis (Love *et al.* 1976) and remain comparatively immature.

The solubility of seafood collagen is generally greater than that of bovine and porcine collagen. In addition, the solubility of seafood collagens relates to the depth of the respective species' habitat. At greater depth and lower habitat temperature, the denaturation temperature of seafood collagens is lower than that of species harvested from warmer waters (Vivitsky 1978).

In addition to heat and enzymatic action, there are chemical means to increase the rupture of collagen. These include treatment with solutions that have either an acidic or basic pH. Acids would be unsuitable since they would likely denature surface protein and would cause an undesirable toughening of the flesh, and surface etching and discoloration. An alkaline pH, with the appropriate ingredient(s) (like SPA or polyphosphates), would break the collagen linkages while not adversely affecting sensory attributes. SPA or polyphosphates may also denature the surface proteins leading to case hardening of these proteins, preventing their loss by subsequent water leaching. Thus, the use of the appropriate additive, permits the efficient and economical use of mechanical peeling in place of hand peeling. Without the use of a processing aid, the yield with hand peeling is much higher than with mechanical peeling. However, with the use of a processing aid the yields become similar, although hand peeling still gives a higher yield.

One of the species for which experiments have been done using SPA is Pacific shrimp *(Pandalus jordani)*. The normal process is to use automated steam cooking and subsequent peeling by roller agitation and water jets. Logically, when heat denatured, the connective tissues (collagens) would be gelatinized to allow separation of the edible flesh from the shell. Without the use of a processing aid such as SPA or polyphosphates, aging of the Pacific shrimp is necessary prior to cooking and peeling to allow the enzymatic action that leads to rupture of the connective tissue.

Without the use of a processing aid, it can be observed that a significant amount of edible flesh remains attached to the shell after cooking and peeling. The existing process protocol did not allow for the complete breakage of collagen between the meat surface and the shell. Incomplete recovery of the meat during peeling resulted in reduced edible protein which is a major economic loss and at the same time increased the biochemical oxygen demand (BOD) of the processing waste water and of the shrimp shell waste which is environmentally undesirable.

The normal commercial practice for the processing of Northern shrimp is for the shrimp to be chilled at sea and then processed in a shore-side facility. When the chilled shrimp are brought to the plant, the first step is to de-ice them in water. Even when fresh shrimp are available and being processed, the first step is generally to soak or hold them in water or brine (salt). Thus, Na levels at the beginning of processing will generally be slightly higher than for unprocessed shrimp. Note: SPA contains Na, thus the interest in determining the changes in Na content with processing.

Due to the large amount of water used in mechanically peeling and in the subsequent washings, any residuals from SPA or polyphosphates will be washed away. After treatment with the processing aid, the Pacific shrimp are steam cooked for 90 to 110 second and mechanically peeled using friction or rollers (in the commercial experiments with SPA reported here a mechanical Laitrum Peeler was used) with large amounts of water. It has been estimated that up to four gallons of water are used per pound of Pacific shrimp. The cooked meat is water flumed (part of the washing process) to a final shell fragment culling station, followed by a forced air drying step and then hand inspected. The shrimp are then either salted or brine treated and packed for the fresh market or frozen (IQF), glazed with potable water and packaged. For shrimp peeling, no further treatment with SPA is applied after the steam cooking. Furthermore, all components of SPA are natural constituents of seafood tissues.

We have obtained data from what amounts to a worst case scenario which shows the increase of Na for shrimp soaked in SPA and then hand-peeled without any subsequent washing steps. The data suggest that the sodium level of the shell-off shrimp went from about 0.12% Na to about 0.22% Na, while the shell-on shrimp went from about 0.18% Na to 0.36% Na.

With respect to Na, the natural variation in shrimp as reported in Nettleton's "*Seafood Nutrition*" (1985) showed values ranging from 0.19% to 0.21%. A value for Australian shrimp prepared under the direction of the Australian Nutrition Committee of the National Health and Medical Research Council was 0.14% Na. The shell-off shrimp reported above fall within this range.

In addition, in many plants, as mentioned above, additional Na (salt) is added after processing or during the initial brine soak. Thus, SPA is generally a minor contributor to the final salt concentration in cooked processed shrimp. Other proprietary ingredients have been tested and confirm that SPA does not significantly increase the amount of any of the constituents naturally found in seafood.

One issue that is of particular interest to both processors and regulators is the moisture content of the cooked, peeled product. The data shows that the moisture content of the cooked SPA treated shrimp (80%) is below that of the raw shrimp (81%) and is very similar to that for cooked shrimp, either untreated or treated with polyphosphates.

A second set of experiments were run specifically to evaluate SPA in a commercial shrimp processing plant using staff from the OSU Seafood Laboratory. This experiment was done to test the applicability of SPA under commercial conditions. These results confirm the previous results AND provide additional data to support the benefits of SPA during peeling (see Table 1). In addition, the following observations were noted:

1. SPA is more soluble than polyphosphates. This simplifies the procedures in the plant, making it easier for the plant to maintain control of the process.

2. The plant people observed a "cleaner peeling" shrimp with SPA than with polyphosphate or no treatment (the positive and negative controls).

3. The data shows the effect of SPA for a number of parameters of interest (yield, pH, moisture, ash, Na, and protein). All of the data clearly suggest that SPA often leads to less change in these parameters then the already approved polyphosphate treatment. In no case did it lead to more change. The slightly lower yield than polyphosphate suggests that SPA will most likely only be used in those cases where polyphosphates are inappropriate.

4. Sodium levels did not increase significantly by the time the entire process was completed. The Na values range from 0.13% for the original material to 0.19% for the longer SPA treatment. These remain insignificant amounts of Na in a flesh food.

The heat treatment of cooking inactivates the proteins and therefore minimizes any affect of the added SPA on protein functionality of the finished product. The Pacific shrimp are not treated with SPA after the cooking and peeling operation.

FINFISH

All finfish, because of their high water content in comparison to red meats and poultry, tend to lose water during storage, particularly during frozen storage (i.e., on subsequent thawing) and during cooking. This often leads to a dry, tough product. To maintain the moistness of fish during frozen storage and during cooking, various additives, particularly polyphosphates, are used by the fish processing industry. Work by Applewhite *et al.* (1993, 1994) at the University of Florida has suggested that moisture retention in seafood (specifically shrimp and scallops) provides consumers with a more satisfactory product, i.e., they actually prefer products that have been treated with polyphosphate. For many consumers in the papers referred to above, the levels preferred were above the level approved by the FDA.

Gadoid fish, which includes cods, haddock, pollocks, whitings, hakes, and cusk, all undergo additional textural degradation beyond that common to all species during frozen storage because of the enzymatic production by trimethylamine demethylase of dimethylamine (DMA) and formaldehyde (FA) from trimethylamine oxide (TMAO). TMAO is found in many different species of marine fish and is believed to be involved in either osmo-regulation and/or protein confirmation maintenance in these fish (i.e., to counteract the influence of urea, a known denaturant).

Depending on the species of fish, the level of trimethylamine oxide and of trimethylamine demethylase activity will vary. The variation in enzyme level is due to inherent differences in enzyme levels in various tissues, or to differences in co-factor requirements and their presence in the fish. Processing, particularly mincing, is known to accelerate gadoid textural deterioration by bringing substrate and enzymes together. Kidney tissue, which may become a contaminant of minces, in particular, is a rich source of the enzyme, thus accelerating gadoid texture formation. In the laboratory, kidney tissue is often added to accelerate the "gadoid" texture change.

Gadoid texture change gives cooked fish a dry, tough, "cottony" mouthfeel that consumers find objectionable, thus limiting the length of frozen storage, particularly of minces. Storage below -30C is one way to minimize this problem. Unfortunately the cold chain in most countries does not support such a low distribution temperature for frozen products.

Table 1: Post-processing shrimp

Treatment	Yield (%)	Moisture (%)	Ash (%)	pH	Na (mg/g)
Untreated	24.7	78.5	1.1	7.75	1.3
Phosphate	32.4	80.8	1.1	7.87	1.8
SPA - 15min soak	29.9	79.5	1.1	7.85	1.8
SPA - 30min soak	30.5	79.6	1.2	7.80	1.9

Recently a large processor of Atlantic cod experienced difficulties in working with Pacific cod. Because of greater problems with gadoid texture changes in Pacific cod, in comparison to Atlantic cod, this species does not seem to be able to withstand double freezing (i.e., the process whereby fish are frozen in the round or headed and gutted at sea, thawed shore-side, processed into fillets and then refrozen) - a process which is now routinely used by many processors.

Preliminary research at Cornell (Muyonga & Regenstein 1996, unpublished) suggests that SPA may interfere with the TMAO to DMA and FA reaction. The SPA also helps maintain the water retention properties (Regenstein 1984) of fish. Table 2 shows some data concerning various concentrations of added SPA on expressible moisture (exudate under pressure). Notice that in the first 4 weeks of frozen storage the SPA had a beneficial effect that seems to be lost at about 8 weeks of accelerated frozen storage at -14C.

Table 2: Expressible moisture of cod mince

Treatment	Week 2	Week 4	Week 6
Untreated	51.2	56.2	52.9
0.25% SPA	49.8	52.7	50.0
0.5% SPA	44.3	47.4	42.6
1% SPA	35.4	40.4	47.5
2% SPA	36.8	36.2	48.6

The effect of SPA at 0.5% on some of the textural properties (Table 3) can also be explained by the assumption that in general lower values of these properties are desired.

Table 3: Effect of SPA-S on textural properties of Cod mince after 4 weeks

Characteristic	Control	0.5% SPA
Hardness 1 (Newton)	43.1	36.5
Hardness 2 (Newton)	39.6	30.5
Cohesiveness (work)	0.46	0.35
Gumminess (Newton)	19.7	12.9
Chewiness (Newton*mm)	58.5	29.3
Springiness (mm)	3.0	2.3

Fish technologists generally measure DMA production when trying to follow texture changes during frozen storage of gadoids. This suggests that a proper and systematic study of SPA in gadoids would be potentially beneficial to the fish processing industry.

All fresh fish suffer from rapid microbial breakdown. A few species, e.g., Pacific whiting, also suffer from rapid proteolysis of the flesh tissue due to the presence of a parasite in the flesh of many such fish. Thus, any food grade materials that can help with one or more of these product quality problems would be worthy of further exploration. The interaction of SPA with these proteases, particularly if SPA is beneficial with respect to gadoid texture, needs to be understood.

Preliminary observations of fish fillets injected or dipped with SPA indicates that this new processing aid may offer additional benefits, such as preventing gadoid texture changes. These results also indicate that it would be worthwhile to examine whether this material can provide various benefits to the fish processing industry and to consumers by further exploring the four areas discussed above, i.e., prevention of gadoid texture, antimicrobial activity, protease inhibition, and antioxidant effects.

Note: The standard method for following gadoid texture change is to measure DMA production. This amounts to a measure of the FA produced, as these are produced in equal amounts in the breakdown reaction. However, the major texture changes that occur in fish with gadoid texture problems, occurs after the FA formation, i.e., by reaction of the FA with the appropriate protein sites. Circumstances could be found where DMA production is not reduced, but the food additive functions by interfering with the later stages of texture change. Thus, simply measuring DMA without also looking at the functional/textural/sensory properties of the fish may be insufficient.

Other underutilized fish are often fatty fish where rancidity problems can limit their marketabiliity. Fatty fish whether fresh or frozen, tend to suffer primarily from rancidity, i.e., fat oxidation. Oxidation, in addition to causing a flavor defect, can also lead to negative texture changes. Thus, the use of antioxidants can benefit the shelf-life of these materials. Work on mackeral and menhaden at the Cornell laboratory has demonstrated that the water soluble anti-oxidants ascorbic acid (Vitamin C) and isoascorbic acid (erythorbic acid) are beneficial in preventing lipid oxidation in these species. Other water soluble or fat soluble antioxidants tested did not work as well.

The role of SPA both as an anti-oxidant in its own right and/or its interaction with more traditional antioxidants (both water and fat soluble) will need to be investigated before SPA can be routinely used with fatty fish. Work being planned will begin to study this process.

As part of any new ingredient treatment for fish (or other foods), it is important to determine what effect the material might have on the microbial population of the product. Thus, this fourth component of the proposed research also needs to be looked at. various commercially important species, including but not limited to gadoid and fatty fish need to be examined as part of this phase of the work.

Thus, we believe that SPA may offer some important benefits to the fishing industry. Preliminary work in a limited number of plants around the world suggest that SPA will have a number of applications, providing a means to improve the quality of seafood for consumers.

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QUALITY ASSURANCE
In the Victorian seafood industry

By Karen Campbell[1]

Abstract

Victorian fisheries developed a draft Seafood Value Adding and Quality Assurance Strategy during 1995, in an attempt to improve the handling, storage and transporting of Victoria's fish resources. The Strategy involves the Department of Natural Resources and Environment working together with the Victorian Fishing Industry Federation to implement the recommendations, which mainly deal with Quality Assurance, including Hazard Analysis Criteria Control Point (HACCP) quality practices and Codes of Practice.

A system of Fish Retail Awards for businesses which achieved high standards in fish retailing, is now to be replaced with a retail sector quality assurance audit program.

The paper describes progress with the implementation of the new Strategy, which has been welcomed by the industry.

Keywords: Seafood; Quality Assurance; Victoria; Strategies; Value-adding; Markets

INTRODUCTION

Although the oceans are vast, it is well documented that global fish production has now reached its limit and increases in wild catches are not expected. With an increasing demand for seafood, how do we 'make the most' of what we harvest from the ocean?

The Victorian government and industry have a joint responsibility to make the most of Victoria's fisheries resources. Recognising the need for government to be active in supporting initiatives which improve fish handling practices and maximise the value of the resource, Victorian Fisheries has released a 'Seafood Value-Adding and Quality Assurance Strategy'.

The Strategy, developed in conjunction with industry, focuses on raising the quality of product from local industry through establishing codes of practice and quality assurance programs. The Strategy also identifies opportunities for value-adding and developing market identities for particular species of Victorian fish.

BACKGROUND OF THE VICTORIAN FISHING INDUSTRY

The Victorian fishing industry has approximately 1900 licensed fishers and crew on a fleet of over 1000 Victorian registered fishing vessels, over 100 licensed processing businesses and an estimated 3000 retail outlets. Service industries that support the fishing industry employ a significant but unknown number of Victorians.

The seafood market is characterised by low volumes of a diverse range of species. The Melbourne Wholesale Fish Market dominates the handling of fish for domestic sales, while processors export the high value products such as abalone, rock lobster, scallops and giant crabs.

THE SHOPFRONT - THE FISH RETAILERS

Victorian Fisheries, together with the Victorian Fishing Industry Federation and the Melbourne Wholesale Fish Market, introduced Victorian Fish Retail Awards a number of years ago. The awards aimed to recognise good fish retailers and motivate other retailers to improve standards. Retailers were awarded for overall excellence in seafood, shop presentation and customer relations.

The awards were well received but did not achieve the outcomes wanted. Improvements in standards were limited to very few retailers. Year after year the same high standard retailers worked hard to win an award, whilst the retailers with lower standards continued to operate at the same level. The incentives for these retailers to improve were not there, or perhaps higher standards were seen to be beyond their reach. Something had to be done.

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The Victorian Fish Retail Awards were not held in 1995. Instead industry, with the support of the government, began work on developing an accreditation system for fish retailers.

A working party comprising government and industry representatives and a consumer representative (after all, it is the consumer that must be satisfied) was formed. At the first meeting, the group looked at why an accreditation system for fish retailers was needed. The group suggested that an accreditation system would help:

- raise the self esteem of fish retailers;
- give fish retailers confidence in the product they sell and their industry;
- provide incentive for retailers to demonstrate quality and strive for best practice (not minimum standards);
- increase product and quality knowledge;
- foster quality across the industry;
- give consumers confidence that fish is a high quality product.

It is significant that currently there are no guidelines or training requirements for anyone wishing to enter the fish retail business. It was suggested that any guidelines developed needed to be precise and place the onus on the retailer to meet requirements. Also, a system without a monitoring mechanism was of little use. For such reasons it was agreed that the core of the system would be a quality assurance program based on a HACCP (Hazard Analysis Critical Control Point) system.

HACCP is a preventative quality control system which aims to control hazards at all stages of food production. The key responsibility for the system is on those who produce and distribute the product. They are supported by government authorities who have an advisory and auditing role (rather than the traditional regulatory role).

The auditors for a fish retail accreditation program in Victoria will most probably be Environmental Health Officers (EHOs). The EHO will assess the applicant and decide whether to recommend accreditation. Under this system the onus will be on the retailer to perform, rather than the EHO to catch him or her doing the wrong thing.

An outline of how an accreditation system might work has now been developed although there are still several questions to answer. What will happen to the retailers who are not accredited? What fee should retailers pay to the State Accreditation Committee, for training and the assessment service? What happens if the retailer sells the shop? Will an accreditation system reach the goal of industry self-regulation? It is intended that a pilot system be trialed in Victoria in 1997.

The working party are looking further than Victoria and recognise that the ideal would be to develop a system that could be adopted and adapted by each State. Ideally a customer could travel anywhere in Australia and be confident of the quality of the seafood they purchase. No longer would customers ask "Is this fish fresh?", a question that many retailers are often asked by customers.

While developing our proposal, we 'shopped' around. To our surprise we found there is a lot happening in the area of quality assurance for retailers - the Meat and Allied Trades Federation of Australia have developed a "Shop with Confidence" program for butchers and the National Food Authority and the Department of Human Services are working with a number of delicatessen owners to introduce HACCP practices in their businesses. The Victorian Fishing Industry Training Committee has already developed a HACCP program for fish retailers. This program would be suitable for improving retail standards.

So much is happening in the area of quality assurance. Perhaps we need a good map to show all the programs being developed to ensure some co-ordination, and a compass to make sure we all travel in the same direction. The challenge is to develop and implement an accreditation system that is simple yet effective and can be easily implemented by small businesses as well as the larger retailers.

Recommendation of the Strategy

Replace the current fish retail awards with a retail sector quality assurance program which can be audited and approved by local Environmental Health Officers.

But fish retailers are of course near the end of the story. What about the rest of the market chain?

THE BEGINNING - THE HARVESTERS

The Strategy discusses a number of issues that highlight the need for a quality assurance program and codes of practice amongst the harvesters.

- In the South East Fishery many tonnes of the catch can be harvested in one shot - fish often lie on the deck for some time, exposed to the weather, before being sorted, gutted and refrigerated.

- Squid are delicate fish that perish quickly in poor conditions. When caught as a trawl by-catch, they are often treated as any other fish and, as a result, most of the squid found in the domestic market are of poor quality.

- Shark fishers are usually away for more than a week. Nets are not always hauled as frequently as they should be, leading to possible damage of the catch from deterioration and sea lice.

- At the Market, it is common to see fish from ports distant to Melbourne being far superior in quality to fish only hours old from Port Phillip Bay and Westernport. This is usually due to poor handling methods combined with lack of refrigeration or ice.

- Scallop fishers have a reputation for delivering mixed quality produce to processors and it is common to see dead shellfish mixed in with fresher catches.

It would seem that most damage occurs to fish after capture. For the best return, fish must be handled in a manner that gives the fish retailer sufficient time to limit the risk of deterioration and wastage.

The Strategy also discusses the advantages of packaging fish for the market. Bins containing fish should be labelled so that fish caught on different days are not sold together. If the port of landing, correct marketing name and identity of the fisher are included, this information could be used later by the retailer (or perhaps restaurateur) for marketing purposes.

Recommendation of the Strategy

- To develop and implement HACCP quality practices and approved codes of practice for all major Victorian fisheries (Bay and Inlet fisheries, Scallops, Rock Lobster, Abalone, South East Trawl Scale fish and the Cephalopods). These would include targeting:
  - minimising damage to fish as a result of fishing methods
  - handling and storage of fish on board the boat
  - method of packaging the fish for the market
  - labelling bins or crates of fish
  - method of storage between the boat and market.

THE NEXT STEP - THE PROCESSORS

Approximately one third of processing establishments in Victoria are modern and designed to produce export product. These operate with quality assurance programs required by the Australian Quarantine Inspection Service (AQIS). However, those that produce local product are not required to maintain standards administered by a single authority and the standards vary dramatically.

In Victoria's most valuable fishery, the abalone fishery, there is a growing shift away from canning and freezing to live export. AQIS standards in place for export abalone product could be adopted by domestic abalone processors.

Eighty percent of scallops and Southern Rock Lobster are exported with the balance being sold on the domestic market. As with abalone, AQIS standards that apply to exporters could be adopted by domestic processors of scallop and Southern Rock Lobster.

In 1994, AQIS implemented Food Processing Accreditation (FPA) to replace traditional inspection. The FPA audited quality system is based on HACCP.

Recommendation of the Strategy

- Introduce a quality assurance audit program for domestic fish processors similar to the program in place under the Victorian Meat Industry Act 1994 and the AQIS standards for export processors.

DEVELOPING A MARKETING IDENTITY FOR THE CATCH

Consumers may have a preference for local seafood and should be informed if the food product they are purchasing is Australian. Shark landed in Victoria is largely destined for the Victorian fish and chip trade. However, fish and chip proprietors are increasingly using imported shark products such as South African shark and black tip shark from Northern Australia. A marketing identity needs to be developed for Victorian flake so consumers can make an informed choice when buying seafood.

King Island cheese is known as a quality product produced in a clean environment. A similar identity could be attached to fish harvested in a geographical area according to a recognised quality assurance program. Victoria's bays and inlets are managed according to ecologically sustainable development principals and produce some of the best quality table fish available. Under this scheme a marketing logo or brand could be developed for fish harvested in Corner Inlet for example.

In the absence of legislation, non compliance with codes of practice could lead to loss of accreditation and withdrawal of permission to use the marketing logo or brand. The logo or brand would have to be heavily promoted for this to be effective.

Recommendation of the Strategy

- To develop marketing identities and brands for specific Victorian fish, including an accreditation scheme so that approved persons can be issued with a licence to market their catch with the registered brand.

NEW MARKETS AND VALUE-ADDING OPPORTUNITIES

In Victoria, the majority of value-adding takes place in restaurants and take-away food outlets. Much more could happen at the processor level. Australia exports few processed seafood products. The Australian product is often processed by the importing country.

Australia imports millions of dollars worth of squid products from all over the world. There is a great opportunity for value-adding and expanding this fishery. It is also worth investigating methods of using damaged product unsuitable for the live market such as Southern Rock Lobster.

Industry should be the ones to undertake research and development while Victorian Fisheries should provide support and foster relationships between the sectors.

Recommendations of the Strategy

- Investigate opportunities for developing new markets for species such as the squid fishery, for shark by-products and by-catch species.
- Investigate opportunities for value adding for scallops and Southern Rock Lobster.

PROGRESS WITH THE STRATEGY

Victorian Fisheries has recently joined forces with Agriculture Victoria. Both organisations now operate under the Department of Natural Resources and Environment (DNRE).

Agriculture Victoria has played a role in developing quality assurance programs for the meat industry. Through this experience, Agriculture Victoria has found the program to be effective with the government:

- developing and documenting quality assurance procedures;
- providing technical input including written information;
- training and assessing auditors;
- assisting with initial education and quality assurance training for industry staff.

Industry was responsible for:

- program co-ordination;
- providing ongoing education for industry staff;
- ongoing review of standards and codes of practice.

With this model in mind, industry should be the driving force for implementing the 'Seafood Value-Adding and Quality Assurance Strategy', with Victorian Fisheries providing strong support. Quality assurance programs and codes of practice will only be successful if industry accepts that change is necessary and drives the change itself.

The recommendations of the Strategy are extensive. Other recommendations such as assisting the aquaculture industry to investigate value-adding opportunities and developing a quality assurance program for wholesalers have not been discussed. However, we have already started at one end of the chain, and as discussed earlier, are developing an accreditation system for fish retailers. If all goes according to plan, we are well on the way to running a pilot program for this system in Victoria in 1997.

The next stage for implementation of other parts of the Strategy will involve setting up a working group that is convened by industry. The working group will probably consist of representatives from the Victorian Fishing Industry Federation, Food Victoria, the Department of Small Business, the Melbourne Wholesale Fish Market, Victorian Fisheries, Agriculture Victoria and Environmental Health Officers. The working group will oversee the implementation of the Strategy.

The fishing industry and the Victorian government have an enormous challenge ahead. With fewer resources and an increasing demand for seafood, we all have an obligation 'to make the most of the catch'. This is not an easy task but through reducing wasteful practices, implementing quality assurance programs and codes of practice and seizing value-adding and marketing opportunities, we will ensure customers receive a high quality product with a Victorian identity and will continue to do so well into the next seafood-loving generation.

GOVERNMENT FOOD INSPECTION SERVICES

Do they have any value?

By John Sumner[1]

Abstract

Government inspection systems thrive in only two sectors of the food industry (meat and seafood processing). Despite overwhelming evidence that such systems are inadequate to deal with modern problems which are almost exclusively microbiologically based. While Hazard Analysis Critical Control Point (HACCP) concepts have flourished throughout the food industry, they have languished in the meat and seafood sectors with work on modifying Codex Alimentarius codes of practice for Fish and Fisheries Products beginning only in 1995.

In the meat and seafood sectors, there is a pervading regulatory stance that product safety can be guaranteed only via a government system. Despite ample evidence to the contrary.

The present paper takes the stance that government inspection systems are not only inadequate, but actually inhibit development of food safety systems by confounding the company role in food safety. Evidence is provided of recent evaluations in the Australian meat industry of improved product hygiene via company-based quality systems compared with systems based on government inspection. The role of the Australian Seafood Industry Quality Assurance Project is also presented as an example of how company-based systems can deliver standards which are impossible under government inspection schemes.

Keywords: Quality Assurance; Government services; Hazard Analysis Critical Control Point; HACCP.

BACKGROUND

Government inspection services have existed for centuries - ever since the potential for fraud and damage to public health became known. As early as Biblical times, chemicals were used to mask quality losses in foods and adulteration became rife in the Middle Ages with water added to beer and wine, and clay added to flour. Food fraud accelerated after the Industrial Revolution with the earliest industrialised food processes of brewing and baking being especially susceptible. In the United Kingdom, this led to laws prohibiting adulteration which dated from the mid 1800's.

In Australia, fraud was imported with the first settlers. In his book Farrer (1980) charts the history of our food industry. The first conviction for food adulteration in Australia was in 1792 when a Sydney woman was found guilty of adding stone grindings to flour. In those days a trace of stone in bread was unavoidable given that the grain was crushed by large grinding stones but the offender in this case added 40%. She was sentenced to six months in an iron collar.

The Pure Food Act was promulgated in Victoria in 1905, NSW in 1908 and the remaining states by 1912. With the laws came the analysts who, progressively became better trained and equipped in food analysis. So, the beginning of the 20th century saw the establishment of a framework for food quality with the amalgam of food laws, trained analysts and scientific methods which formed the basis of our present system.

It was about this time that food inspection services were set up, particularly for meat and poultry processing. For red meat, inspection was designed to eliminate diseased animals from the processing chain. Meat inspectors were trained to recognise lesions, pathology and conditions and to carry out 100% inspection, a process which has not changed significantly for almost a century despite dramatic technological advances in food processing and packing.

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GOVERNMENT INSPECTION SERVICES

Government food inspection services have been developed in every country, their activities guided by a peak world body, the Codex Alimentarius Commission. During the past half-century, the Codex has instigated huge investment in the construction of food premises and equipment and has promoted the primacy of government inspection. Despite the perceived improvements, however, the prevalence of foodborne disease has burgeoned and, in all countries which make available a budget for collection of statistics, the prevalence of food poisoning has increased dramatically. It is now universally acknowledged that traditional food inspection procedures are inadequate for controlling the microbiologically-based food safety problems which beset the industry.

Clearly, there is a need for the introduction of systems which can rein in this upsurge and the food industry has introduced quality assurance systems, components of which identify hazards and risks, and associated preventive controls.

Current evolution of such control systems is the Hazard Analysis Critical Control Point (HACCP) concept, which has been in existence since the 1970s. For food professionals, HACCP is merely the latest in a line of hazard control systems starting with Wilson's Triad in the 1930s, via LISA (Longitudinally Integrated Safety Assurance). Today's regulators, by contrast, attribute mythical powers to HACCP often with little understanding of how it must be applied in order to have any real impact on food safety.

This paper assesses the effectiveness of government inspectors and concludes that presentday food inspection services fail to deliver a level of food safety appropriate for modern food processing and, by virtue of their cost structure, may actually impede food companies wishing to develop appropriate quality systems.

This paper takes a global approach to government food inspection and while references are made throughout to the Australian Quarantine Inspection Service (AQIS), it is emphasised that AQIS have fostered and continue to foster many of the precepts of superior quality systems.

SEAFOOD INDUSTRY CONTEMPORARY FOOD SAFETY PROBLEMS

In Table 1 is presented some significant foodborne disease incidents of the past two decades. The selection is designed to show that a wide range of countries, processes and packaging formats are afflicted by a range of micro-organisms.

A feature common to most, if not all, of these incidents is that the problem emerged from a system under government inspection either at the plant, or downstream level. For example, the canned salmon was processed in export-registered US canneries; smoked mussels emerged from an export plant under New Zealand government inspection. The 1990 oyster incident in Sydney involved product which was depurated under State government overview.

For balance, Tables 2 and 3 contain well-publicised examples of food safety breakdowns in the meat, dairy and processed food sectors. As before, the selection is made to encompass a range of countries, products, packagings and processes. The common feature is the overview of a government inspection system, be it Federal, State, Provincial or local government. Sometimes, as in the case of the Garibaldi incident of 1995, lines of responsibility become blurred with two State and one Federal agency having involvement.

RESPONSIBILITY FOR FOOD SAFETY

Where government inspectors police a processing plant, the pivotal question is: who bears ultimate responsibility for food safety? The answer is unequivocal - the food inspector, under the relevant Act, has that responsibility. AQIS meat inspectors, for example, have the power to cause production to cease in plants under their authority.

Table 1: Selected foodborne illness associated with seafoods

Year	Country	Product	Organism	Impact
1977	Australia	Oysters	Virus	>2000 ill
1978	UK	Canned salmon	C. botulinum	4 cases, 2 dead
1982	Belgium	Canned salmon	C. botulinum	2 cases, 1 dead
1983	Canada	Smoked salmon	C. botulinum	5 cases
1984	Holland	Frozen shrimp	Shigella	39 dead
1988	China	Clams	Virus	300,000 ill
1988	Canada	Canned tuna	Spoilage	Recall
1990	Australia	Oysters	Vibrio vulnificus	750 ill
1992	Peru	Ceviche	Vibrio cholerae	>400,000 ill >4,000 dead
1993	New Zealand	Smoked mussels	Listeria	2 dead

Table 2: Selected foodborne illness associated with meat and meat products

Year	Country	Product	Organism	Impact
1978	USA	Cooked beef	Salmonella	>2000 ill
1981	Australia	Salami	Salmonella	>300 ill
1981	Australia	Frozen meat	Substitution	US market jeopardised
1989	Australia	Frozen meat	Bone taint	Product recall
1990	Australia	Pate	Listeria	6 dead
1993	Australia	Salami	Salmonella	>100 ill
1992	USA	Salami	E. coli	Product recall
1993	USA	Hamburgers	E. coli	5 dead >500 ill
1994	Australia	Frozen meat	Faeces/ingesta	Product recall
1995	Australia	Salami	E. coli	1 dead, >20 ill

Table 3: Selected foodborne illness associated with dairy products and processed foods

Year	Country	Product	Organism	Impact
1982	USA	Pasteurised milk	Yersinia	16,000 ill
1983	USA	Pasteurised milk	Listeria	49 ill, 14 dead
1984	Canada	Cheddar cheese	Salmonella	2700 ill
1985	USA	Pasteurised milk	Salmonella	>200,000 ill 2 dead
1985	USA	Mexican style cheese	Listeria	142 ill, 47 dead
1985	UK	Baby food	Salmonella	76 ill, 1 dead
1987	Switzerland	Cheese	Listeria	>70 dead
1989	UK	Hazelnut yoghurt	C. botulinum	27 ill, 1 dead
1992	France	Pork tongues	Listeria	279 ill, 63 dead
1996	Australia	Peanut butter	Salmonella	>100 ill

It should be emphasised that, in all but one of the incidents cited in Tables 1-3, no fault or negligence is attributed to individual inspectors who carried out the tasks in accordance with procedures developed by senior management influenced, in turn, by pronouncements of the Codex. The exception is the Australian meat substitution incident of 1981 in which horse and kangaroo meat were substituted for beef. Subsequently, the Woodward Royal Commission found that government inspectors had acted improperly and criminal charges were laid against some members of the service, who were jailed, as were company staff involved in the substitution.

IMPEDIMENTS TO ENHANCED FOOD SAFETY

For several reasons, government inspection systems may actually impede food processing companies in the development of enhanced food safety systems.

Cost of the service

With the increasing tendency towards 'user pays', government inspectors have become extremely expensive. Because of Federal government edict in Australia, AQIS inspectors are charged at a rate around A$70,000/annum to meat processing plants and, where an AQIS veterinarian is required, around $100,000/annum is levied. In the meat industry, where inspectors undertake routine Quality Control (QC) activities such as on-line inspection tasks, those points on the process line manned by inspectors add considerably to the cost of production. In total, an AQIS inspection team can add more than A$1m to a large operation, an investment in QC which diminishes the ability of a company to develop comprehensive Quality Assurance (QA) programs.

Audit versus inspection

Creditably, AQIS have instigated a number of inspector-replacement systems e.g. Approved Quality Assurance (AQA), Production Quality Arrangement (PQA), Food Processing Accreditation (FPA) and Meat Safety Quality Assurance (MSQA) which allow replacement of inspectors with suitably-trained company staff. Such inspector-replacement schemes are a useful entry level for companies wishing to develop a comprehensive Quality Assurance (QA) system.

In the seafood industry, for companies operating an AQA or FPA, inspectors carry out narrowly-focused audits which concentrate on standard of construction and equipment and on perceptions of cleanliness. Whether these are audits or inspections is a moot point because seafood companies regularly rate major nonconformances for dust on ledges or rust on equipment (this latter extending even to fishing boats!).

One seafood company recently lost its 'A' rating, when the inspector cited the lack of strings on aprons worn by the processing team as a major nonconformance. The episode bears telling in

some detail. Management were aware that the apron strings would need to be replaced and waited for the inspector's visit to confirm with him that the type of material they planned to purchase would be acceptable. When assured it was, they removed the strings and went to purchase the new materials. On their return the inspector had concluded his inspection and left the plant with the adverse finding of 'No strings on aprons'. The plant was not processing that day, a fact made known to the inspector.

Incomplete training in the food inspection service

Of significance for the modern, diverse food processing industry is the expertise provided by the service. While both veterinarians and meat inspectors are fully trained to deal with animal diseases and conditions and with pathological lesions of carcases, there are a number of crucial gaps in expertise. Areas of expertise vital for the modern food industry are:

- Microbiological risk assessment
- Predictive microbiology applications
- Biofilms and their control
- Emerging pathogens
- Microbial control mechanisms
- Packaging technology
- Hurdle technology
- Process control of various food sectors
- Minimal processing technologies
- Quality management systems

The range of expertise required in the food industry has progressed far beyond what can be accommodated within the training undertaken by veterinarians and meat inspectors. AQIS have invested significant resources in retraining both veterinarians and inspectors in aspects of Food Technology. A more cost-effective solution would be a mix of animal health and food professionals within the food regulator.

Misuse of HACCP by government inspection services

For at least two decades, the food processing industry has fostered and developed HACCP-based quality systems as the most appropriate means of minimising breakdowns in food safety. What has been lacking until recent times is suitable verification that the hazard is being controlled. Thus, the food processing sector is becoming attuned to accommodating the commercial risks of a food incident and the need for demonstrable due diligence by installing powerful quality systems which include a HACCP component.

It is of great concern that government inspection services are poised to usurp and mis-use the HACCP concept as an inspection tool. This *in†vacuo* use of HACCP was legislated on July 6, 1996 when President Clinton announced new food safety rules for the US meat and poultry industries, rules which will be applied to all countries which import to USA and will extend to seafoods. Said Agriculture Secretary, Dan Glickman at the White House launch *"Today, consumers ... will have the assurance that their food has been inspected using the most modern, the most scientific methods available ..... HACCP."*

That regulators have 'found' HACCP and pronounced it the new magic bullet will fill food professionals with dismay. United States regulators, in particular, believe HACCP will eliminate the annual 4,000 deaths and 5 m illnesses from meat and poultry consumption and the 20-60,000 seafood poisonings.

Reliance on testing

Whenever there is a food incident, the call goes up for 'more testing' from consumer groups which, particularly in USA, exert great influence over food regulators. There is a belief among consumer groups that product testing, another form of QC/inspection, will prevent a problem. However, even a passing knowledge of statistics and microbiology is sufficient to dispel any reliance on testing as a means of prevention. And testing regimes undertaken in actual food incidents provide expensive examples of the futility of searching for pathogens.

Example 1: *The John West salmon incidents of 1978 and 1982.*

> In 1978, four age-pensioners in Birmingham, UK, Jesse Farmer (64), his wife Betty (66), brother Leonard (79) and wife Clara (72) sat down to the fateful Sunday afternoon tea which saw all four contract botulism and only two survive. In 1982, Belgian schoolteacher Eric Mathey and his wife contracted symptoms of botulism and he died.

On both occasions, immediate worldwide recall of canned salmon followed news of the botulism outbreaks. After cans of salmon had been recalled, health authorities all around the world faced the dilemma of what to do them? Destroy them all? The lethal can was one of around 15 million produced during the frantic 10-week Alaskan canning season as the salmon migrate past the Aleutian islands. What if the other 14,999,999 cans were OK?

In fact, health authorities around the world cooperated in a massive sampling and testing program.

(i) Cans from the same batch as the incriminated ones were tested for the presence of botulinum toxin, an expensive procedure. In the 1978 incident, a total of 3,515 cans was so tested, and in 1982, 1,000 cans were tested for toxin. No can was found to be positive for toxin.

(ii) In the 1978 incident, 14.6 m cans were subjected to a visual examination for damaged seams and to dud detection (each can was tapped to check whether it was still under vacuum). No can was found to be defective.

(iii) In the 1982 incident, more than 60m cans were recalled, from 9 canneries. The number tested is not known but it is believed to be >1 m, none of which was found to be defective.

At the end of sampling, cans were progressively released onto the market, apparently without incident. Losses from both incidents, including lost sales, exceeded $US250 m.

Example 2: *Mettwurst contaminated with E. coli.* In early-1995, Mettwurst manufactured by Garibaldi caused at least 150 illnesses of which more than 20 required hospitalisation. There was one death. In the aftermath, an intensive sampling program was undertaken for the specific *E. coli* which had caused the incident. A total of 16,000 samples was tested for *E. coli* O111. Despite confining sampling only to suspect product, only two positives were recovered from the 16,000 samples.

Blurred lines of responsibility

At present, if a company cannot meet its quality obligations it stands liable for financial damages and its officers stand liable for criminal damages. But if a company is operating under government inspection and paying for that service with all its attendant claims of quality of performance, is not the company absolved of any product failure and, by extension, is not the supervising government officer liable? What is the responsibility of an inspection service to be able to demonstrate duty of care/due diligence towards its customer, the company which employs it? At the moment, in mid-1996, these are questions which no inspection service would be comfortable addressing in litigation proceedings.

Extravagant claims

Globally, government inspection services make various claims for which there is no evidence:

(i) 'The industry' cannot be trusted. While not every member of an industry can be trusted, this claim is unsubstantiable.

(ii) Only government inspectors can assure food safety. The foregoing will dispel this claim.

(iii) If the inspectors leave, the industry will crumble. Overwhelming evidence, Australia-wide, has dispelled this claim.

Unfocused regulation

For almost a century, regulators have concentrated on processing plants as their focus for improvements in food safety; the complete agri-food continuum has been ignored despite evidence implicating the food service sector as the major area of food abuse. Thus regulators have required meat, poultry, seafood and processed food manufacturers to adopt standards of construction and procedure far in advance of those in the wider food service sector. This disparity is being perpetuated by current legislation by the US Food Safety and Inspection Service towards pathogen reduction (read elimination) at the processing plant level. Even if this were possible, there is no assurance that pathogens will not be reintroduced and proliferated at points downstream from the processing plant by operators without skill and infrastructure.

Political versus technical imperatives

In the era of the soundbite, those with the camera and microphone hold sway. Lobbyists and consumer groups can effectively hold governments to ransom, especially in an election year. Thus the world food industry is currently being required to implement radical changes over short timeframes, stemming primarily from US regulators influenced by consumer and lobby groups. That these groups represent family of those who died or were injured in the Jack-in-the-Box hamburger incident presents twin ironies. Firstly, The epidemic arose because of undercooking at numerous restaurants within the franchise; globally, no other hamburger chain had similar problems. Secondly, the families all have the sincere wish to prevent a recurrence of the problem. That they have been led to believe that increased testing and other components of the new rules will prevent a recurrence is tragic.

FOOD SAFETY - A NEW, BETTER FUTURE

An improved future for food safety depends on each stakeholder being responsible for what it does best.

Regulators

Regulators can operate more effectively under a redefined and reduced role for government inspection services. Inspection as a food safety guarantee is a devalued coinage. Only comprehensive quality systems can reduce the prevalence of food safety incidents. By focusing their activity on improving the regulatory climate for enterprises to operate quality systems of the highest technical and management capability, regulators can truly serve their constituents.

Food manufacturers

Food manufacturers, and this includes vessels which process at sea, be it only grading, packing and freezing, can provide a safer product by implementing a quality system which has a strong HACCP component. The quality system which best serves a manufacturer's needs is the ISO 9002 system which combines elements of food safety with 'business' elements designed to improve a company's profitability. On its own, HACCP is ineffectual, relying on the strength of the quality system to harness the power which it (HACCP) can generate.

Auditors

The key to operating a successful quality system is auditing, both internal and external to continually improve the system by challenging it. Auditors need to develop skills in integrating the HACCP concept into the quality system.

Governments

For food safety to rise above political agendas, and the current USA (meat safety) and European (Mad cow, sheep, goat, deer) furores are examples of where political imperatives subsume real safety needs, requires unflinching direction from government. The current gun debate in Australia exemplifies how strong a government must be, even when backed by the overwhelming majority of the community. On the food safety front, a government which places reality before the community in a way we can all understand will need to be courageous in the Yes Minister sense - the greatest challenge we can ask of government.

A SCENARIO FOR THE SEAFOOD INDUSTRY

There are a number of stages by which the seafood industry can progress to a future which it can manage more effectively:

Stage 1: *Certification to ISO 9002*

Fortunately for enterprises which process seafoods, the way forward on the food safety, quality and profitability fronts is encapsulated by one commitment - ISO 9002 certification. This robust, flexible framework maximises an enterprise's opportunities for continued improvement and profitability.

Stage 2: *Equivalency*

The Australian government should actively prosecute the cause of ISO certified companies along the lines of equivalency with systems in countries to which we export.

Stage 3: *AQIS involvement*

An ISO certified company should be audited by JASANZ-accredited auditors.

The government inspection system should not be involved at the company level.

Alternative systems

An enterprise wishing to remain within the government inspection system should be inspected/audited by AQIS.

CONCLUSIONS

The answer to the question: 'Government food inspection services - do they have any value?' is both yes and no.

They have value to:

(i) Consumer groups which believe 'the government' will look after food safety more successfully than will 'industry'.
(ii) Fellow regulators in other countries who are able to cover an entire industry by dealing with one telephone on one desk.
(iii) Politicians who require decisions based on expediency.

They have little or no value to:

(i) Consumers.
(ii) Manufacturers.

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HACCP MODELS
Some traditional fishery products

By Poonsap Virulhakul and Varatip Somboonyarithi[1]

Abstract

The demand for traditional Asian fishery products is not limited to developing countries but is worldwide due to the increased consumption of oriental foods by western people. The strict regulations by Authorities in major importing countries create challenges in introducing quality assurance systems to processors/packers/exporters in developing countries. The Hazard Analysis and Critical Control Point (HACCP) system is not new for most non-traditional fishery industries, however, it is rather new for the traditional ones.

The actual practices for fresh fish handling and processing of major traditional products (i.e. salting/drying, smoking and fermenting) were reviewed.

Hazard analysis, CCP determination and HACCP plans for production of plara, fish sauce, dried shrimp, (i.e. Thai style fermented fish) and shrimp crackers were done. The results showed that 1 CCP (packing) for the process of plara, 2 CCP's (receiving and bottling/capping) for the process of fish sauce, 4 CCP's (receiving, peeling, sizing and packing) for the process of dried shrimp and no CCP for the process of shrimp cracker were identified. The monitoring procedures, corrective actions and verifications of the identified manufacture CCP for each product were then established.

Keywords: Hazard Analysis and Critical Control Point; HACCP; Critical Control Point; CCP; Plara; Fish sauce; Shrimp; Fermented fish.

INTRODUCTION

Fish is one of the most important foods in the world. The demand for fish is increasing exports from developing countries, especially in the ASEAN region. Fish utilisation has changed from traditional to more modern non-traditional processing in developing countries. Exported fishery products are mostly non-traditional forms such as frozen and canned.

In the past, traditional fishery products were important foods in the domestic market of developing countries. As the migration of population from developing countries to developed countries occurred, the demand for traditional fishery products has been increasing, as has western consumption of oriental foods. Several items are exported at the same time with regulatory authorities in developed countries becoming stricter. This creates problems for exporters and processors. They must develop a strict processing quality system. Hazard Analysis Critical Control Point (HACCP), which is recognised as an effective way to ensure food safety, may be new and difficult for traditional food processors to adopt. Transferring HACCP knowledge to these people is needed for them to survive in their business. This paper aims to help them in developing their HACCP system.

FISH HANDLING AND PROCESSING OF TRADITIONAL PRODUCTS

Fresh fish handling

In developing countries fish used as raw material for traditional processing is caught by small and medium-scale fishermen. For small scale fisheries, fish is sold soon after landing and some may be sent directly to the processing plant. Fish caught by trawler is scored fair to poor in quality due to poor handling on board and the long duration of fishing trips. Freshness of fish immediately after harvesting is actually superior. However, much of the fish is left without ice for a long time before being processed. Fish spoils rapidly by autolysis, bacterial and chemical action. Any further processing should be begun with fish with a high degree of freshness.

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Salting/Drying

Curing by salting and drying is a popular method of fish preservation in many Asian countries. Most plants are household scale or small scale facilities. Sun drying is also used by individual fishermen or groups. Drying on the ground still occurs in some areas. Some processors use artificial drying which gives a better quality product in terms of hygiene.

Fish is soaked in brine or salted before drying. Salting can be an effective way of reducing water content of fish flesh. Salt serves as a preservative to prevent bacterial growth. However, under tropical condition of high humidity (60%-70%) dried salted product will reabsorb moisture creating conditions susceptible to mould growth. Under poor storage condition and improper packaging, dried fish with mould infection can be unattractive and, perhaps, unsafe for consumers.

Smoking

Traditional smoked fish is prepared by cooking fish over a hot, smoky fire, the process reduces the water content of the flesh and kills bacteria and insects. The process itself can cause physical damage because pieces of fish will fall into the fire and be lost. High temperature of smoking can lead to case hardening of the outside while inside flesh is not yet dried sufficiently. Then the smoked fish will spoil from inside if not kept refrigerated. The incompletely dried smoked fish may permit growth of pathogens when spoilage bacteria are killed by hot smoke.

Fermentation

Fish fermentation is the process by which fish is mixed with salt alone or salt and carbohydrate (cooked rice/roasted rice). The mixture is kept in an appropriate container for a certain period of time depending on the type of products (3 days to 1 year). Various types of fermented fish products have been processed in Asia and vary from country to country. Fish sauce is commonly produced in Thailand, Vietnam, the Philippines and Myanmar, but each country has its own names for the products.

Some processors are unaware of the need for good quality sorting of fish. The use of not fresh or spoil fish may lead to toxic substance like histamine being in the product. The improper handling of raw fish before salting and insufficient acid production in very low salt fermentations may lead to outbreaks of botulism. This toxin is easily destroyed by heat treatment, but is very stable in salty and acidic condition.

Fish can be dangerous if the product is consumed raw or partially cooked, parasites are another health hazard. Larvae of nematodes (*Anisakis* sp.) may cause appendicitis-like symptom in humans.

IS THE HACCP SYSTEM NEEDED FOR TRADITIONAL FISHERY PRODUCTS?

Recently, several countries have implemented HACCP seafood programs. The system gives greater assurance of product safety without relying on finished product testing. The principles of the HACCP system are:

1. Identify potential hazards
2. Determine the Critical Control Points (CCPs)
3. Establish critical limit to make sure that CCP is under control
4. Establish a monitoring system
5. Establish corrective action when CCP is not under control
6. Establish procedures for verification
7. Establish a record keeping system

Traditional fishery products are a group of processed foods for human consumption. Nowadays they are distributed to consumers not only in the country of origin but served in foreign countries as well. The HACCP system is being used to regulate fish processors in the major importing countries such as the USA and the EU.

Most producers have intentionally not exported their products by themselves. Packers or exporters buy products from producers or suppliers and pack them according to orders. Little has previously been known by the processors/packers about the details of production of fishery products or of any foreign regulations or enforcement efforts and a knowledge of the hygiene and sanitation used to produce the product. should be given to them. The Ministry of Public Health in Thailand is, in fact, responsible for controlling the safety of foods, particularly for domestic consumers. Both domestic and foreign consumers have the right to consume safe foods. The production of safe foods have to be encourage and promoted not only by government agency having authority but other agencies involved.

ARE HACCP MODELS NECESSARY?

Since various types of traditional fishery products are processed entirely by different small scale processors, they earn very little from selling their products. They must first survive to stay in business. They do not have time to think about safety. Similarly, most packers/exporters only think about profit . There is now little time for them to study HACCP system. One way to help them is to build up ready-to-use models requiring little modification to fit their own practices.

Although the Department of Fisheries has organised many HACCP seminars and workshops, both national and international but major participants came from non-traditional industry, therefore, HACCP workshop with the introduction of HACCP models should be organised to make sure that they understand HACCP system, able to write HACCP plan and implement HACCP system.

ESTABLISHMENT OF HACCP PLAN FOR TRADITIONAL FISHERY PRODUCTS

The types of traditional fishery products that were selected to establish HACCP plan were plara (Thai-style fermented fish), dried shrimp, fish sauce and shrimp cracker (chips).

Procedure:

1. Describe product - its intended use and how to use:
   - formula/recipe;
   - important characteristics;
   - how it is used;
   - type of packaging;
   - shelf life/temperature;
   - where it will be sold.
2. Draw flowchart .
3. Hazard analysis:
   - list ingredients/steps in HACCP Form;
   - identify potential hazard;
   - establish preventive measures for each hazard.
4. Determine CCP using Decision Tree for each ingredient/step listed.
5. Write CCPs on HACCP Plan Form
6. Establish critical limit, monitoring system, corrective action, responsibility and verification of each CCP and fill in HACCP Plan Form.

Plara (Thai-Style Fermented Fish)

Plara is a fermented fish product which contains many varieties of fishes from fresh water, brackish water and seawater (but generally fresh water fish are used), salt, roasted rice powder in the ratio of 3:1:3 by weight and the fermentation period is 6-10 months. The product is salty and a little sour, with a strong and characteristic flavour. It also has a strong smell during cooking. The colour is yellowish brown to dark brown, depending on the fish used, ingredients and method of preparation. The shape of the fish is retained during fermentation, but the flesh is soft and dissolves on boiling. It can be used as an ingredient for several Thai dishes either cooked and uncooked. Infants and medical patients should have it cooked. (See Figure 1).

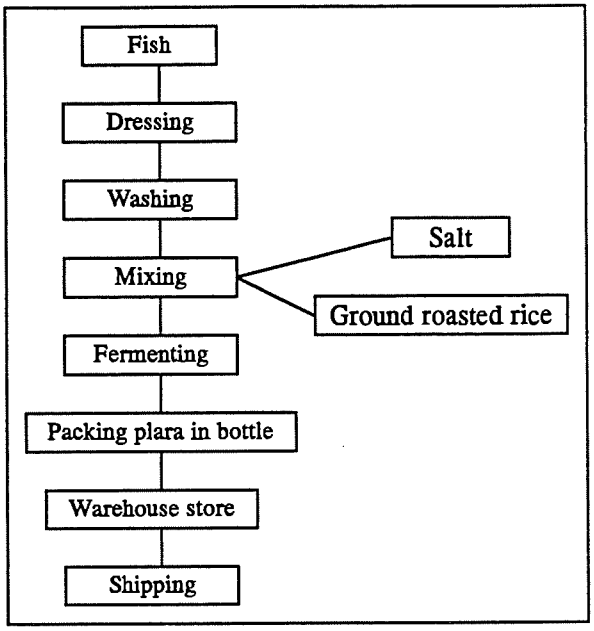

Figure 1: Plara production

Fish Sauce

Fish sauce is a liquid fermented product with a clear amber color, in which fish is preserved in high salt (> 20%) for a period of 9-36 months, and the exuded liquid drained off and used as a condiment in those areas when rice is the staple food. Glass bottles are used for packing. (See Figure 2)

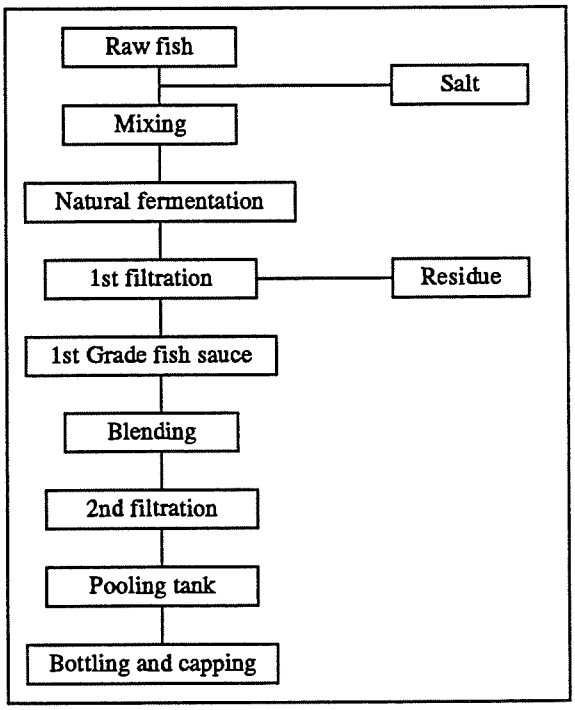

Figure 2: Fish sauce - 1st grade production

Dried Shrimp

Dried shrimp is a fishery product which is prepared by boiling in 10% salt for 5 min and either sun-dried on cement pad or mats for 1-2 days or dried in the oven. Normally this product has an *Aw* of about 0.72-0.76. It could be consumed directly or used as an ingredient in several kinds of Thai dishes.

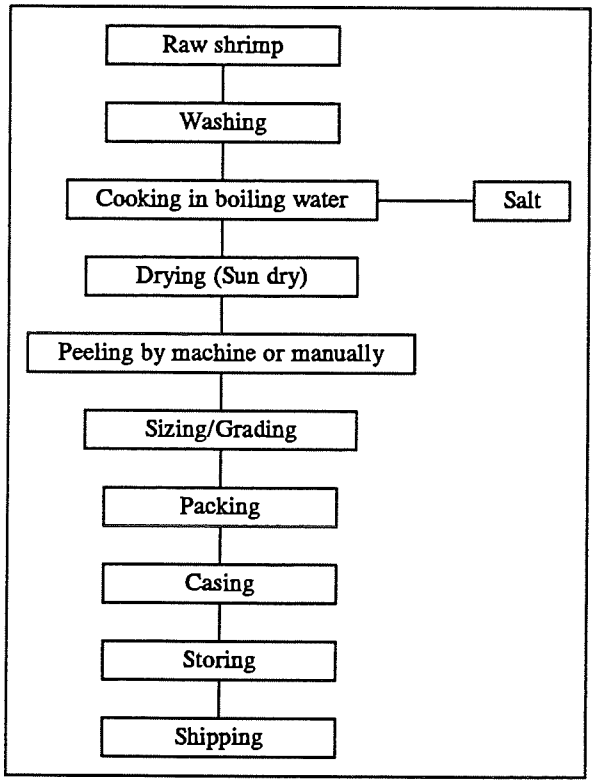

Figure 3: Dried Shrimp production

Shrimp or Crab or Fish Cracker

Shrimp, or Crab, or Fish Chips is a traditional fishery product made from mixing its meat with flour and spices, then kneading, steaming, slicing, drying and frying. The product itself is crispy and served as snack. (See Figure 4)

CONCLUSION

HACCP plan models were evaluated for the hazard which might present risk to the consumer.

One CCP was identified for plara. The most important ingredient of plara is fish. Therefore, a reliable source of fish with the receiving temperature under 7°C is needed to prevent histamine formation by microorganisms. The nature of plara's high salt content and the long period of fermentation, which is essential, is able to destroy parasite contaminates in fish. The other ingredients and steps are controlled by GMP or hygienic procedure. Other processing steps are able to assure safety of the product.

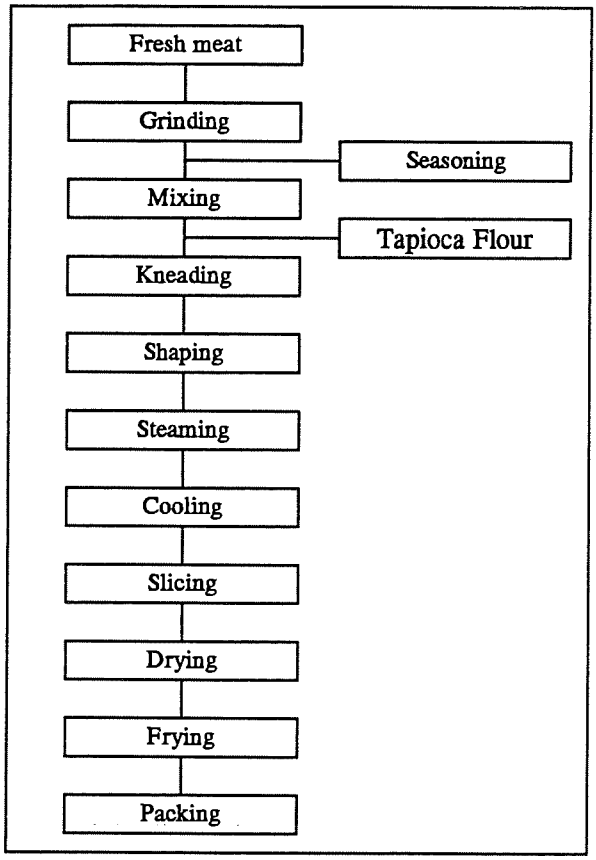

Figure 4: Shrimp or crab or fish cracker production

The fish sauce process was found to have 2 CCPs. The 1st CCP was receiving the fish as raw material which could have histamine forming bacteria. It causes a high histamine content in the fish sauce if the fish is not fresh enough. Therefore the processing step should be strictly controlled by the QC to evaluate freshness before proceeding to the next step. Bottling and capping was the 2nd CCP. The microbial contamination from the capping process could allow all products on the line to have mould spores added to fish sauce in the bottle causing product spoilage. Moreover, a piece of glass from mouth of manual capping practice may be found in the product due to the use of bottle with broken mouth.

Four CCPs were identified in the process of dried shrimp beginning with raw shrimp, peeling by machine, sizing/grading and packing. Normally, dried shrimp is consumed without further cooking and the process of dried shrimp at boiling in a short time may not be enough time to destroy microorganism contamination in raw shrimp. Microbial contamination may occur along the processing steps of receiving, peeling, sizing/grading and packing if the control at these steps are not hygienic handled. Therefore, the specifications of the raw material and GMP should be implemented.

No CCP was identified in the fish, shrimp or crab cracker process. It is a cooked product produced by automatic machine. Usually the average Aw is 0.58 which is quite safe from bacteria and mould growth, thus it will ensured the safety of the product.

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MARKET POTENTIAL
Ready-to-eat portion-controlled scallops

By Eli Goldbaum[1] and Felicia Kow[2]

Abstract
In response to the scallop industry, an added value, ready-to-eat, entree or main meal product has been developed from Southern scallops (*Pecten fumatus*).

Sensory taste testing was conducted to establish the preference and acceptability for various recipes, followed by a retail survey investigating market potential.

Results indicate that there is a strong market potential for the product developed especially packed as ready-to-eat portion-controlled seafood product.

Keywords: Southern scallops; *Pecten fumatus*; Northern scallops; *Amusium balloti;* Ready-to-eat meals; Portion-controlled; Sensory testing; Value-adding.

INTRODUCTION
Seafood has been a constituent of the human diet for thousands of years, being a major nutritional source of protein for several cultures worldwide.

The global trend for seafood consumption is escalating steadily, due to consumers becoming increasingly aware of the substantial health and nutritional qualities of seafood.

Shellfish, particularly scallops, have been increasing in value as a significant fraction of overall Australian fisheries income. However, the total catch volume has decreased, implying that prices could be the supporting factor of the scallop industry. Due to the presently inefficient and destructive nature of scallop dredges, combined with relatively low stock recovery and lack of biological data, there is a need to introduce alternatives aiding the survival - and success - of the industry.

The aim of this study was to process a "ready-to-serve (to eat)", portion-controlled, value-added scallop product, using fresh scallops; and then to conduct affective taste testing, as well as a retail survey based on this product; furthermore, to use the results of taste test and survey responses to establish the acceptability and market potential of this product in the wholesale/retail industries and to use this information to show the scallop fishing and processing sectors why there is scope for such products to enter the market in the near future.

PRODUCTION, MANAGEMENT AND FISHING
The gross value of Australian fisheries production has risen slowly over the last three to four years, despite the decrease in total catch volume. From 1991 to 1994, scallops represented between 4% and 6% of this production as well as representing a fair portion of Australian exports over the past two years despite exports also decreasing in volume (scallops as a % of exports are 1992-93 - 8.3% and 1993-94 -7.4%) (ABARE 1994).

The strong growth in exported Australian shellfish products over the past two years is primarily due to increasing prices. The main export markets for scallops are Hong Kong, Singapore, U.S.A. and France, with the majority of exported scallops being either fresh, chilled or frozen (IQF) (ABARE 1994).

The value of scallop imports has been lower than that of exports (FAO 1989). This, combined with the relatively low variety and availability of processed scallop products in today's market, points to a potential for new, value added products to enter both domestic and export markets.

In Australia, two species have been significantly fished on a commercial level. These are *Pecten fumatus* (in Southern Australia) and *Amusium balloti* (in Northern Australia - the warm water species). In particular, *P. fumatus* (commonly named the Commercial scallop) are fished mainly

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in Victoria, Tasmania and to a lesser extent, in New South Wales (Cover 1996).

Commercial scallops are fished using toothed mud dredges and by diving (in N.S.W.). Management bodies are addressing the problem of indirect mortality caused by the mud dredges (McLoughlin *et al.* 1991), as they not only damage the scallops but practically destroy their habitat. Characteristic of most dredges commonly used today, are damage rates of 0% to 20% and a mere 1% to 28% efficiency with respect to the catching power of the dredge (McLoughlin *et al.* 1991). In other words the dredges kill up to one third of the available stock and only capture about 15% (on average) of this available stock.

Given that scallop stocks (and many fish stocks) are fully exploited, it is reasonable to imply that the growth of Australia's fishery income will not occur by catching more fish, but from getting more money for what is caught. Thus to enhance the industry this way, a new national marketing strategy should be developed (Anon 1994).

This strategy should cover advertising, better methods of capture and handling, processing, packaging and transport among others, to reduce costs and wastage as well as improve quality and service. This will add value to the industry rather than just increasing prices. To aid in this, seafood promotion - currently lacking but extremely important - may potentially improve sales (Anon 1994).

Despite the fact that scallops already attain a high value (wholesale - $20/kg for Commercial and $27/kg for Northern), there is further scope for developing a value added product.

Due to rising production costs, the "tastes good, looks good - try it and see if it works" strategy has been discouraged. Instead, new methods of product development regarding a "total concept" approach is being adopted.

This approach minimises the risks of developmental communication gaps between marketing, research and development, manufacturing, finance and other project participants. In other words, a product should be fully conceptualised before its development begins.

The final decision regarding the product, will be based on the market for which it is being produced. The questions that need to be asked are: "Is it a convenience product designed as a main course?" and "For whom (which market) is it convenient ?". Processed foods offer more opportunities for making a market niche and even products undergoing minimum physical processing can add substantial value through packaging and marketing (Trewin 1987).

Essentially, value adding is a part of product development in that it covers all aspects of handling - from the fisher to the consumer - including fisheries products, preservation, processing, distribution, marketing and promotion and of course, the costs of production.

METHODS AND MATERIALS

The scallops

The scallops used in the recipes prepared throughout this project were wild-caught, Tasmanian, roe-on scallops. All scallops taken from south-east Australia are usually termed "roe-on" scallops, as the roe is eaten and not removed (as done in Queensland and Western Australia) (Grant 1993). The average scallop attains a 50 mm shell size after its first year and may reach a maximum size of 145 mm at 10 years of age (Kailola *et al.* 1993). Harvesting is possible at two to three years of age, but the third year is usually better (80 - 90 mm).

When consuming the roe of scallops caught in waters subject to dinoflagellate blooms, there is a risk of paralytic shellfish poisoning (PSP). This is one reason why the roe of warmer water scallops is removed (not consumed) and the southern scallop's roe is maintained.

On board the vessel, the scallops were bagged while still alive. Once landed, they were either put in wet-wells or on dry benches overnight. They were shucked immediately the next day and put in a cool room having a temperature range of -1°C to +1°C. Soon after, the scallops were transported by a refrigerated vehicle to the seafood wholesaler from where they were purchased (Petuna Seafood).

Ultimately, the scallops were dead for only about one and a half days prior to being received for cooking.

Sensory methods

Affective sensory evaluation was conducted for both pilot and refinement studies, as well as for part of the retail survey. Panellists used facial scales with a score range of 1 (like a lot) through to 5 (dislike a lot).

Before the trial, panellists were asked whether or not they normally ate seafood, so that if a panellist did not normally eat seafood, then bias could be avoided. In the pilot study, only one panellist did not eat seafood and in the refinement study, three

panellists did not eat seafood. These results are considered insignificant in regards to creating biased, low preferences of those samples in particular.

Two types of panels were selected for sensory evaluation. The pilot and refinement study panels included fellow students and lecturers of the Australian Maritime College (AMC). The survey respondents were either a head chef or restaurant manager. It was hoped that this would ensure a sound response based on the experience of people directly involved in the seafood industry.

For the retail survey, each respondent was interviewed individually in the workplace. The samples were defrosted and cooked by microwave prior to tasting. The results were analysed using the conventional t-test.

DEVELOPING THE PRODUCT

Recipe pilot study

In order to decide which recipes to use for the pilot study, several existing seafood recipe books were consulted. Four recipes were chosen, coded as 1-4 respectively. Immediately after cooking, the dishes were frozen to -25°C in the AMC seafood laboratory deep-freezer. They were defrosted 9 days later in a coolroom overnight, at +4°C.

The scallop dishes were cooked by microwave and appraised by students and staff at AMC. From these preliminary trails one recipe was selected and four variations of it were prepared and similarly evaluated. From this one recipe was chosen and refined for further trails on the basis of panel comments.

The scallop was then prepared and packaged immediately using a COMPACK® Modified Atmosphere Packaging (MAP) machine. However, the samples were not flushed with CO_2 or N_2 gases because these are usually intended for use in the shelf life extension of chilled products (Statham *et al.* 1989). As the samples were intended for freezing, there was no reason to use these gases.

Tuf-flex® plastic bags were used for packaging as they were adequately impermeable to oxygen and also heat-sealable (OTR=60cc/m^2/24h; MVTR=6g/m^2/24h @ 38°C and 90% RH). The heat sealer in the MAP machine was also used as a divider to create six "portion-controlled" bags (approximately equal in size) out of one large bag. Once packaged, the samples were placed in the A.M.C. deep-freezer (-25°C).

The retail evaluation

The portion-controlled samples were transported in well insulated containers and were evaluated at ten reputable outlets, six on the Gold Coast, Queensland and four in Hobart, Tasmania (see Table 1).

Table 1: Ten outlets on the Gold Coast and in Hobart that responded to the retail survey

Seafood Outlet	Nature of Business
Gold Coast	
Grumpy's Wharf Fine Cuisine	Seafood A La Carte
Seaworld Nara Resort	Seafood A La Carte
Deep Sea Fisheries	Retail/Fresh Market/Wholesale
The Rusty Pelican	Seafood A La Carte
The Peninsula Paragon	Seafood A La Carte
Gold Coast Seafood Trawler	Seafood A La Carte
Hobart	
Mure's Fish Bistro	Retail/Cafe/Bistro
Mure's Fine Cuisine Restaurant	Seafood A La Carte
The Pier Waterfront Restaurant	Seafood A La Carte
Hobart Sheraton - The Cove Buffet	Seafood A La Carte

It should be noted that in general, 100 respondents are considered necessary for consumer surveying. Due to the constraints of time, this sample size was not achieved (n=29).

RESULTS AND DISCUSSION

Pilot study

The mean panel scores for the four recipes were 2.12; 2.52; 1.72 and 1.90. The third recipe was selected for further refinement on the basis of its score and on comments from the panel. It was designated as 'Scallops with a Hit'.

Refinement analysis

The panel scores of rthe four variations on the recipe were 2.07; 2.07; 1.72 and 1.76. The t-test showed no difference between the third and forth samples but the fourth recipe variation, a thick and spicy dish, was chosen for development and further evaluation on the basis of comments from the panel.

Retail survey

All outlets agreed that the prepared disk was readily acceptable. In answer to questions on what should accompany the dish, the common replies were pasta or rice. Two panellists said that chicken and rice with pappadums would also make suitable accompaniments to the dish.

Eighty percent of respondents estimate the average prices for an entree and a main meal serve with accompaniments, to be $11.00 and $17.00 respectively. One retailer said that the price of an entree-size serving of 200 g (portion-controlled)

sells for the equivalent cost of 1 kg of the raw product (scallops).

A respondent working in a retail outlet suggested a sale price of $28.50/kg for a frozen, ready-made product. There is no suggestion of a sale price, given by the wholesale fish market.

The most common criticisms of the disk were that one of the ingredients (salami) was too overpowering and that the consistency could have been thicker.

Cost of raw materials

Each five kilogram batch of scallops cost about $100. The cost of ingredients for 'Scallops with a Hit' amounted to about $20.00, making the total cost of raw materials to be approximately $120. Thus to produce 1 kg, it costs about $25.00.

Given that an entree size portion (with a sale price of $11.00) is about 200 g of product, about $55.00 could be achieved per kilogram of product. If the cost of production is $ 25.00/kg, then a 120% profit is achieved. Essentially, this entails the concept of adding value to scallops through processing a new product.

CONCLUSIONS AND RECOMMENDATIONS

The initial testing indicated that a recipe designated as 'Scallops with a Hit' was the most suitable on which to base a retail survey. Although the survey was limited by circumstances to 29 staff in 10 restaurants nd retail outlets the results indicated that this recipe was very acceptable and may have market potentila as a frozen, ready-made, portion-controlled seafood product. Further work would be needed to establish the cost effectiveness and the shelflife of this product.

Retailers questioned the freezer life of the product, as well as its stability (colour, flavour and consistency) whilst freezing. Suggestions were also given regarding the ingredients, particularly, the overpowering nature of the salami flavour. Respondents found the salami overpowering, as they are accustomed to lightly-flavoured, traditional styles - either fresh or fried - of seafood. Australia's growing, multicultural population is gradually creating changes in traditional and ethnic values for new taste-desires in food products. Many people are eating flavoured, spicy foods, moving away from traditional styles of food. In other words, the nature of demand for seafood is changing. This is one reason why 'Scallops with a Hit' has future potential for success in the seafood market.

In attempting to prove that there is strong potential for value adding and product development, it is hoped that the scallop industry will recognise the need for conducting more research on marketing, fishing methods and also biological interactions, regarding scallops in Australia.

This study tried to establish whether or not there was a market potential for a new, value-added product, there is much scope for further research, particularly involving :

(a) Stability and shelf life trials, including microbial analysis, considering packaging and storage methods.
(b) Trials involving consistency, flavour and colour of the product in the frozen form (by measuring acceptability under different conditions).
(c) Developing appropriate marketing strategies involving presentation, promotion and new products.
(d) Similar research on value-adding and new product development for other seafood species.

Increasing the range of scallop products will bring the need for advertising and promotion thus giving people better knowledge of prices, availability and the nutritional state of scallop products.

ACKNOWLEDGEMENTS

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PREDICTING SEAFOOD QUALITY
Use of new computer systems

By Michael Morrissey, Greg Peters, John Bolte and Gil Sylvia [1]

Abstract

Controlling seafood quality is an important problem confronting the seafood industry. Seasonality and variation in the supply of raw materials make it risky to invest in equipment necessary to improve product quality. Understanding the interaction of harvesting, processing and the natural characteristics of a fishery is critical to addressing quality issues. The objective of this research was to understand these relationships through advanced computer techniques allowing processors to produce a more uniform product and optimise economic benefits.

The model used in this research is based on the Pacific whiting (*Merluccius productus*) surimi industry. Data sets were collected over the 1992-94 fishing seasons and include information on the harvesting, processing and intrinsic characteristics of Pacific whiting. This data was combined with other research to develop a comprehensive model of the Pacific whiting fishery. New modelling methods, such as neural networks and M-5 induction, were used to explore the relationships of large, complex and highly interactive data sets. The major factors influencing quality of Pacific whiting surimi are the time it takes to process the product and the temperature at which the fish are stored until processed. The date of harvest (seasonality) also showed a notable effect on both quality and yield. Other significant factors of the two models included variables related to the fish (moisture content, salinity, pH, length, weight) and processing variables (processing time, wash ratios, machine settings).

The information derived from these models can be used to optimise production decisions and maximise profit. Through an understanding of the relationships that exist, managers can better control variability and produce a more uniform product to assist in quality assurance and marketing.

Keywords: Seafood quality; Computer models; Pacific whiting; *Merluccius productus*; Surimi; pH.

INTRODUCTION

Seafood products are processed from over a hundred diverse species with widely varying quality characteristics. Because trawl fish are "wild", their product characteristics are not easily controlled or standardised. Fish may also be captured large distances from processing and distribution centers, making it difficult to preserve product qualities. In addition, seasonality and significant variation in annual supply makes it risky to invest in the equipment necessary to improve and control product quality. This variation in product quality makes it extremely difficult to develop and distribute products which have the necessary characteristics to consistently satisfy consumer demand and improve market opportunities.

Many of these problems affect products processed from Pacific whiting. Pacific whiting has many intrinsic characteristics that can have a detrimental impact on final product quality. These characteristics include a relatively soft flesh, the presence of a "fat" layer located laterally beneath the skin that is associated with a rancidity problem, and infestation of various parasites including myxosporidian parasites. These parasites are associated with high levels of protease enzymes and cause softening of the muscle tissue (Morrissey *et al.* 1993). These intrinsic characteristics can lead to a number of product quality problems including unsightly appearance, bruised or mushy flesh, rapid rancidity and reduced shelf life. In addition to physical characteristics, Pacific whiting, also have behavioral characteristics which may affect final product quality. These characteristics include high recruitment variability, complex migration patterns, and quality changes due to spawning.

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Until recently, these problems have led to relatively low market prices and have made it difficult for the U.S. domestic industry to profitably process Pacific whiting. Prior to 1991, the Pacific whiting fishery was considered "underutilised" by domestic processors and most of the available resource was harvested by American trawl vessels participating in joint venture (JV) operations with foreign processing ships from Europe and Asia. During 1991, however, the Pacific whiting fishery became fully domesticated and a combination of catcher/ processors, floating processors, catcher vessels, and land-based processors participated in the fishery (Radtke 1995). This rapid change in the use of the fishery occurred as a result of global price increases of over 30% for hake species, rapid increases of over 100% in prices of surimi (washed and refined fish mince), shortages of other West Coast trawl fish supplies relative to West Coast fishing capacity, and development of methods for counteracting texture related quality problems.

The Pacific whiting fishery is an important industry to coastal Oregon economies already depressed by declines in other local industries such as salmon fishing and logging. Consequently, a great deal of effort has been directed toward solving some of problems associated with the harvest, processing, and marketing of the fish. Research funded by private companies and government agencies have been detailed in numerous articles, reports, and scientific journals. Studies demonstrated that many of the product quality problems could be minimised if handling of the product was strategically controlled and coordinated along the entire distribution chain, from fishermen to consumers. Research (Crawford *et al.* 1972; Crawford *et al.* 1979; and Nelson *et al.* 1985) demonstrated that careful handling during capture and processing, combined with the use of proper freezing techniques, could extend shelf life to as long as 18 months for fillet based products while still maintaining acceptable sensory characteristics for taste and texture. In addition, research by other investigators including Porter *et al.* (1993), and Morrissey *et al.* (1993), showed that with the addition of enzyme inhibitors, Pacific whiting could be successfully used in the production of surimi. Currently, the vast majority of Pacific whiting is processed into surimi. The results of these studies, along with the efforts of the private sector, have served as the foundation for a number of applied projects. These efforts have led to increased recognition of the need for developing industry standards for the harvesting, processing, and distribution of Pacific whiting.

There is often a large variation in handling practices among fishermen and processors. Improving the quality characteristics may or may not be suitable or cost effective for coastal trawlers and processors. Consequently, fishermen and processors must carefully consider the trade-offs between quality and cost when developing industry standards for Pacific whiting. To maximise profit potential, it may not be cost effective to produce the best possible product (Sylvia & Peters 1991). Even though higher quality product may be more highly valued by consumers, they may be less profitable due to the additional cost of production. Conversely, processors must also consider the long term effects of lower quality products such as loss of sales. Quality guidelines must be based on optimising long term industry profits, rather than only on product quality. With this type of objective, dialogue between industry and researchers becomes easier and more productive. The purpose of this research was to establish patterns of relationships between the effects of on-board handling, physical characteristics, storage conditions, and raw material quality.

MATERIALS AND METHODS

To determine relationships that exist in the Pacific whiting fishery, several different analytical tools were used. Multiple regression, neural network, and induction analysis were used to establish patterns and relationships showing the effects of on-board handling, physical characteristics (geographic area, time-of-year, etc.), and dock-side storage conditions on product quality. Although several products are currently made from Pacific whiting, surimi was chosen for final product quality analysis. Surimi was chosen for two reasons:

1) the majority of Pacific whiting harvested is processed into surimi, and
2) surimi has defined quality characteristics that are easily measured.

Data concerning fish characteristics, harvesting and processing variables was obtained from processing plants in the Pacific Northwest for the 1992-1994 Pacific whiting seasons. Industry cooperation has been crucial for relating product handling, intrinsic fish characteristics, and processing strategies to the ultimate quality of whiting products. The Oregon Department of Fish and Wildlife (ODFW) has observers on 20% of all whiting fishing expeditions in Oregon and have shared their data on harvesting variables (e.g. tow size, tow length, geographic location, and weather conditions). Also, log book data from the fishing vessels were collected. This information was combined with on-shore observations and a quality evaluation (Woyewoda *et al.* 1985) to get a complete representation of the variables affecting fish quality. ODFW observer information and log books were supplemented by data from fishermen including output from

computerised time/temperature recorders mounted in fish holds.

The necessary information was collected during the 1992 through 1994 whiting seasons. Table 1 lists some of the variables that were collected to help define this relational model. Over 80 different input variables which may influence the quality of Pacific whiting were collected and used to develop each of the models.

Table 1: Examples of variables collected for determination of quality relationships and interactions for Pacific whiting surimi

Fish Characteristics
- Moisture content
- Percent parasitation
- Average length
- Average weight
- Salinity of the flesh
- Storage temperature of the fish
- Length of time fish were stored prior to processing
- Rate at which the fish were cooled after harvest

Site/trip Characteristics
- Longitude
- Latitude
- Tow size (mt)
- Tow speed
- Number of tows on board
- Method of cooling fish (RSW, Champagne ice)
- Date
- Time of day
- Weather conditions
- Bottom depth
- Net depth
- Percent by-catch

Processing Characteristics
- Recovery of mince
- Recovery of surimi
- Percent of each grade produced
- Inhibitor lot number
- Water:meat ratios for all washes
- Temperature throughout processing
- pH throughout processing
- Salinity throughout processing
- Microbial count throughout processing
- Refiner speed
- Percent inhibitor added to surimi
- Percent cryoprotectants added to surimi
- Time to complete processing

Quality Characteristics of surimi
- Gel strength
- Impurities
- pH
- Color (L*, b*)
- Microbial count

Figure 1 diagrams some of the variables and the model design. Surimi quality attributes (gel strength, color, moisture, etc.) and the recovery (yield) of surimi were the dependent variables in the models. The most important quality variable in terms of market price is gel strength. For the purpose of clarity, results will be presented only for gel strength (Fc) in this paper.

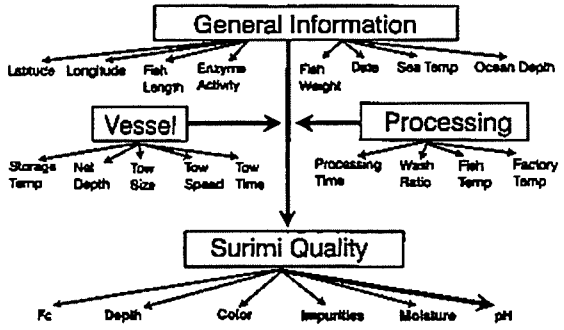

Figure 1: Factors that may affect surimi quality

Expected results were determined anecdotally through professional opinions of industry and academics familiar with the fishery. These theoretical relationships were later used to determine starting points for the models as well as the validity of the computer predictions. The raw data was organised using a computer database with each variable having its own column. The variable names were stored in the first row, with subsequent rows being values of the variables. The files were then stored in text format to be later imported into the various analysis programs.

The information was first analyzed using stepwise selection multiple linear regression for all variables and their first order interactions to determine any significant linear effects. Due to limitations of the software, only 15 variables could be examined at a time. Significant variables and interactions from these 15 variable blocks, were recorded for use in the final model. This procedure was repeated several times with different groupings of the blocks. The significant variables determined from each submodel (15 variable block) were used to develop the final linear model.

The same computer database was used for neural network analysis. The pattern recognition and generalisation capabilities of the neural network make this method well suited for Pacific whiting. The back propagation neural network algorithm was used to relate the influences and their effects on quality. The neural network software, Brainmaker (California Scientific Software 1988), was used for the analysis. Through automatic learning by the computer system, relationships were determined for all variables and their interactions, simultaneously. This works well for prediction of expected quality, however, the exact effect of each variable is not directly apparent since the system is somewhat of a "black box." This

problem is overcome by alternating an input or pair of inputs while holding the rest constant. This allows a graphical representation of the desired variable. This process is repeated for all variables to determine the effect each input has on final product quality.

In addition to multiple regression and neural network analysis, the artificial intelligence technique known as induction was used to help determine the significance of each variable. The M5 algorithm was used for induction analysis (Quinlan 1993). This program takes the information from the spread database and divides it into a set of smaller subsets based on discontinuities or thresholds in the original data set. These subsets are again divided until no discontinuities or nonlinearities exist. Each final subset was analyzed using multiple regression for a resulting series of linear equations that relate variables to their effects on quality under various conditions. The resultant decision tree yields a set of If-Then rules that describe the data set.

RESULTS

Exploratory analysis was performed on the data sets to help determine the relationships between variables. For this, correlation matrices and scatter plots were developed to quantify simple relationships between variables. An example of two scatter plots is shown in Figure 2.

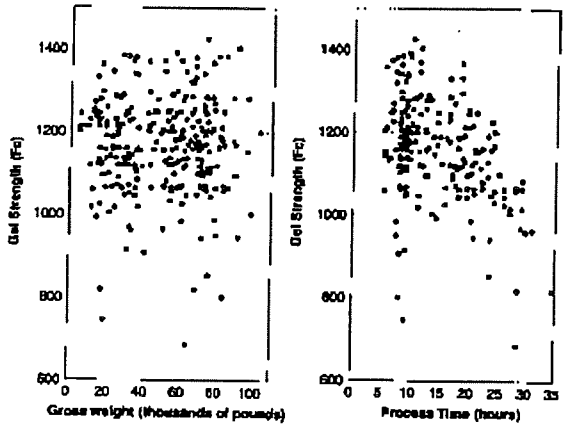

Figure 2: Scatter plots showing fish hold quantity and time to process versus gel strength

These plots show relationships of two variables to gel strength. The two variables are gross pounds harvested per vessel per day and the time it takes to process the fish (harvest to final product). This scatter plot represents data for one vessel over one fishing season. The gross weight variable showed little relationship to gel strength, basically a random scatter. The time variable, however, demonstrated a definite pattern of a decrease in gel strength with time. Similar correlation scattor plots were done to give visual representation of readily observable patterns with regard to dependent and independent variables.

The multiple regression model which used gel strength as the dependent variable and all other variables (Table 1) as independent variables yielded three significant variables of the 88 measured; the time it takes to process fish, the temperature at which the fish are stored, and the date when the fish are captured. After accounting for these three variables, 73% of variation of the data was explained. The multiple linear model was as follows:

$$Gel\ strength = 949 - 18.9*time(hrs) + 0.12*time^2 - 1.21*time*temp(C) + 1.64*date - 0.0034*date^2$$

This model showed the importance of storage time, storage temperature, and harvest date but due to a high degree of variation, discontinuities, and non-linear effects, other possibly important influences were not detected. Temperature, by itself, was not important, but the interaction of temperature with time was found to be significant. For example, if fish were processed within a few hours, storage temperature did not appear to be a pivotal factor. However, if fish took longer to process, storage temperature had an effect on final product quality. This model showed that fish stored at lower temperatures for longer periods of time may be of identical quality as fish that are not refrigerated but processed rapidly. Although multiple regression analysis showed the importance of time, temperature and date on the processing of Pacific whiting, the method was limited in determining other factors that impact final product quality.

Neural networks were more successful in describing several of the factors that affect quality. However, the significance of any given variable and their exact coefficient could not be determined because the information is in the topology of the network and not in a polynomial equation. By alternating inputs, it was possible to determine which variables affect the prediction of gel strength. These variables included process time, storage temperature, salinity of the flesh, moisture content of the flesh, pH of the flesh, meat:water wash ratios, date, geographic location, and the length and weight of the fish.

The final method of modeling used an induction algorithm to isolate the effects of each variable at various levels. Similar variables were significant for both induction and neural network analysis. Not as many variables were significant using induction, however, most likely because of complex interactions and nonlinearities. Using the induction model, the significant variables included

processing time, holding temperature, date of harvest, moisture content, meat salinity, and size (length, weight) of the fish. A more extensive discussion of the decision tree and equations for each subset of data is given in Peters *et al.* (1996).

A summary of the significant variables for the three analytical systems tests are reported in Table 2.

Table 2: Factors affecting surimi quality

Regression
Time
Temperature
Date
Neural Networks
Time
Temperature
Fish length
Fish weight
Flesh salinity
Flesh moisture
Flesh pH
Wash ratios
Date
Geographic area
Induction
Time
Temperature
Fish length
Fish weight
Flesh salinity
Flesh moisture
Date

The major factors influencing the quality of Pacific whiting are the time it takes to process the product, the temperature at which the fish are stored until processing, and the time of year that the fish are processed. Time and temperature were plotted against gel strength in Figure 3.

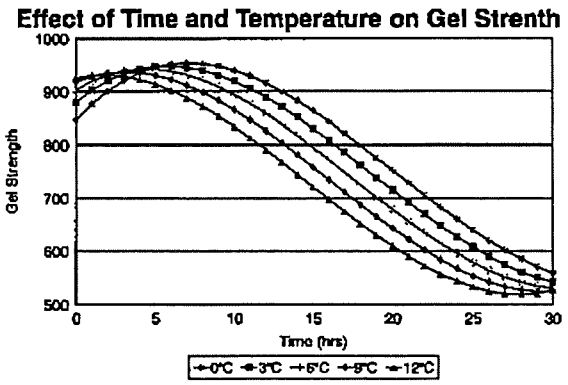

Figure 3: Effect of time and temperature on product quality

Surprisingly, to maximise product quality, it is necessary to wait at least 2 h between capture and processing when fish are not refrigerated. The time to wait varies depending on the storage temperature of the fish. If the fish are stored at refrigerated temperatures, waiting times should be 6-8 h to maximise quality. The quality of the fish declines rapidly after a certain period of time. For non-refrigerated fish, processing should be completed in less than 8-10 h. With refrigerated fish, processing can be extended as long as 20 h for the best quality fish. Quality declines rapidly after these crucial time periods. The following graph shows how the quality of fish changes with storage time and temperature. There is no apparent difference in quality between fish held at ambient temperature for 6-8 h and fish held at or below 4°C for 18-20 h.

In addition to quality changes in the fish. If fish are not allowed to age properly (wait 2-8 h), dewatering time in the surimi process will be more difficult and production must proceed at a slower rate. The effect of aging a fish is most likely due to the fish passing through rigor. This is generally not a problem for shoreside plants because the time it takes to transfer the fish from the ocean to the plant exceeds this time threshold.

Other factors are also important for surimi product quality. Different times of year produce different yields and quality than others. Typically, early in the season, the fish are thinner and both the yield and quality are decreased. This is related to the proximal composition (fat, protein, moisture, ash) of the fish. The earliest date at which good quality product can be obtained changes from year to year. In 1994, for example, the fish were of adequate quality earlier than the previous two years. On average, the quality of fish will begin to increase around the first to the middle of May.

Figure 4 shows the proximal composition (fat, protein, moisture) changes over the season for the 1992-1994 whiting seasons. Figure 5 depicts the average expected quality (gel strength) and yield changes throughout the season. There is a maximum quality and yield in the middle of the season. The quality and yield are directly related to the protein content of the fish and indirectly related to the moisture content. The protein content should be above 15.2% before processing begins for best results. Another factor affecting yield is the amount of surimi processed in a day. The more surimi processed, the higher the yield. Many other factors may be important. (Note: A Julian date of 105 corresponds to the start of the season on April 15th.)

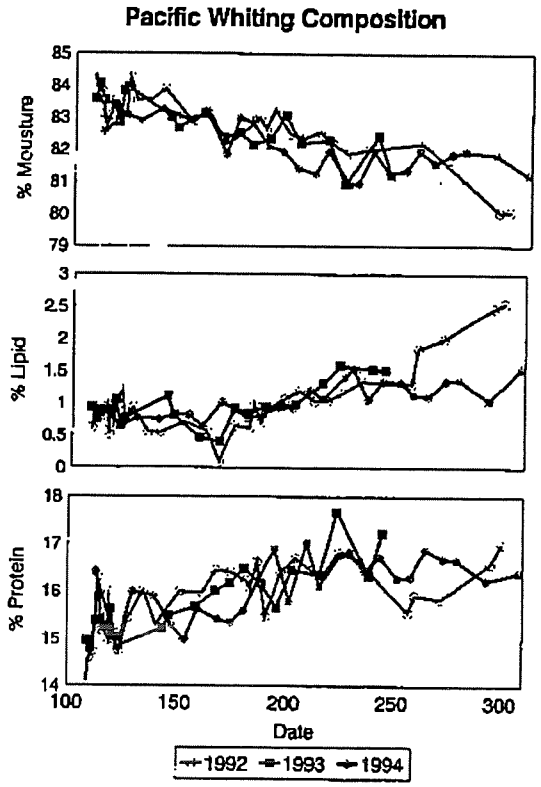

Figure 4: Proximal changes of Pacific whiting (1992-94 seasons).

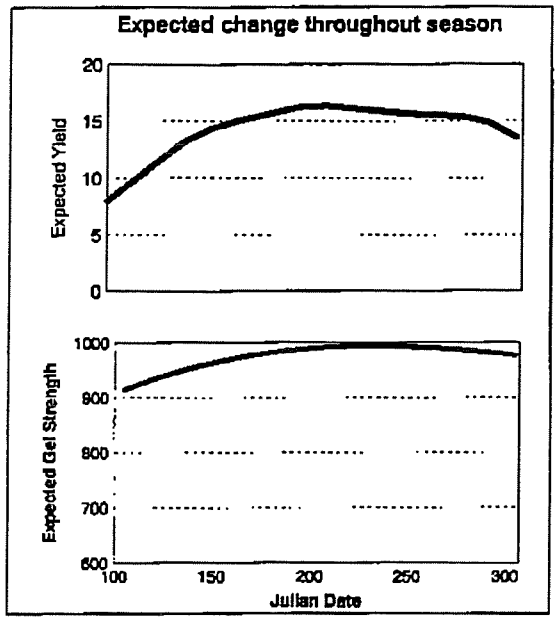

Figure 5: Expected yield and gel strength throughout the season.

Different schools of fish may be very different from each other. If a school of poor quality fish is encountered, it is best to pull up gear and search for a different school of fish. Surimi quality is dependent on the fish characteristics (moisture content, protein content, salt content, length, weight, and parasite concentration) as well as certain processing characteristics (time, temperature, wash ratios, date, total amount processed).

The fish attributes can be tested to determine the fish's suitability for surimi production and processing characteristics can be adjusted to maximise production from a specific group of fish.

Moisture content of the fish is highly related to other variables such as salinity, and processing time. Even so, after accounting for these relationships there is an effect of moisture content on gel strength. At both a low and high moisture content, there was a negative effect on gel strength. There is an apparent optimum moisture content for maximum gel strength at around 82.5% moisture.

Fish less than 43 cm in length have a lower recovery than larger fish, however, the quality was slightly higher. This information can be used to trade-off quality for yield depending on market conditions in order to maximise profits. Smaller length/weight ratios (i.e., the thicker the fish), give higher product quality characteristics and a higher yield. The length/weight ratio, size, and protein content of the fish all change throughout the season and from school to school.

In the processing plant, alterations can be made to either increase yield or quality. The higher the water to meat ratio in the wash tanks, the higher the gel strength and lower the yield. There is an optimal wash ratio depending on the prices for the various grades. When high grades have a premium price, wash ratios can be increased and the additional price for the higher grade more than offsets the loss in yield. Alternately, when there is little difference between grades, wash ratios can be decreased to increase the yield which more than offsets the lower price per pound.

In addition to wash ratios, mixing times have a similar effect. Most of the effect of washing occurs in the first 90 sec of mixing. Any time after that removes very little additional material and only improves gel strength slightly. Nevertheless, by adjusting mixing times, quality and yield can be traded off for each other. Moisture content can be adjusted or maintained by continuous monitoring. Moisture levels can be decreased by slowing down the screw presses or increasing the mesh size of the screen. By continuously monitoring and adjusting production, product of a uniform moisture content can be obtained.

Anecdotal information was obtained through industry managers and other whiting surimi experts. This information, although not quantified gives a qualitative validation of the statistical models. Experts confirm that time and temperature

are the most important factors. Experts have also stated that other significant variables may include salinity of the flesh, length/weight ratio, time of year, wash ratios, protein content, and moisture content. Some also have claimed there were other unknown factors that affect product quality but cannot be readily determined. The described research has shown potential methods to quantify these influences as well as determine interactions between variables. This will enable industry to better manage the fishery for maximum economic benefit in the future.

In summary, it is best to keep raw fish stored below 4°C before processing unless processing can occur in less than 10 h. If the fish are kept below 4°C then processing should occur in less than 20 h. The fish should generally be caught between mid-May to mid-October. These dates change from year to year depending on oceanic conditions and food supply of the fish. Fish should be examined upon arriving for processing to determine pH, moisture content, flesh salinity, length, weight, temperature, parasitation, and other factors. If the tolerances are not met, it may be beneficial to capture alternative schools of fish at a different geographic location or, if necessary, fishing can be halted until conditions improve. Table 3 illustrates the acceptable levels for different fish characteristics.

Table 3: Optimum range for various fish attributes

Storage temperature	< 4°C
Processing time	within 20 h
Fish moisture content	81.0-83.5%
Fish protein content	>15.2%
Fish pH	6.8 to 7.0
Fish salinity	0.65-0.85%
Weight/length ratio	>12

Depending on surimi market conditions yield can be traded off for quality. Yields can be increased by decreasing the water to meat ratio in the wash tanks, however, quality will decline slightly. Mixing times can also be decreased. There is very little benefit to washing more than 90 sec, but additional washing does enhance gel strength and color slightly while reducing yield slightly.

These new computer systems proved to be a valuable tool for modeling a fishery and the factors that affect quality. They are especially helpful for situations involving large amounts of data, uncertain information, and complex relationships of a number of variables. The fishing industry has made tremendous advances, over the past decade, in the utilisation of sophisticated electronic gear for increasing the capture efficiency of their vessels. There is also an exciting opportunity to use new computer systems for increasing yields and improving quality of fishery products as well. There is an ever increasing bank of information collected by fishermen, government agencies and researchers with regard to intrinsic and extrinsic properties for specific fisheries. The use of computer-based analysis of this data for determining quality relationships among the myriad of variables involved in a fishery such as Pacific whiting is a novel approach for determining critical factors affecting quality. Results show that quality is dependent on a number of interactive variables in the biological, harvesting and processing sectors of the fishery and that these variables impact product quality, recovery rates and economic benefits.

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SENSORY PROPERTIES
Effect of feed on aquacultured barramundi, rainbow trout and prawns

By Anne Ford and Rob Roberts[1]

Abstract

The range of artificial feeds currently available for seafood aquaculture is limited and feeds are expensive. Research into specific feeds for individual species, which provide the required nutrition for fast growth, incorporate less expensive raw materials and enhance desirable characteristics, is necessary in order to allow the industry to expand and become more cost effective. It is also important to ensure that these feeds do not cause any major changes in the sensory properties of the flesh which may affect consumer acceptance of the final product.

This paper reports briefly on some of the results from sensory assessments conducted at the Centre for Food Technology on fish and prawns from three separate feed trials.

Keywords: Sensory properties; Barramundi; Rainbow trout; Kuruma Prawns; *Penaeus japonicus*.

METHODOLOGY

The fish and prawns tested had all been cultured in commercial grow out conditions as part of research trials.

Sensory evaluation

The questionnaires and experimental tasting designs were customised for each type of seafood. Profiling questionnaires based on the Australian Standard Rating Test (AS2542.2.3), with unstructured graphic line scales were used. Attributes measured included appearance, odour, flavour and texture characteristics, and scales were labelled "none" at one end and "very" at the other end.

The fish and prawns were assessed by experienced panels of seafood tasters selected from staff at the centre. The panels identified the individual characteristics to be scaled during preliminary tasting sessions.

All the samples were served in individual booths under white light (daylight equivalent) and purified water was provided for palate cleansing. Order of tasting samples was balanced over the panel to minimise bias from tasting order Data was collected directly into computers using an integrated software package, CSA (Compusense Inc., Canada).

Barramundi

The fish tested were from four replicates of each of four diets:

- Control including fish meal
- Including meat meal 1
- Including meat meal 2
- Commercial

They were received frozen whole and were held at -18°c until required for testing. The fish were then weight ranked, heaviest to lightest, within each replicate of each dietary treatment.

Five fish from one weight matched replicate of each diet were defrosted overnight at 5°C and filleted. Fillets were rinsed under cold tap water and two samples (average weight 22.5 g) were cut from the central portion of each fillet. Samples were placed in individual foil dishes and covered with a foil lid. They were placed in a 5°C refrigerator and removed to room temperature (24°C) to equilibrate for one hour prior to cooking. Samples were then cooked in a fan forced electric oven at 200°C for 6 min and were transferred to a holding oven at 75°C for up to 30 min prior to tasting.

A total of 16 tasters (13 male, 3 female) assessed four samples (one from each dietary treatment) at each of four sessions. A list of descriptors used to identify eating characteristics is shown in Table 1.

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Table 1: Descriptors used on scales to describe characteristics of seafood tested:

	Barramundi	Rainbow trout	Raw prawns	Cooked prawns
Odour	Fishy Weedy/herbaceous Muddy/earthy Meaty/baked Milky Other	Clean Fishy Chicken/meaty Buttery Mouldy/musty Muddy/earthy Weedy Other	Not used	Not used
Appearance	Colour of internal flesh: Greyness Yellowness Other	Flesh colour: White Grey Cream Beige Orange Pink	*Tail:* Brightness Blue Maroon White Yellow *Abdomen:* White Maroon Black *Head:* White Maroon Black	*Stripes:* Orange Red
Texture	Firm Moist Fibrous Sticky Other	Soft Oily Moist Dry Chewy Fibrous Chalky Other	Firm Moist Fibrous Sticky Dry Springy Soft Rubbery Watery Other	Firm Moist Fibrous Sticky Dry Springy Soft Rubbery Watery Other
Flavour	Metallic Meaty Sweet Fishy Muddy/earthy Stale Weedy/herbaceous Other	Clean Sweet Fishy Chicken/meaty Oily Buttery Salty Mouldy/musty Weedy Bitter Aftertaste Other	Metallic Meaty Sweet Seafoody Muddy/earth Fresh Salty Weedy/herbaceous Other	Metallic Meaty Sweet Seafoody Muddy/earthy Fresh Salty Weedy/herbaceous Other

Rainbow trout

Rainbow trout were grown out under commercial conditions at Snob's Creek Freshwater Research Station, Victoria and fed one of three diets:

- Commercial Diet 1
- Commercial Diet 2
- Experimental diet including meat meal.

The trout had been cleaned and gutted prior to packing in plastic bags in ice and airfreighting to Brisbane. When received, they were individually weighed and ranked within feed groups according to weight. They were rinsed in tap water, placed in rank order in clean plastic bags, immersed in ice, and stored in a refrigerated room at 1-2°C, until they were tested during the following two days.

After removing the head, fish were cut into two portions providing a "head end" and "tail end", individually wrapped in aluminium foil, and oven-baked at 200°C for 11 min. Samples were then held in a warming oven at 75°C. Throughout the cooking and testing procedure individual fish were identified by weight rank order so that fish of similar weights were compared from each diet.

Thirteen panellists tasted fish from all three diets at each session. Three replicate sessions were held based on fish size within dietary treatments. Lists of descriptors used to profile the eating characteristics are in Table 1.

Kuruma prawns

The Kuruma prawns (*Penaeus japonicus*) had been fed on one of four diets A,B,C,D at a prawn farm in Northern New South Wales. They were airfreighted live in sawdust and held at 13-15°C until tested (within 3 days).

Raw prawns were assessed after they had been rinsed under cold tap water while still alive, decapitated, then served immediately together with the head.

Cooked prawns were rinsed to remove sawdust, and covered and cooked in a 600 watt microwave oven to a "just done" level (70-75°C), and served warm to panellists.

Twelve panellists assessed prawns from all four diets at each session. A total of six sessions were held, three each for raw and cooked prawns.

RESULTS AND DISCUSSION

Numerical scores of 0 and 100 were assigned to all scales on the questionnaire, with 0 representing the left hand end (=Not at all) and 100 the right hand and (=Very much) of the attribute labelled on the profiling scales.

The data was averaged over all tasters and all sessions for each treatment. Where no rating was given for a particular characteristic, a score of zero was assigned. All data was subjected to analysis of variance, and pairwise comparison of means for those attributes which showed a significant difference ($P<0.05$) between the diets.

Barramundi

Fish from all dietary treatments were considered equally acceptable although some differences were noted in flavour and texture. Odour profiles were very similar for all diets, with odours described mainly as fishy and meaty/baked.

Sweet and fishy flavour showed significant ($P<0.01$, $P<0.05$ respectively) differences between dietary treatments (Figure 1). Inclusion of meat meal appeared to increase the sweetness of the flesh. The commercial diet produced fish with less fishy flavour than the other diets. There were no significant differences in other flavour characteristics.

Fish fed the control diet, had flesh which was rated significantly less firm than that from the other diets.

Rainbow trout

In general the fish from the different diets were fairly similar. There were obvious pink markings on the skin of the uncooked fish fed Commercial Diet 1, and the flesh colour of 87% of samples tested was described as pink or orange. The flesh colour from other feeds was mainly described as white/grey or cream/beige. The only odour attribute which showed any obvious difference was "fishy". The meat meal diet produced slightly higher (but not significantly so) scores than either of the others as can be seen in the odour profiles in Figure 2.

In general the fish were considered to have a predominantly clean, sweet, chicken/meaty and fishy taste (see Figure 2). The only flavour characteristics showing a significant ($P<0.05$) overall difference between diets were "clean" and "weedy", but pairwise comparisons of treatment means using Turkey's LSD at the 5% level were all non significant. Flavour scores for "fishiness" showed the same rank order as those for fishy odour, but were not significantly different.

The flesh texture of all fish was rated soft, moist and slightly fibrous. No significant differences ocurred between feed treatments.

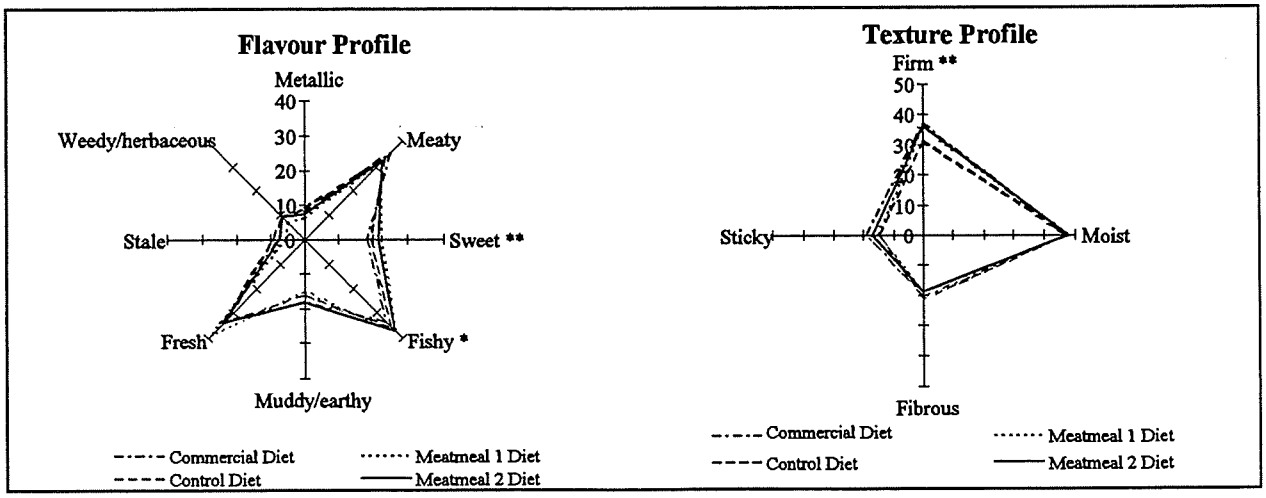

Figure 1: Barramundi profile - mean sensory scores

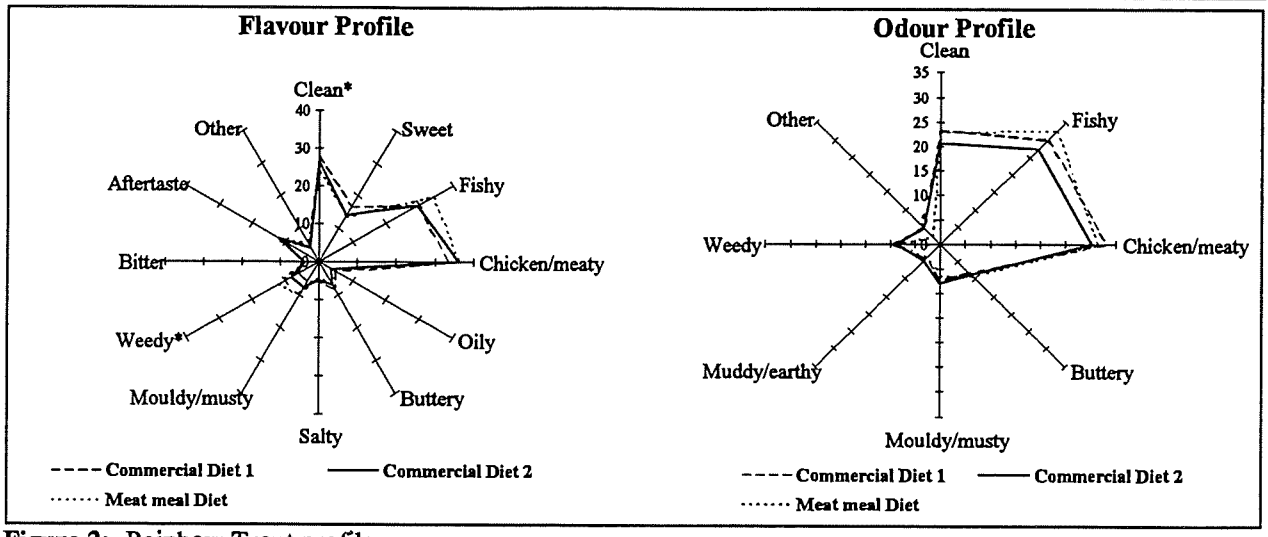

Figure 2: Rainbow Trout profile - mean sensory scores

Kuruma Prawns

The flavour and texture of the prawns were fairly similar. However, some significant differences in colours and flavours were detected between Diet D (control) and the three artificial feeds.

Colours in the tail fan of raw prawns were judged significantly brighter in prawns fed Diets A and C than those fed Diet D. Diet D produced stripes with a significantly lower maroon intensity than any other diet, and Diet C provided the best maroon colour in both bodies and head of the prawns (See Figure 3). Black colouration was significantly darker in the bodies and heads of prawns fed Diet D, and lowest in those fed Diet C.

In general, the raw prawns were considered to have predominantly fresh, sweet, meaty and seafoody taste (see Figure 4). Prawns fed Diet D received significantly lower scores for fresh and sweet tastes, and significantly higher scores for muddy/earthy and weedy/herbaceous tastes. There were no significant differences between any of the other diets in any flavour characteristic. All diets produced prawns with very similar textural qualities. Prawns fed Diet D were rated significantly "stickier" in texture, but the difference was small.

Colour and flavour differences were not apparent once cooked, and the only attribute showing significant diet effects in cooked prawns was "rubbery" texture. This was significantly higher for Diet D than for Diet A (Table 2).

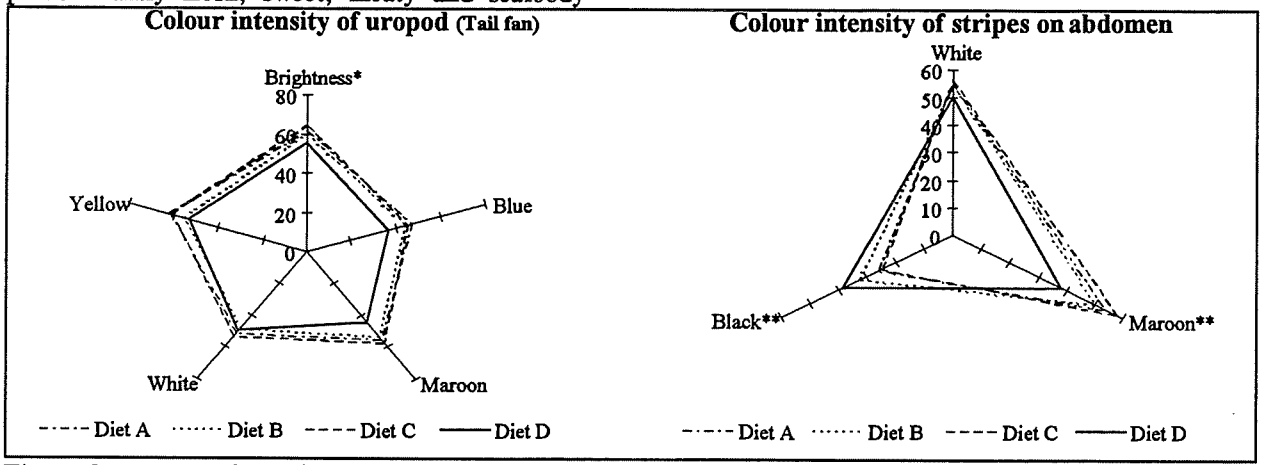

Figure 3: Effect of including pigments in the diet on the colour of the stripes in raw Kuruma prawns

Table 2: Texture scores for cooked prawns (mean of three replicates)

	Firm	Moist	Fibrous	Dry	Springy	Soft	Rubbery*	Watery
Diet A	56.7	46.8	11.7	4.2	20.9	13.0	11.1^{a}	4.9
Diet B	60.7	43.2	10.8	7.2	21.4	10.5	14.7^{b}	3.9
Diet C	62.2	49.2	11.3	6.7	20.9	6.0	13.0^{ab}	4.9
Diet D	62.2	45.4	12.2	7.1	21.7	7.1	16.1^{b}	3.3

0 = Not at all 100 = Very much

* Significant difference between diets ($P < 0.05$)

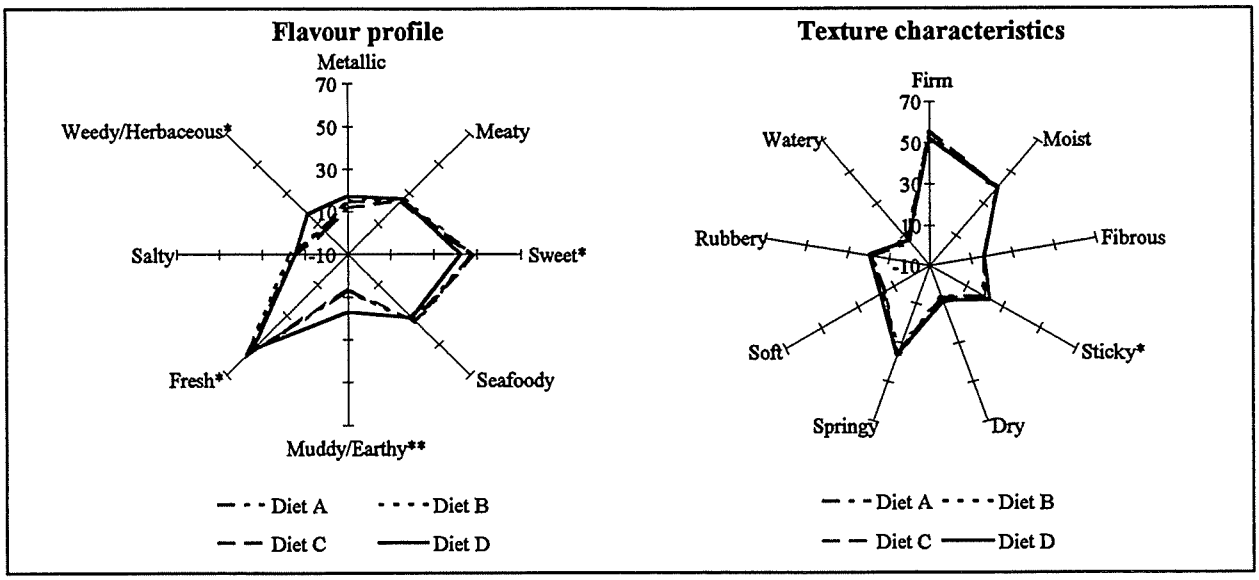

Figure 4: Raw prawn profile - mean sensory scores

CONCLUSION

Trials with rainbow trout and kuruma prawns have shown that it is possible to alter both skin and flesh colour in fin fish, and to increase the intensity and brightness of pigmentation in the shells of live Kuruma prawns by inclusion of pigments in the feed. This could increase the market value of the products provided it does not cause any decrease in the eating quality.

Substitution of fish meal with meat meal in aquaculture diets was shown to modify the flavour profile in both barramundi and rainbow trout. Surprisingly one of the main effects was an increase in "fishy" odour and flavour in fish fed the diets containing meat meal. Texture was also altered slightly by diet, probably due to the difference in saturation level of the fatty acids in the respective diets.

The next step for this research is to ascertain that these changes do not in anyway lower the acceptance of the products to consumers.

The difference in results obtained for raw and cooked prawns also demonstrates the importance for the product to be assessed in the form in which it will be consumed.

The trials reported here have confirmed that aquaculture feeds do have an impact on the final product quality, and it would be wise to incorporate this type of assessment into all research on potential feeds.

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IMPROVING COMMUNICATION
Between research and industry

By Torger Børresen[1]

Abstract
The situation in the seafood industry is characterised by small profit margins and day-to-day problems. Long term planning is made difficult by large fluctuations in raw materials supply. Implementation of research results is made difficult when communicated in a language not understood by the industry, lacking skills to read scientific literature. The research institutes are suffering financial cut-backs from governmental sources, and have to rely more upon industry oriented project financing. Researchers need to improve their skills and better understand the industry needs. Possible ways to break the ice between the research and industry include short or long term employment of researchers in the industry, or collaborative projects in which PhD. students work part-time in the industry and part-time in a research institute. Technology transfer should be facilitated through extension services to universities or separate institutes linked to universities.

Keywords: Communication; Seafood industry; Research and Development.

INTRODUCTION

When discussing the situation in the seafood industry with researchers at universities, an opinion is often expressed that the industry is not very intelligent in the sense that it does not require great sophistication to convert the raw materials into finished goods. Product development is literally kitchen based and coping with quality is usually done by sticking to the experience of good old practice and maybe try out some modifications and see how it works. This is experimentation done by trial and error, not having anything to do with a scientific approach to development. Further, it is the opinion of the researchers that there is a reluctance in the industry to implement the results of research.

When discussing the same matter with people from the seafood industry, and confronting them with the opinion of the researchers that they are reluctant to implement the results of research, the industry people say that the seafood industry is too busy to earn money every day, and they do not need, nor have the time to, exploit results of research. In addition, the research is too far from reality, aiming at theoretical problems. The people in the industry also say, that when they criticise the researchers for not doing the right things, they reply in a language that cannot be understood, so communication is impossible. Anyhow it is unnecessary, because industry is way ahead of the research already.

It is obvious that there is a long distance between the research side and the industry. The language spoken is very different, and there seems to be ice in the communication between the two parts. The present paper considers the conditions prevalent in the seafood industry, but the situation is not very different in other industries. Literature references are scarce, but recently a book appeared (Konecny *et al.* 1995), considering the research relationship between chemical industry and universities. Otherwise, the subject is mostly discussed in organisations like The European Industrial Research Management Association, EIRMA (1988) and The Industrial Research and Development Advisory Committee of the Commission of the European Communities, IRDAC (1993).

In order to examine the relationship between academic research and seafood industry closer, the author initiated a survey among the seafood industry and research centres in 10 European countries. An investigation was carried out by conducting qualitative interviews with 19 industrial enterprises and 10 research institutes. The aim was to understand the industry's attitudes toward research in general and to have the needs expressed by the industry people in their own words. In addition to the central question of communication between research and industry, the people interviewed also gave their opinion as to the general situation within their respective areas

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today. A detailed report of the study was published subsequently (PA Consulting Group *et al.* 1995).

THE SITUATION IN THE INDUSTRY

From the interviews with the industry representatives, a picture emerged of a production situation with very small profit margins. Due to large fluctuations in the supply of raw materials, production planning was made very difficult. A high degree of traditional thinking characterised the industry. In many cases the present owner had taken over from his father or had started as a fisherman, processing fish from his own vessels. Very few people with academic education were employed, which in turn created communication problems with research people. Lack of advanced management systems, planning, management information systems and advanced technology was the common picture. The industry in general was focused on day-to-day problems with survival being the name of the game. This situation was surprisingly consistent throughout the countries.

The people in the industry was also asked about their opinion of research and what they expect could be achieved through research. All companies interviewed perceived themselves as having limited skills to receive and understand the results of research projects as well as to convert the results into further technological development. In order to better understand the written project results from research institutes, some sort of a "readers digest" service was suggested, such that the results could be explained in common terms.

Most companies did not communicate with research institutes on a regular basis, and failed to exploit the opportunities. In order to estimate the expenses used for research and development purposes, most companies mentioned numbers in the order of 0-1% of the turnover. An average was calculated as less than 0.5%. Companies in general expressed that they lacked the money to invest in research due to low or even negative profit margins.

When asked about their attitudes towards research institutes, some companies independently of each other mentioned that "some research institutes do not want industrial participation in their research!" This finding was quite surprising. The explanation in the industry was that the research institutes are hunting research grants, and when they obtain support they want to do their research undisturbed and in addition, they are not willing to share project money with the industry!

When asked about their attitude towards the concept of precompetitive research, it was badly received in the industry, in most cases the word precompetitive was not really understood. To many companies it meant time consumption, extra expenses, lack of control and uncertainty. In addition there was a strong tendency to consider precompetitive projects risky, as the companies feared that they risked to reveal company confidential information to their competitors and the public in general.

What are the needs then, as the people in the industry express it themselves? Due to the day-today orientation the focus is on short term projects with a clear commercial target. Sometimes the impression is that if the industry cannot see the result as something they can produce and market tomorrow with great profit, then they are not interested. The investigation showed that only a few companies expressed an interest in longer term projects, if they could be provided with long term advantages. Another experience made is that when asked at a specific time of what their needs are, a company may point at a specific problem to be solved. If returning to the same company (e.g. later the same year), with a suggestion for a solution to the given problem, they may not be interested anymore, because now another problem has emerged. This again emphasises the day-to-day orientation.

When asked about general preferences and needs for research of benefit to the industry, regardless of the funding source, all companies in the present survey expressed that new product development was a high priority focus for their needs. However, when using the term Research and Development they concentrated on the Development rather than the Research. This corresponds with the fact that they do not employ people with academic education and hence cannot absorb the results of research projects.

Further, the need for a general improvement of quality was expressed by most industries. In this context, they meant quality control of handling and processing, but also improved hygiene and environmental measures. Other, more specific subjects included packaging in relation to the extension of shelf life and better preservation methods, ingredients such as enzymes, and better exploitation of the fish waste. For someone with some experience within the area, this sounds as very traditional needs, being heard for quite a long time.

It was therefore interesting to note a certain expression also for improvement of more generic skills as the real development needs. This included improved manufacturing effectiveness, more use of management information systems, improved marketing skills and a better understanding of

environmental issues. It is the impression that the latter needs usually are expressed in less specific measures, not so closely linked to present production.

THE SITUATION IN THE RESEARCH INSTITUTES

Due to recession in basic funding from e.g. governmental sources, the research institutes are becoming increasingly dependent on grants and contract work with industry. This in turn changes the focus towards more industry oriented research. The institutes generally consider increased industrial involvement in precompetitive projects of paramount importance to ensure the applicability of the results.

How does this then compare with the expression in industry that some research centres do not want industry to participate in their projects? The first reaction from the researchers was that this was certainly not true. When listening to the explanation given by industry people, some could understand such an accusation, and could even suspect some of the other institutes to act as said by the industry! This more than anything else underlines the extremely tough competition there is among the research institutes for obtaining funds.

Even if most research centres believe that they have a good understanding of the problems in the industry, some institutes admit that they are not good enough at understanding the industry's needs. Actually, in most cases they simply do not ask the industries what their needs are. Neither do they focus on consumer needs.

However, in order to improve their industry oriented tasks, more than half of the research institutes express that there is a need for improving their skills related to improved productivity and marketing, ISO standards, other quality standards and environmental issues. Finally, they also mention other managerial skills such as management information systems, etc.

In general, when comparing the opinions about specific future industrial needs as expressed by the research institutes and the industry itself, the future research needs seen do not differ very much. However, the research centres take a more holistic view relating to the improvement of exploitation of underutilised species and improvement of the nutritional values of fish products.

Almost all research centres interviewed believe that their general contact with the industry is good. This is, with a few exceptions, contradicted by the industry, thus illustrating a major gap in communication.

IMPROVING THE COMMUNICATION

It appears quite obvious that the first prerequisite to improve the research involvement in industrial enterprises and for the institutes to better approach the industry, the communication pattern must be changed.

In order to facilitate good communication, it is necessary to speak a language that is understood by both parties. The researchers therefore must express themselves in a language that is understood by the present industry people. Maybe some sort of a translation is needed. However, initially the problems expressed by the industry must be translated to research language before being worked at. When the results emerge, one should not forget that it is necessary to translate the message back to a language that is understood by the industry. If the researchers have problems in translating the language, they should work in the industry for a while.

The translation seems to be most needed for the small enterprises. Medium size and larger enterprises may have their own people who understand what is being said by researchers and is able to communicate with them. Companies having people with an academic background in leading positions in their company are usually also having another attitude towards future development.

The smaller companies, often referred to as Small and Medium size Enterprises (SME's) very often need help to become research intensive. The definitions of SME's may vary, sometimes considered as companies with less than 500 employees, sometimes with less than 250 employees.

Some companies, starting out as very innovative and scientifically based operations may not need research help, even with just a few employees. However, when growing to larger numbers of people engaged they very often meet the same problems as less in novative, but prosperous companies. When typically approaching a size of about 50 people and a turnover of $10-50m, they reach a critical stage, when invested capital cannot be returned unless new progress is made.

THE "ICE-BREAKERS"

In Denmark, a program has been operated with success for a couple of years, especially designed for small companies. The aim has been to improve the understanding between the industry and

research, or to break the ice between the two areas. Therefore, the program has been named the "ice-breaker" program.

Support is given to hire a person who has graduated from a university or from a college. A targeted project needs to be formulated that could contain e.g. quality management, product development, new production technology, collaboration with other companies, introduction of a new management structure in the company or improving internationalisation. The requirement is however, that the company must not have more than 50 people employed, or an annual turnover of maximum 40m Danish Kroner (approximately $7.5m), and must not be owned by a larger corporation.

Even though the salary support is not more than $2,000/month, and is only given for a period of six months, the program has been a great success. More than 1500 companies have used the support and in more than 70% of the cases, the person engaged has obtained permanent employment fully paid by the company after the project period. The program is typically oriented in the technical or business direction. About 43% of the people engaged have been engineers, while about 36% have been within business administration.

It is thus evident that the small companies in order to develop further need a little push to employ people with higher education. Having done so, they discover that these people are not dangerous at all, and they can be used to the benefit of the company.

THE INDUSTRIAL PhD. EDUCATION

Another program for improving research cooperation between the industry and research institutes has been operated for many years in Denmark. It is intended for medium size or larger enterprises and consists of an educational cooperation. A PhD. student is employed by the company, but support is obtained for up to 50% of the salary. The student works partly in the company and partly at the institute. This is called an industrial PhD. study, but the academic requirements are at the same level as an ordinary PhD. In addition to the academic courses required, a course or two is also needed within management.

The student must work on a project having a sound research content as judged by academic standards, contain a new development potential and be applicable to the industry involved. The requirements must all be fulfilled as judged by a special board appointed by the Academy for the Technical Sciences, which is the body that actually grants the governmental support.

Until now more than 250 students have finished the education. Among these, 190 are presently employed in private companies and 150 are actively involved in research and development. More than 50 are engaged in administration, being either research directors or administrative directors in their companies. The fact that more than 200 new studies are presently under way emphasises the success of the program. In an evaluation (Erhvervsfremmestyrelsen 1996) which was made recently it has been estimated that the companies participating in the educational program and employing the PhD. candidate after the study can actually calculate a higher earning following the new research.

In addition to these valuable programs, institutional links are also needed for successful technology transfer from universities to industry. This may be done as an extension service connected to a university institute, or a special institute could perform the links. However, it is of extreme importance that such an institute is closely linked to the university environment and that the people employed are able to perform good research themselves. The best results are obtained if the extension service or the transfer institute is geographically located very close to, or actually on the same premises as the university. Therefore, a day-to-day contact is facilitated and researchers and equipment can be shared. Further, when the people responsible for the technology transfer are having students around they are more up on their toes concerning new development within research.

CONCLUSION

In order to improve the communication between research and industry and to facilitate a successful technology transfer, it is necessary that the research people is able to translate their results into a language that is understood by the industry. On the other hand, the industry should aim at employing more people with an academic background, thus paving the way for new philosophies in business development, being less traditional than in the past. The institutional links necessary to perform technology transfer from research to industry must be closely connected to the university environment, possibly as a special extension service. The people involved in technology transfer must be able to perform research of high quality standards.

ACKNOWLEDGMENT

The author wish to thank Mr Niels Hansen and Mr Søren Georg Jensen of the PA Consulting Group for conducting the industrial interview survey with great skills. Planning and supervision of the survey was assisted by Dr Roy Kirby, Escola Superior de Biotechnologia, Portugal and Mr Harald Pedersen, Norconserv, Norway. Inspiring and encouraging discussions with Mrs Tove Secher, who acted as academic secretary to the project group, are highly appreciated. The project study was partly supported by the European Commission.

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TECHNOLOGY TRANSFER
Fish processing industry in south-east Asia

By Sen Min Tan[1]

Abstract
The fish processing industry in south-east Asia has undergone tremendous growth over the past decade. This is reflected in the diversification of fish processing techniques, implementation of quality control, hygiene and sanitation management programs and improvements to the cold chain distribution.

Coupled with the introduction of technology through commercial joint ventures, the rapid growth of the industry is also due to inputs by government and regional projects to promote the development and transfer of appropriate technology and good manufacturing practices for the industry.

Since 1980, the Marine Fisheries Research Department (MFRD) of the South-East Asian Fisheries Development Centre (SEAFDEC) has conducted research and development activities in fisheries post-harvest technology and provided technical assistance to the fish processing industry in the south-east Asian region. The technology developed is transferred directly the industry through training and demonstration courses for government officials and fish processors.

The ASEAN-Canada Fisheries Post-Harvest Technology Project - Phase II was started in 1992, with an emphasis on improving quality control and fish inspection services, implementation of improved methods and technologies in fish processing, preservation and packaging, and enhancement of the transfer/adoption of appropriate technologies to the fish processing industry through training and extension services.

Keywords: Technology transfer; South-east Asia; Fish processing; Hazard Analysis and Critical Control Programme; HACCP; Good manufacturing practices; Training courses.

INTRODUCTION

Over the last decade, there has been tremendous growth in the fisheries industry in south-east Asia. This is reflected in the corresponding rapid growth in the fish processing industry leading to diversification of fish processing techniques, implementation of quality control, hygiene and sanitation management systems, and extension of cold chain distribution systems. Except for Singapore and Brunei, the countries in south-east Asia are primary industries based with major economic activities is agriculture, forestry and fisheries. In 1992, the total fishery production in the region was about 9.6m t valued at $US6.2b, with Indonesia, Philippines and Thailand being the main producers. The region is also a net exporter of fish and fishery products with total exports in 1992 of 2.0m t worth $US4.55b. The fish processing activity in the region has seen rapid growth and development especially in tuna fisheries and processing, aquaculture and processing of prawn and processing of surimi and surimi-based products. As these products are targeted mainly for export, there has also been a corresponding emphasis placed on the development of quality control programmes such as good manufacturing practices (GMP) and hazard analysis and critical control programmes (HACCP). This paper discusses the role of government and regional organisations in the development of these fish processing activities in south-east Asia.

DEVELOPMENT OF THE SURIMI INDUSTRY IN SOUTH-EAST ASIA

In 1980, the Marine Fisheries Research Department (MFRD) of the South-East Asian Fisheries Development Center (SEAFDEC) introduced the concept of surimi to the fish processing industry in south-east Asia. Since then, there has been tremendous development not only in the processing of surimi for export but also in the upgrading of the local fish jelly products industry in countries like Thailand, Malaysia and Singapore.

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Table 1: Types and number of training courses conducted by MFRD from 1980 to 1996

Name of course	Number of courses conducted
Regional Training Course in Fish Processing	22
Regional Training Course in Fish Quality Preservation	4
Regional Training Course in Fish Quality Assessment Methods	4
Regional Lecture Demonstration Course	13
Regional Training Course in Marine Food Packaging	4
Regional Training Course for Vietnam	2
Regional Training Course in Practical Microbiology	3
Regional Fish Retailers Course	1
Local Lecture Demonstration Course	7
Local Retailers Training Course	5
Local Training Course for Fisheries Officers	3
ASEAN-Canada Training Course for Fish Inspection and Quality Control	1
Special Fellowhips	18
TOTAL	87

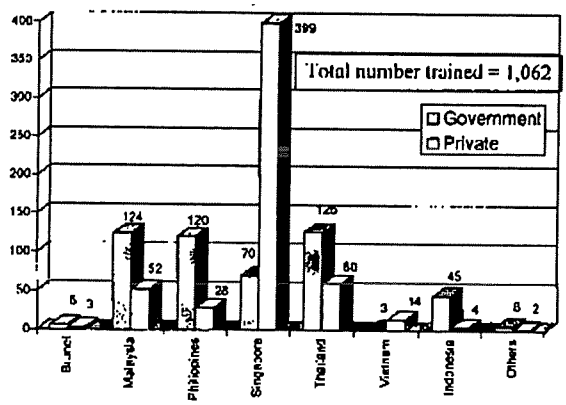

Figure 1: Total number of government officers and private sector personnel trained at MFRD from 1980 to 1995

The MFRD is one of four technical departments in SEAFDEC and conducts research and development activities in fisheries post-harvest technology and provides technical assistance to the fish processing industry in the region. The technology developed is transferred to the industry through training courses demonstration courses and publication of technical manuals (Table 1 and Figure 1). The main success of this technology transfer programme has been through the demonstration of technology directly to the fish processors, nominated by each member country, during the lecture-demonstration courses. Subsequently, technical personnel (supervisors, etc) receive further training through the regional training courses in fish processing and packaging.

Soon after the introduction of surimi technology in 1980 by MFRD, the surimi industry in the region started to develop. There are now 14 surimi factories in Thailand with a total production of about 50,000 t/year with 90% exported to Japan and South Korea. The remainder is exported to Singapore and Malaysia. These factories produce surimi from threadfin bream, bigeye snapper and croaker. Some factories also produce lizard fish surimi but generally of lower quality. The main problem facing the Thai surimi industry is the supply of raw materials. With the over-exploitation of the resources in the Gulf of Thailand, the fishing fleet have to go to further away, leading to lower quality raw materials for surimi production. Most of the surimi producers have therefore gone downstream to produce value-added products like imitation crabsticks for export and other surimi-based products (fishball, breaded fishcakes, cuttlefish ball). There is also a joint Thai-Indonesian venture using a surimi factory ship (production capacity of 40 t/day) operating in the eastern Indonesian waters. A new surimi plant was also established recently in the Aru Islands in the Indonesian Iran Jaya Area.

The surimi industry in Malaysia started off later and by 1990, there were three surimi factories (each with a capacity of 5 t/day) in East Malaysia, and two on west coast of Peninsula Malaysia. A new 5 t surimi factory started operations in the east coast of Peninsular Malaysia in 1995. A Japanese imitation crabstick factory was established in Malaysia in the late 1980s, sourcing the surimi from factories in southern Thailand and Malaysia. Recently, the local fishball-fishcake industry in Malaysia have realised the advantages of using surimi and have acquired equipment for preparation of leached fish meat for local use.

Since the early 1980s, there has been tremendous growth in the fishball-fishcake industry in Singapore, both in productivity and mechanisation. During this period, the MFRD introduced the technology for production and use of surimi for production of fishball and fishcakes, including the use of related machinery.

Coupled with the development of the surimi industry in Thailand, the fishball manufacturers were able change from use of fresh fish to surimi. Singapore now imports about 4,500 t of surimi per year. This has enabled them to upgrade their processing technology and invest in machinery to increase their productivity. There are now about 50 fishball-fishcake manufacturers producing about 50 t of products per day, mainly for local consumption. The largest

factory now uses surimi from Thailand and Malaysia to produce about 4.5-5 t of products per day and have invested in the use of silent cutters, automated forming machines such as fishcake forming machines, chikuwa forming machines and an automated fishball forming-setting-cooking and chilling line. A local manufacturer produces about 2-3 t of leached meat per day from frozen threadfin bream and bigeye snapper for daily distribution to local fishball manufacturers. To remain competitive and because of the high cost of labour, the Singapore manufacturers have to automate to increase their productivity and quality of their products. Manufacturers are also looking at the export market, especially of frozen fishball and cuttlefish ball to Australia, Japan and the USA. However, manufacturers will have to pay attention to product development, product modifications and improved packaging and shelf-life to be able to compete in the international market. Several Singapore manufacturers have also invested overseas and have established fishball-fishcake factories in Malaysia and China.

IMPLEMENTATION OF QUALITY CONTROL MANAGEMENT PROGRAMMES

With the rapid expansion of export-oriented fish processing industry in south-east Asia, there has been a corresponding emphasis on the implementation of quality control management programmes both from the industry as well as from the government institutions. In this respect, the fish processing industry in south-east Asia works closely with related government departments for guidance and technical assistance is upgrading processing line control to ensure consistent quality and safety of their products. The Department of Fisheries of Thailand, Indonesia, Philippines and Singapore work very closely with the industry in the understanding and implementation of the concepts of GMP and HACCP. Memorandums of Understanding have been drawn with inspection agencies of USA, Canada and the EU on the implementation of these concepts leading to accreditation of inspection agencies and fish processing plants and to promote trade of processed fish products from the region to these countries.

The ASEAN-Canada Fisheries Post-Harvest Technology Project was started in 1992, with emphasis on strengthening and upgrading fisheries products quality control and fish inspection services with ASEAN countries; to assist in the development and implementation of improved methods and technologies in fish processing, preservation and packaging; and on the basis of regional collaborative efforts to enhance the transfer and adoption of appropriate technologies to the fish processing industry. This is done through training and extension services to strengthen government/industry capabilities and to improve information preparation and dissemination in the region.

The Project is coordinated and administered by the ASEAN Executing Agency (AEA) incorporated in MFRD/SEAFDEC. The project also established regional centres for fish processing technology (RC-FPT, Singapore) fish inspection and quality control (RC-FIQC, Indonesia) and information preparation and dissemination (RC-IPD, Malaysia). Each ASEAN country also conducts two project activities.

Brunei Darussalam:

- Mechanisation and quality control of small and medium fish processing plants.
- Developing technologies for processing underutilised fish species into value-added products.

Indonesia:

- Improved quality control for fresh and frozen shrimp.
- Improved quality control for fresh and frozen tuna for sashimi or frozen for canning.

Philippines:

- Development and improvement of breaded shrimp/surimi products.
- Improved handling and grading technology for cephalopods.

Singapore:

- Developing battered and breaded fish products from surimi and fish mince.
- Identifying suitable packaging techniques and materials for packaging of breaded fish products.

Thailand:

- Controlling decomposition of tuna and tuna products.
- Improvement of aquaculture shrimp quality.

In addition, the Project is also preparing an HACCP training curriculum for use of the government institutions and the industry to train their personnel in the implementation of HACCP in fish processing. In the area of fish technology, the Project has assisted in the development of a textured breaded and battered product using as one of its ingredients low-valued or under-utilised species of fish. This technology is now being used commercially. Additionally, the Project has helped in the development of various value-added products for use by cooperants in the region.

In the area of fish inspection and quality control, the Project has been more active. It has assisted the region in the following areas:

Training: in-Canada training regional workshops (2 from each country)
- *fish inspection, microbiology, good laboratory practices, chemistry (antibiotics/pesticides), HACCP in microbiology, sensory analysis.*

Activities: (incorporating GMP's and HACCP):
- *canned tuna, sashimi and frozen tuna (on board), processing and shipping), farmed shrimp (quality practices for farmers), shrimp processing, and cephalopod handling.*

The Project has supported the Canadian DFO activities in assisting various countries (particularly Thailand & Indonesia) improve their fish inspection systems. The results of improved inspection by Thailand are remarkable, and Indonesia is now incorporating a new system of inspection based on the Canadian QMP.

Most of the Project's success has been on a national level, building on information gained through the national activities. The Project is trying to expand this base to all ASEAN countries through a program of information dissemination.

All the activities will have a manual developed and printed, and a regional demonstration conducted so that the information may be shared. All the activities are expected to be finished by March 1997. As the activities are very specific, a series of information packages or video/workbooks are being developed for use by everyone within ASEAN on general processing requirements such as hygienic fish plant construction, equipment hygiene and design, fish plant hygiene and sanitation, personnel hygiene and HACCP

The Project is supporting the development of an ASEAN Network of Fisheries Post-Harvest Technology Centres of which there are several programs:

i) regional split-sample testing between fisheries laboratories

ii) electronic information exchange through the Internet - maintenance of a website at httjp:/www.asean.fishnet.gov.sg.

iii) harmonisation of quality assurance programmes in the region, through the development of a HACCP curriculum. The Project is supporting an ASEAN HACCP Curriculum Development Working Group which is putting together packages for Managers, Supervisors (Non-QC & QC), and Line Workers. These packages should be available in March 1997.

The Project is scheduled to end in March 1997. This Conference has provided an opportunity for the transfer of information developed by the Project to the industry.

SEAFOOD TRAINING
The Missing Link

By Dick Lee[1]

Abstract

The paper reviews seafood training facilities and opportunities in the United States, New Zealand and Australia.

Seafood training in Australia is described in relation to the National Training Reform Agenda and in comparison with other industries. A more detailed review of training in Queensland is provided with an emphasis on the role of the Queensland Fishing Industry Training Council, Industry Associations, Government Departments and Private Providers.

New initiatives in the retail sector, in supermarkets and in quality assurance are explored and the paper concludes with an assessment of the current status of training in the industry and suggestions for the future.

Keywords: Training; Australia; USA; New Zealand.

In my experience, topics dealing with training at a seafood conference are relegated to the last session of the last day to coincide with the free seafood tasting and the post seminar cocktail party. I am relieved that the snacks and drinks have not been offered today and I can look up and see almost a full house.

Training in the seafood industry can be compared to a new airport or a suburban access road - everyone will tell you how important it is and how much it is needed, but put it somewhere else - let somebody else have it. In political terms, seafood training is a NIMBY - a Not In My Backyard.

Regrettably, training in the seafood industry does not share the high profile of value adding, sashimi or aquaculture.

During this seminar, speaker after speaker has optimistically and enthusiastically described new techniques, processes and methods to upgrade the industry to meet future demands. It is certainly not my intention to disparage these suggestions or question the goals. I agree with them 100%. However, may I suggest that the predicted and hoped for beneficial change in the industry will not be achieved or at least will be severely retarded by a lack of attention to the skills of our most valuable resource - the crews on the boats, the workers in the factories and the staff in the shops and restaurants.

I intend to briefly compare the seafood training scenes in the United States, New Zealand and Australia looking for patterns, similarities and parallels. Are there any best practice models? I will review some new and current seafood training initiatives and programs here in Queensland.

Finally, I want to propose a strategy, based on our familiarity with the grass roots of the industry, to achieve the end results discussed at this symposium. Of course, I want to stress training as a fundamental component of that strategy.

I want to demonstrate a link between "what is" and "what could be" in the seafood industry. That link is training and to a very great degree that link is currently missing.

Quite often in the classroom or on the job or towards the end of a symposium such as this, a little humour helps to lubricate the learning process or at least relieve the boredom - but humour relevant to the seafood industry is not a common commodity.

I have always been interested in humorous newspaper headlines from around the world. There are very few relating to seafood.

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Headlines
- Eighth army push bottles up Germans
- Brisbane broken down by age and sex
- Chip shop owner battered man
- Icelandic fish talks - not likely

In many areas, we look to the United States as a model to follow in industry and the community. With respect to the seafood industry that perception is often not correct. Our fisheries and seafood and the management of the industry often serve as models for the Americans and others. The Northern Prawn Fishery is a good example of this.

With regard to training and development, however, there is little doubt that some of the American facilities and programs are first class. An hour on the Internet produced an amazing range of services, information and procedures dealing directly with seafood.

One program that recently caught my attention was the Seafood Splash course advertised by the Food Marketing Institute and the National Training Branch of the National Oceanic and Aerospace Administration (NOAA). The course was billed as "hands-on training programs for store-level seafood department personnel" in this case supermarkets. Please have a good look at the content and the course characteristics as I want to compare these with New Zealand and Australia later.

Seafood Splash content
- Quality - Sanitation - Handling - Promotion - Profitability
- HACCP Principles - Profitability
- Reduce shrink - Maximise sales

Portable - tailored to individual companies
Industry tours - labs, lectures & skill building

Programs developed quite independently in this country are very similar in content and approach.

New Zealand has a very progressive, efficient and successful seafood industry. Training appears to have been an integral component for some time. The New Zealand Industry Training Board was producing training aids such as Seafood Sense - An Handbook for Fish Retailers as far back as 1983. This volume was the standard then and is still the bible for many retailers in this country.

Seafood Sense
- Consumer Attitudes to Fish
- Fish Quality
- Hygiene and Sanitation
- Business Management
- Shop Presentation
- Cooking for Takeaways
- Advertising and Promotion
- Trends in Retail Packaging

The New Zealand Seafood Industry Training Organisation is currently promoting a National Certificate in Seafood Retailing as one of their programs.

National Certificate in Seafood Retailing
- Marketing
- Promotion
- Cleaning and Sanitation
- Display techniques
- Product knowledge
- Seafood quality
- Cooking for takeaways

The delivery method for this program is notable for the attention to a career structure.

National Certification in Seafood Retailing
- Distance learning
- Career in seafood retailing
- Practical exercises
- 3 - 4 months duration
- Nationally accredited

Once again notice the similarity of content with the American program.

In the 1980's, Australia revised the national education and training network and the National Training Reform Agenda was born. Work clever, not harder became the catch cry. From a torrent of training activity, the introduction and wide spread acceptance of competency based training (CBT) has had particular significance for the seafood industry. Prior to this, seafood training was based on traditional schooling methods, the way most of us received our education. Programs were of a specific duration and progress was time based.

The seafood industry is very practical in application. How do these traditional education methods rate when training a person to perform specific job related skills?

Imagine a trawler skipper who is required to upgrade his Certificate of Competency to drive a bigger boat. Traditionally, he would enrol in a 3-4 week course at a Technical College.

Training individuals to perform specific, job-related skills

- Will successful completion of all sessions of the course ensure the skipper can drive the bigger boat?
- If he misses 2 days of the course, does this mean he cannot drive the bigger boat?
- At the end of the first week he does poorly on a written test. Does this mean he cannot drive the bigger boat?
- If he achieves a pass mark on all the written tests does this mean he can drive the bigger boat?
- If he achieves 60% on the final exam does this mean he is proficient only in 60% of his job?

Does that type of system meet our demands in the seafood industry??

A competency based training program on the other hand focuses on the competencies gained by the individual rather than on the training process itself. In this example the focus is on the specific skills needed to drive the bigger boat.

Competency based training key elements (1)

- Competencies identified, verified
- Criteria assessing achievement and the assessment conditions explicitly stated.

Competency based training key elements (2)

- Individual development and evaluation of each of the competencies
- Assessment requires actual performance of the competency.
- Participants progress at their own rate (time not important).

For our Skipper, all the skills needed would be identified to a national standard. The Skipper's ability to accomplish the skills coupled with his knowledge and attitude would demonstrate his competency. When satisfactorily assessed under agreed conditions to the standard required the Skipper would be considered competent to drive the bigger boat.

The Queensland Trainee Commercial Fisher course is a good example of a program in the transition phase from traditional to competency based learning. This course is the entry level for the commercial fishers in Queensland. To be awarded a Commercial Fishers Licence a person must complete examinations in five subjects, obtain a certificate of competency for an appropriate vessel and complete two years of log book verified time in the fishery.

Trainee Commercial Fisher

1. Fisheries legislation
2. Seafood handling
3. Net and gear technology
4. Business practices
5. Fishing industry environment
6. Manning certificate
7. 23 months experience

Until now the only courses available for the Trainee Commercial Fisher have been offered by the public provider TAFE and some private organisations to a syllabus devised by the education and marine authorities. Consequently, the training program itself took priority over the training of the individuals. This posed particular difficulties for commercial fishers including working in areas and at times which conflicted with the provider. Travel and accommodation expenses were met by the fishers and there were many skills which were not recognised by the system.

The introduction of CBT to the Trainee Commercial Fisher program would involve substantial change and make the training far more relevant to the industry.

Trainee Commercial Fisher

- Time irrelevant
- Training on the job
- Assessed by industry assessor
- Lends itself to RPL
- Competent when task done

CBT has been welcomed by the seafood industry in Queensland in a couple of areas and there is an active program to apply the new training strategies. The Queensland Fishing Industry Training Council Inc., our peak training body, has applied them to the catching sector. The Council is currently establishing a system of industry trainers and assessors throughout the State with industry support and the encouragement of the Authorities.

The first Train the Trainer and Assessment Training programs for industry members will be conducted in Bundaberg in August 1996 in association with the Trainee Commercial Fisher Course pilot.

In the secondary sector in Queensland, training continues to lag behind the catching sector and other industries. Training has been sporadic, unco-ordinated and often conducted in-house by the Manager or Supervisor. Predictably, requests for assistance from established training providers has come, almost exclusively, from different ends of the spectrum, on one hand from the large successful seafood companies and on the other from small owner operators seeking to minimise the losses from their new venture in seafood.

Transed and Queensland Seafood Trainers and Consultants (QSTAC) joined forces to develop and register with the Training Authority a comprehensive practical, competency based Seafood Handling Course. This course is portable, flexible and adaptable and has provision for RPL. It is conducted under a QA program with a Code of Practice, Refund Policy, Grievance procedures etc.

This course was developed by industry to meet their perceived needs. Note the similarity with the courses from the United States and New Zealand. This course has been conducted in-house, on weekends and early mornings. It has been modified to meet the needs of specific clients. The course has been particularly successful as noted by the testimonials of satisfied clients.

To summarise, the content of the Transed Seafood Handling Course has been developed in close consultation with industry. It is what they demand. Being a recognised program the course is eligible for substantial assistance with Government funding. It is portable, flexible, adaptable and inexpensive. It's the industry course!!!

Now! Have we been inundated with requests to run this courses?? Are we flat out enrolling students?? Have we given up our day jobs??

In August last year, 50 offers were made complete with proposals to assist with funding requests. Employers in most cases would meet around 20% of the training costs. One reply was received from a person who had just bought land for a seafood factory.

In October, 140 approaches were made to enrol additional numbers for a course in Brisbane. There were no takers and the course was postponed.

Training in the retail seafood sector does not enjoy a high profile.

Transed & Queensland Seafood Trainers and Consultants - *Seafood Handling*

- The SEAFOOD INDUSTRY
  Brief introduction to the Seafood Industry.
- SEAFOOD SPOILAGE
  General causes of seafood spoilage
- SEAFOOD QUALITY
  QA systems including FPA
- CHILLING, FREEZING and THAWING
  Principles and best practice in chilling freezing and thawing seafood
- HEALTH, HYGIENE and SANITATION
  Cleaning, sanitising and personal hygiene
- PRODUCT CARE
  Techniques and best practices
- SEAFOOD DISPLAYS
  Techniques of displaying seafood
- SEAFOOD RETAILING
  Customer relations, effective seafood selling techniques and marketing principles

Testimonials

- *"... compliment you and your staff on the recent Seafood Handling course..." "...one of the more worthwhile courses we have participated in."*

  Cameron Maclean, A. Raptis & Sons

- *"...One of our staff has been in the seafood industry for most of her working life and had a good knowledge of seafood handling and general management of seafood." " ... surprised at how little she really knew:" "...$ saving from improved fresh product purchasing and storage."*

  Michael Bull, The Fish Trap, Caloundra

- *"I would have no hesitation in recommending this course to any people employed in the seafood industry. It is suitable for all, no matter how many years they have been in the industry."*

  Ian Baulch, Deep Sea Fisheries

During this seminar, we have been introduced to examples of world best practice and excellence and complex, intimidating problems that are characteristic of this industry.

Where do we go from here? Will the industry contemplate the results of this and other seminars in isolation until another conference next year? Or will the industry, collectively, accept the responsibility for their own future?

I believe the latter will occur but it requires a scheme, a strategy firmly grounded in the grass roots of the industry.

There are three obvious areas in which a sustained effort will yield a return.

The Retail Sector

This is the shop front of the industry. Where better to concentrate on increasing seafood consumption and establishing seafood as a serious contender in the contest against beef, chicken, dairy foods and the inevitable fast food.

RETAIL SECTOR

- **Promotion**
  - convenience
  - target the new lifestyle
  - health
- **Activities**
  - demonstrations
  - tastings in-store - chicken, meat, pork, lettuce
  - cooking demos - stress the simple easy meals - fried fish
  - cheaper cuts of fish - Mullet Provencale
  - trendies - cafe society - smoked gar
  - Orange roughy - white, skinless, boneless and tasteless - look for the mouth feel, the texture - the taste is in the sauce
  - use seasonality of the industry as a plus - seafood on the beach done to death, what about a nice chowder around the fire
- **Customer Service**
  - boneless
  - recipes
  - advice

VALUE ADDING

- **Value adding**
  - Fish stock - appropriate size - frozen
  - Mullet roe - smoking
  - Marinated fish fillets
  - Seafood marinara mix
  - Breading for home consumption - instructions on how to cook
  - Fresh vs frozen - what's wrong with frozen - leave it frozen, teach 'em how to thaw
  - Seafood kebab - prawn, scallop, fish
  - Reef & Beef - JV with a butcher; carpetbag steak; fish sausage - count the examples of value adding in Lenard's
  - Whitebait
  - Small diver whiting - eat whole like smelt - get your calcium in one hit
  - Fish balls
  - Stuffed calamari tubes
  - Branded - Ocean Pride
- **Ethnic communities**
  - Milkfish and oxeye herring - prepare for table by soaking overnight in vinegar and pressure cooking - flesh still flavourless - big aquaculture fish in the Philippines for rapid growth and as a protein source
  - Saurids - the grinners - large specimens are quite good eating
  - Sushi
  - Sashimi
  - Sting ray flaps
  - Dulse
  - Manta shrimp - prawn killer
  - Jellyfish

AQUACULTURE

Fishers threatened - "Say no to drugs - Don't eat farmed fish".

Aquaculture is not the enemy but a substantial partner in the future.

Greener way to go
Safer to eat
Consistent flavour and supply
Predictable price.

Finally and as a precursor for this strategy to work, we must implement basic, fundamental training across every sector of the industry from the water to the plate. We know what is required. We know what will work from the experience of three nations. We have to take the initiative to implement it. We have to do it!!

Training Strategy

- Product knowledge
- Quality, Quality, Quality!
- Hygiene
- Produce care and handling
- Customer relations and service

- Portable
- Flexible
- Adaptable
- Competency based

CONCLUSION

In conclusion, we are faced with a fundamental principle. We cannot make bad seafood good. To achieve the goals that this seminar has outlined every individual in every sector must be given the resources to accept the responsibility to inject quality into this industry. That's the bottom line. Training is an important component of any quest to make the most of the catch.

PRODUCT MODELLING
The seafood industry production chain

By Stella Jónsdóttir[1] and Johan Vesterager[2]

Abstract

The paper addresses the aspects of Concurrent Engineering (CE) as a means to achieve integrated product development in the seafood industry. It is assumed that future New Product Development (NPD) in the seafood industry will shift from being retailer driven and reactive to be more company driven and proactive to comply with the increasing competition, in such a way that the seafood processor will create new products covering both the current and especially latent future consumer demands. This implies a need for a new systematic approach to NPD which integrates assessments and speeds up the process. The objective, therefore, is to estimate the suitability of CE, and, especially, CE through product modelling. This paper describes how the knowledge and information of a seafood product can be modelled by using object oriented techniques. The applicability of product models in seafood industry is examined in a case study carried out in a Danish herring production chain.

Keywords: Product Modelling, Product Development, Seafood Industry, Concurrent Engineering.

INTRODUCTION

The seafood production chain covers the whole chain from catch to end consumer. In general, the important factors influencing competition are quality (i.e. freshness, chemical composition, taste etc.) and flexibility.

Historically, the situation of the industry as to introduction of new products can be described in this way. Before, the seafood producers pushed new products through the supply chain with only partial consideration of or information on customer demand. Today, the general picture is that the customers or the retailers pull through new products - the retailers using information from their sales and planning systems as basis for decisions. Producers in this way are in a reactive position. In the future it is expected that the producers in order to survive will move into a proactive position. This means that producers will have to take responsibility for new product development based on systematic market analysis and identification of new latent customer demands. This often will require a close co-operation with as well raw material suppliers as retailers. But, first of all, it requires that the producers improves own product development processes. By doing so, producers will be able to face and take advantage of the increasing interests by consumers in receiving information on quality aspects like safety, sensory quality, convenience and various aspects of how the product is produced (Jelsøe *et al. 1993*; The Ministry of Agriculture 1994; PA Consult 1994).

The aim of this paper is to discuss the use of Concurrent Engineering in seafood product development as an approach to make future product development effective considering the above mentioned challenges. In particular, the paper will deal with product modelling as one of the methods for achieving concurrent engineering. A draft of a proposed product model to support the product development of marinated herring products will be presented.

In this paper, product development is defined as:

> *New Product Development (NPD) is the development and introduction of a product not previously manufactured by a company into the marketplace or the presentation of an old product into a new market not previously explored by a company. These new products can be classified as line extension (a variant of an established product), new form of existing products, repositioning of an existing product, reformulation of existing product, new packaging of existing product, innovative or added-value products and creative products* (Fuller 1994).

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CONCURRENT ENGINEERING

Increasing competition has forced industrial companies to look for new means of improving the quality of products, decreasing production costs and reducing the time for product development.

One of the means used to meet the challenges is to introduce CE, (i.e. make efforts to better integrate the activities in the whole product development process). Several definitions of CE are described in the literature, though most of them are based on the definition given by the Institute for Defence Analysis in the USA: *"Concurrent Engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from conception through disposal, including quality, cost, schedule, and user requirements"* (Tuxen *et al.* 1993). Other terms as Integrated Product Development and Simultaneous Engineering are synonymous.

The approaches to CE can be placed in two groups: CE approaches without information technology (IT) support, (e.g. team approaches, handbooks, qualitative and quantitative procedures (as checklists etc.)), and quality oriented methods (e.g. Quality Function Deployment and CE approaches with IT support, for instance database technology, simulation and expert systems) (Arturo *et al.* 1995; Tuxen *et al.* 1993). The different CE means – organisational or IT based – do not exclude each other. On the contrary, a systematic design of the NPD process has to exploit all possible means in the right mix. But, today it is hard to imagine a systematic NPD process not in one or another way supported by IT.

In this paper, the emphasis is on CE approaches with IT support with focus on how IT-applications based on product models can help the product developer to:

1. foresee the consequences of decisions made early in the development process;
2. manage the specification of seafood products including quality documentation; and
3. meet regulations and other public demands.

Furthermore, an IT-application is supposed to provide easy access to all relevant information. So, relevant activities related to defining the demands of the customer, determining raw material needs, investigating official regulations, defining packaging material, labels etc. can be carried out almost at the same time or concurrently.

PRODUCT MODELLING

Definition and application

Product modelling is the development of a system model which secures the integration and reuse of knowledge and information in different phases of the product development process. The model based integration of the different life-cycle phases opens up for a more systematically formalised assessment of alternatives as regard product development as a part of the entire chain. In consequence, the quality of the products can be better managed, e.g. decisions on purchase of raw materials and choice of processing methods can be better co-ordinated. In this way, a *Product Model* is a relevant description of a specific product in a specific context. In this context, product models can form the basis of an IT application used to support the NPD of a seafood product.

In principle, product models are not new, for instance, a product specification is a model of a product. But two aspects are new. First – the development of richer product models including contextual knowledge on how specifications are produced. Secondly, the integration or linking models from the different life-cycles phases. Furthermore, new possibilities emerge due to the rapid development in IT as regards applications for processing product specifications, documentation and retrieving of knowledge. A comprehensive effort has been put into development of non-food oriented product models for computer based product specification support. The product models have different purposes, for instance, documenting different development decisions and exchange of data between different computer systems (Hvam 1996). Regarding the food processing industry some effort has also been spent on, e.g. developing computer systems for microbiological risk assessments, and systems able to predict micro biological growth in food products (Jakobsen 1995). Also Schönkopf *et al.* (1996) have reported about an application (software) utilising principal component analysis of variance combined with sensory evaluation in order to systematically develop new food products. The quality assurance in a seafood plant can also be supported by an application for management and documentation of the quality (Datakvalitet 1995). An application based on product models will, compared to the mentioned applications be more process oriented (i.e. it will include how to make product specifications and documentation in product development).

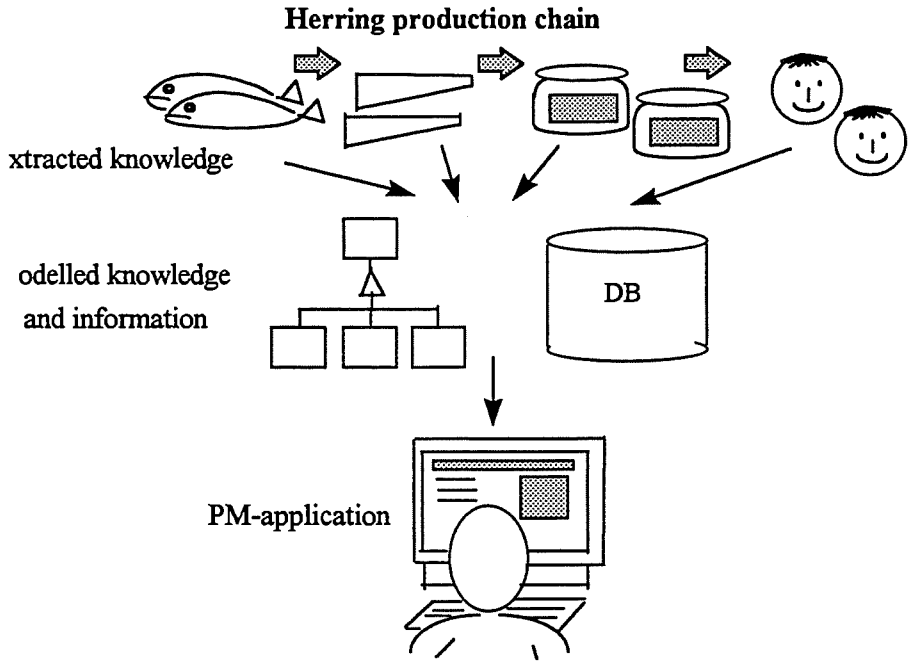


Figure 1: Application of a Seafood Product Model with regard to product development

Seafood product model

A seafood product model is a relevant description of the product in the entire life-cycle, from raw material to end product. Thus, the product model system is based on extracted knowledge and information from the entire chain from catch to end-consumer. Figure 1 shows a sketch of a product model and its use.

This product model should capture the attributes that are relevant for describing a product and the knowledge required to generate the seafood product specifications, quality plans and other documentation.

Product modelling as a tool to achieve CE in seafood product development

The main tasks in seafood product development are to develop new products, both line extensions and creative new products. The line extensions are based on the activity of creating new variants of existing products, for instance adapting products to new markets or raw materials. Consequently, the line extension development is very much based on reuse of information and knowledge. For this reason, some of the tasks can be appropriate to support by product models. It is assumed that by making an IT application based on a seafood product model the product developing time can be reduced and quality enhanced. The main reason for the expected controlled and shorter development time is the fact that access to and use of formalised knowledge often speed up the process of retrieving and processing information on products, raw materials, production processes etc. It is assumed that the saved time regarding line extension development can be spent on development of new products.

NEW PRODUCT DEVELOPMENT IN THE HERRING PRODUCTION CHAIN

A case study is carried out in a herring production chain in order to evaluate the potentials and prospects of how tasks in seafood product development can be supported and improved

The herring production chain

The herring production chain consists of:

1. A fisherman or a vessel which catches and delivers the herring to the 1st processor.
2. The 1st processor produces pre-marinated herring fillet.
3. The 2nd processor produces the end-product, i.e. slices, marinates and pack the product for then to distribute the products to the retailer
4. The retailer finally offers the products to the consumers.

This is illustrated in the Figure 2.

The case study is based on a co-operation with the 1st and 2nd processor and co-ordinated with a retailer in Denmark. The ongoing analysis of the product development is based on activities carried out at the 2nd processor.

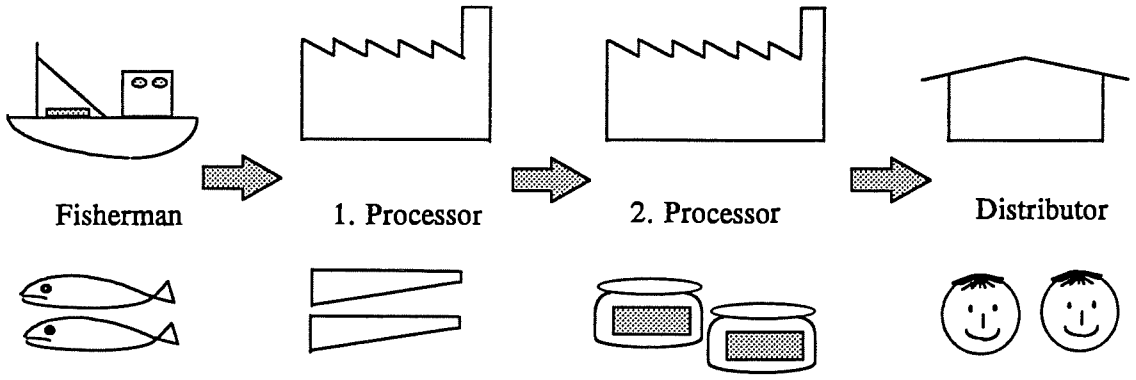


Figure 2: The herring production chain

The critical goals for the new product development

The critical goals for seafood product development is development time and product quality. In general, the amount of new variants of existing line products is increasing, due to different customer or retailer demands. The management of all these product consequently requires more time spent on administration of specifications etc. The consequence is increased costs and less time for development of new products.

Current NPD process

Today, the development work is carried out by employees from the market department, product development department and production department in co-operation with the quality manager and the staff at the laboratory. An analysis of the existing NPD functions is shown in an ICAM DEFinition (IDEF0) model of the technical product development. (See Figure 3)

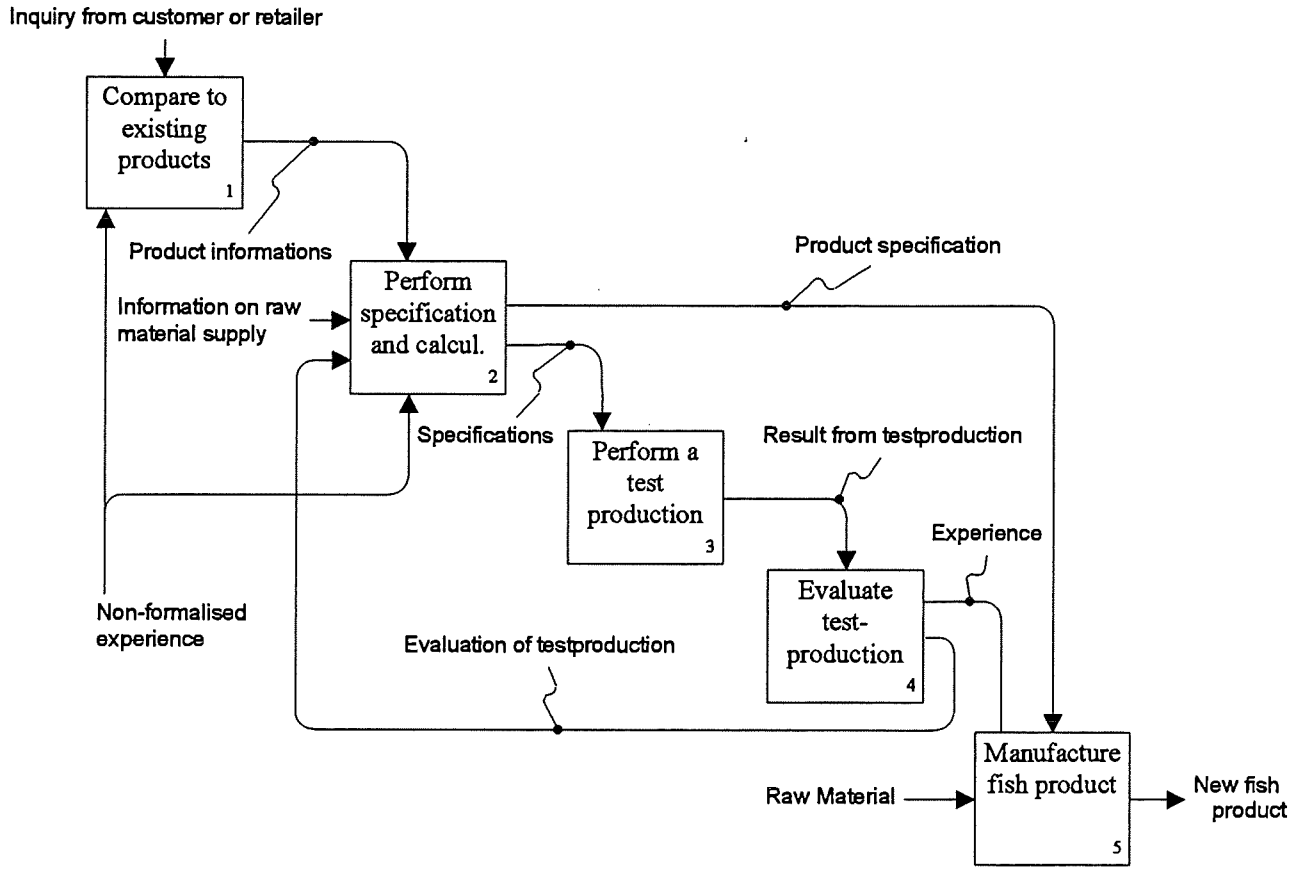


Figure 3: IDEF0 of the existing line extension product development. (A0 - second level of the decomposition) (As it is today)

The IDEF0 model shows the generic functions (boxes) involved in the line extension development. The first activity, *Compare to existing products,* covers the activity of retrieving information on a product similar to the product requested. The next step is to *Perform specification and calculation,* based on information on raw materials available and on the current production facilities. If the chosen raw materials and production processes are very much alike existing products, the product specification can directly be passed on to production. Otherwise a *test production* is carried out on the basis of a pre-specification. Results from the test production are then evaluated. The specification is modified in accordance to the results from the test production in a repeated loop as often as needed.

This process can be illustrated by an example. A retailer wants, a reduction of salty taste in a product. On the basis of this request, the product development team makes a pre-evaluation which among other things covers a feasibility-study of the request in question. The feasibility study includes a search of similar products in the existing product specifications archive and relevant regulations concerning the raw materials, processes, shelf-life etc. Then, the conditions for the raw materials and the processing parameters are described in a draft specification for a test production. The test product is evaluated by the laboratory with sensory, chemical and micro-biological methods. The draft specification is then verified and the prototype product is sent to the retailer for further evaluation. If the new product is accepted by the retailer, a new product specification is written, and then the product can be produced and launched to the market.

Product model for development of marinated herring products

In order to develop an application based on product modelling, there is a need for methods and techniques to model this knowledge and information. The modelling of the different life cycle phases of the product, raw materials, manufacturing, distribution, etc. is carried through by use of object oriented analysis (OOA) and object oriented design (OOD) techniques (Coad & Yourdon 1991).

A marinated herring product model is shown in the Figure 4. The boxes represent the objects. A triangle means "a part of" relationship: in other words, the marinated herring product consists of: Packaging, raw material (pre-processed herring), marinade and garniture. A half circle denotes a "one-of-a-kind" relationship, as shown for the process sequences which can result in an A- and B-product with different processing methods.

The attributes and methods of each object are modelled in a CRC-card (Class-Responsibilities - Collaborations). The CRC-card was originally introduced by (Beck & Cunningham 1989), but later modified by (Hvam 1996) and (Christiansen 1995). An example of the Raw Material object is shown in Figure 5.

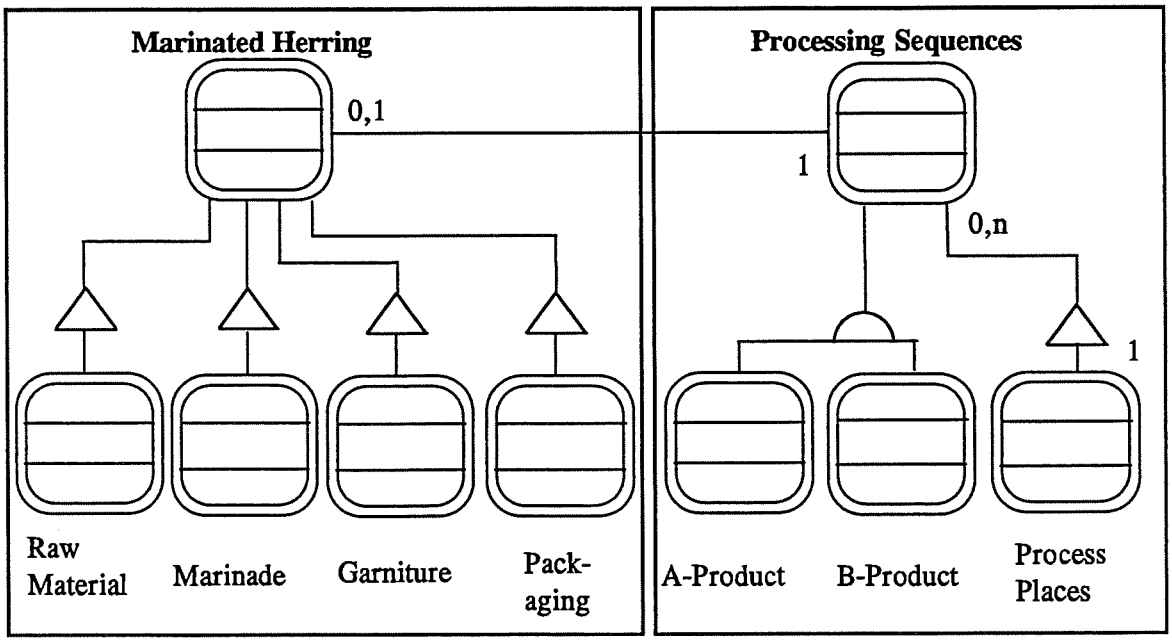


Figure 4: An OOA model of a marinated herring. Notation according to (Coad & Yourdon 1991)

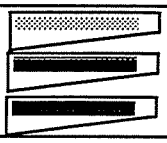
List of superclass	**List of superparts** Marinated Herring no 1
List of subclass	**List of subparts**
Sketch 	Silvermirror = 1 Silvermirror = 2 Silvermirror = 3
Responsibilities Information on possible suppliers on raw material	**Collaborations** Process Sequenses (No 4)
Knows (Attributes) Size of fillets[30...500]g Size of bites[10...100]mm Sensory index [0,1,3] Fat content (3...20)%	**Does (Services)** Determine no of bites pr fillet Determine "fit for production"

Figure 5: A CRC-card (Class-Responsibilities -Collaborations) of the Raw material object shown in figure 4

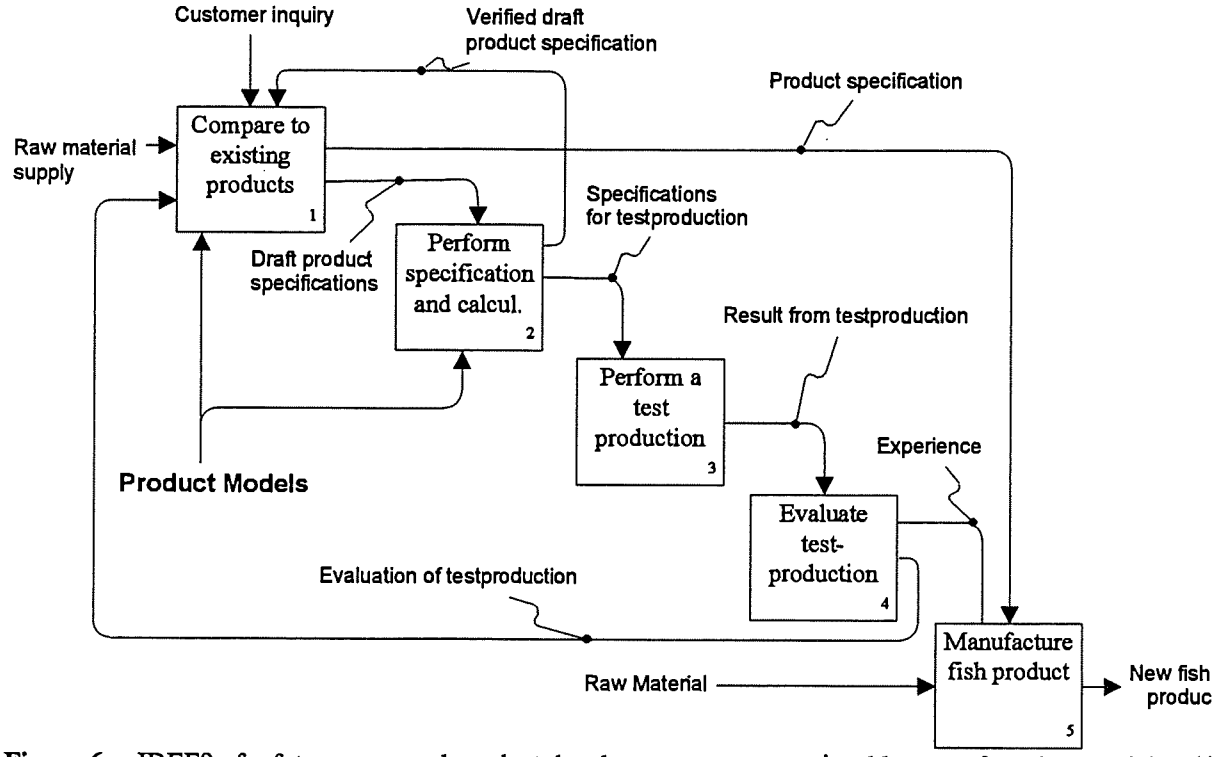


Figure 6: IDEF0 of a future proposed product development process assisted by use of product models. (A0, a future system, as it is proposed to be)

The above shown OOA-model and CRC-card are examples of how the seafood product "marinated herring" can be modelled. The model is a results from the on-going case study and is planned to be detailed in order to learn more about product development.

Product models as a means to support the development of marinated herring

Compared with the present process, a future proposed product development process assisted by the product model is shown in Figure 6.

Future proposed NPD process will be supported by product models in the first steps of the process. Furthermore, the use of product models will enable a fast optimisation loop between the first two functions. It is expected that the use of product models in handling the specifications and the knowledge on production processes, raw materials, quality specifications, national regulations etc. will speed up the process of preparing the product specifications.

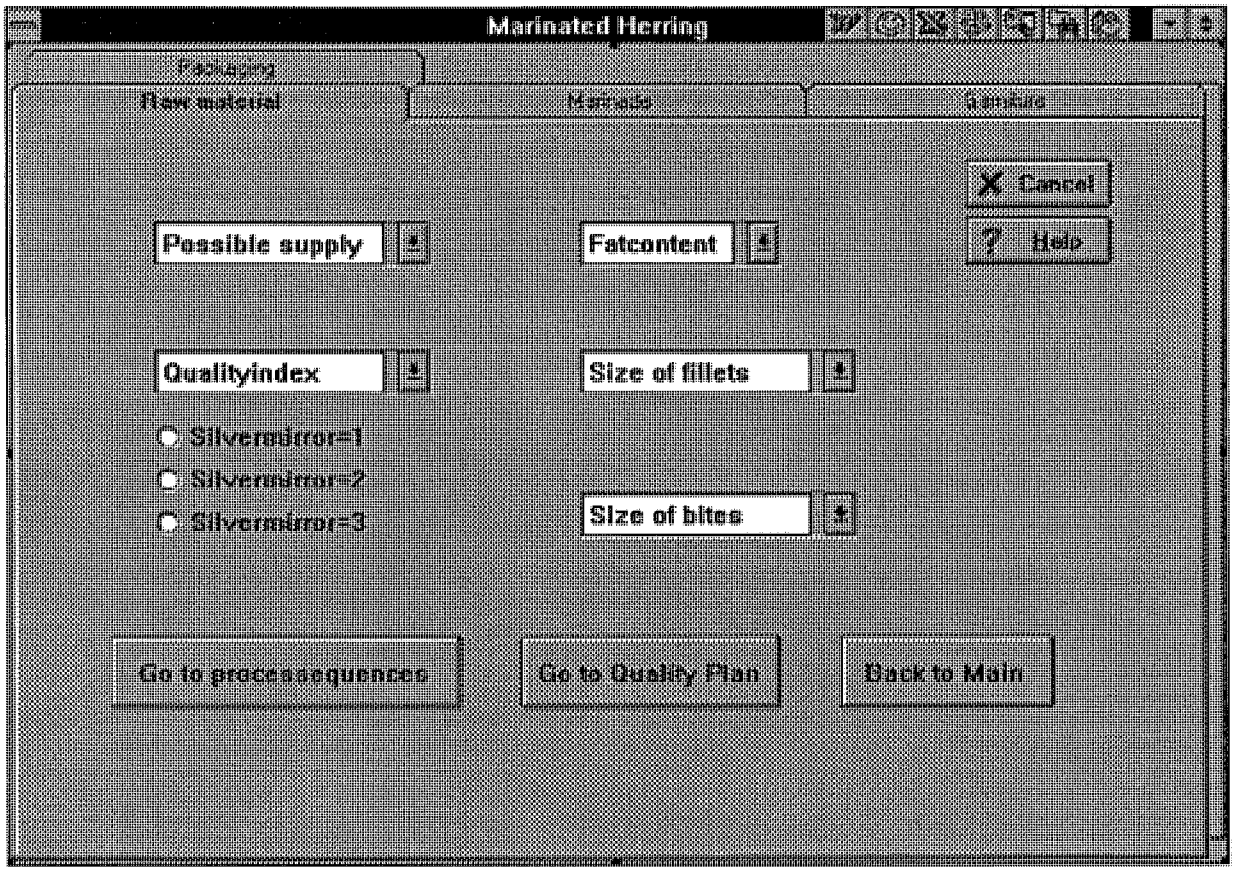


Figure 7: An example of a user interface

It is assumed that greater effectiveness will result from giving the product developer a tool which provides a greater overview and understanding of the match between raw materials, products and processes. The access to information in the entire organisation, i.e. marketing and purchasing people can use the relevant information at an early stage in the product development process and thereby foresee the consequences of decisions made early in the process.

Regarding the application of product models, the product developer will access relevant information and procedures for the product development activities stored in a database linked to different interfaces. A proposed application for how to choose appropriate raw material for a specific product is shown in Figure 7.

In the above shown interface a "Raw material" page is shown. The interface is developed on the basis of the OOA model shown in figure 4 and the CRC-card in Figure 5. The different pages: Packaging, Raw Material, Marinade and Garniture are in accordance with the objects in the mentioned OOA model, and the attributes are the same as shown in the CRC-card.

CONCLUSION

This paper has discussed the aspects of CE as a means to obtaining integrated product development in the seafood industry. Increasing competition and changing conditions for product development forces the seafood industry to look for new means of improving the product development process. The suitability of the CE, especially, CE through product modelling, is examined. On the basis of a case study on a herring production chain, the paper describes how the knowledge and information regarding development of a seafood product can be modelled by use object oriented techniques. The proposed product model based on IT-application will support the product developer in developing line extensions of marinated herring products.

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THE INTERNET
The Asian fish technology network

By Peter Karim Ben Embarek [1]

Abstract

The countries of the Asia-Pacific region are among the world largest producers of fish products. A number of research institutes, universities, regional organisations and national fish inspection services are involved in the field of post-harvest fish technology. However, for these institutions, access to relevant information and data on fish products produced in the region are scarce and often difficult to obtain. There is little tradition for cooperative research programs. Furthermore information on tropical products or standards for tropical fish products are usually derived from information published or available in Europe, North America or Japan. However, regional organisations like the Asia-Pacific Fishery Commission (APFIC), the South-East Asian Fisheries Development Center (SEAFDEC) and others are working to improve the regional cooperation and flow of information in post-harvest fish technology.

In 1994, a regional research project on the utilisation of low-value fish species linking seven institutes in Asia and three in Europe was initiated. One of the objective of the project is to improve the cooperation among the fish technology research institutes involved. To contribute to this objective, a home page on the Internet called "Asian Fish Technology" was established in 1996. It is intended to provide information to encourage networking among the research institutes and university departments involved in the field of post-harvest fish technology in the region. Based on a presentation of this Internet site, the present paper will discuss the opportunities offered by this new technology to research institutions and its possible use in the Asia-Pacific region.

Keywords: Internet; World Wide Web; Technology; Asia-Pacific region.

INTRODUCTION

Origin

The origins of the Internet can be traced back to 1960's when the US Defence Department established a computer network that could continue to maintain communication even if part of it was destroyed (Blanchfield 1996). However, its true birth came in 1974 when a Californian professor developed the norm that could connect all the computers and gave it its name: Internet (Ramonet 1996). In the 1970's and 1980's academic and public institutions established several networks under Internet. In 1989, at the European Particle Physics Laboratory (CERN) in Geneva, a group of researchers developed the World Wide Web (www), a user-friendly interface to the Internet. At the same time, access to Internet was open to general use. Since then, its use has grown steadily and has literally exploded during the last two years.

Actually the number of computers connected to the Internet is estimated to be around 9.5m and it doubles every year while the number of Web sites doubles every three months. There is actually about 30m pages providing all kinds of information. While access to Internet is globally still very limited, the number of academic and research institutes connected is relatively high even in developing countries. In Thailand, more than 20 Universities and Colleges have already their own home page.

The Internet

The Internet is a growing network with new computers connecting to it everyday. It can also be described in terms of its facilities. The most useful are: electronic mail (Email), the www, mailing lists, search engines and databases. Access to the Internet requires a computer connected to a local network (University, organisations, etc.) or a computer and a modem connected to an Internet service provider through a telephone line. Provided that the service provider is in the same local phone area, all on-line connection time will be at local call rates no matter where in the world the information retrieved is located. This, makes the use of Internet much cheaper than the use of phone, fax or mail.

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The Internet is a mean of interrogating computers and databases throughout the world (libraries, universities, research institutes, organisations and companies that have chosen to act as servers) and to acquire or conveying data, text and files of all kinds (Blanchfield 1996).

The World Wide Web (www)

The world wide web consists of pages of text and graphics written in a format called hypertext markup language (html). The use of html permits words to be highlighted and to connect to other sites or other pages. Using a computer mouse to click on one of these words brings the reader directly to the site or the page the word is connected to. Thus, a home page can be a small web with different pages linked to each other and to external sites. In every field of interest, there is a vast amount of information available on the www (Edwards *et al.* 1995; Blanchfield 1996). A growing number of organisations of all kinds maintain home pages on the www. For example, The Food and Agriculture Organisation of the United Nations (FAO) maintain a home page on the Internet to provide information about its work and to distribute reports, documents and material which the Organisation produces. When accessing the FAO home page, an introduction and a table of content appears. All the points on the menu are accessible by a mouse click and brings the reader to the specific topic. The Fisheries Division of the FAO, maintains a number of services, (e.g. the complete catalogue of publications from the Fisheries Division is available as well as papers and reports from recent major conferences). In the beginning of 1996, a home page dedicated to fish technology in the Asia Pacific region was developed.

ASIAN FISH TECHNOLOGY HOME PAGE

The Asian Fish Technology home page is intended to provide information to encourage networking among the research institutes, university departments, regional organisations and national fish inspection services involved in the field of post-harvest fish technology in the region. The idea behind the development of the home page was to address some of the common problems faced by the fish technology research institutes of the region. Isolation is a major problem for these institutions. Regular contact with other researchers in the region are few, and access to up-to-date scientific literature is either difficult or expensive. It is also difficult to be kept informed in time on relevant events such as seminars, workshops and conferences. These problems are some of the topics which the home page is trying to overcome.

The home page has been placed on the server of the FAO under the WAICENT information programme. The site can be accessed directly at the following Internet address :

http://www.fao.org/waicent/faoinfo/fishery/asiafit/aft_pg1.htm

or through the FAO home page at :

http://www.fao.org

and then, choose the successive menu points "WAICENT", "Fishery", "Asian Fish Technology".

The site gives information on a number of topics.

- Conferences and seminars of interest are listed with information on dates, call for papers, venues and announcements. For some meetings, the detailed programme will be displayed, and if possible, the complete list of abstracts of papers or the papers presented will be accessible.

- A number of links to other home pages of interest to fish technologists such as the ASEAN Fisheries Post-harvest Fish Technology Information Network of SEAFDEC/MFRD the Nordic Network Fish Processing of the Nordic European Countries or the American FDA Seafood Information home page are available.

- Regulation, standards and import requirements from some of the major importing markets are directly available.

- A complete list of publications by the Danish Institute for Fisheries Research, Department of Seafood Research (FF) can be consulted.

- The text of the new seafood import regulations of the FDA can be downloaded at any time.

- A list of on-going research projects in Island can be consulted.

These are only a few examples of the type of information available.

Another major source of information made accessible is the possibility to read the table of contents of the latest issues of virtually all the major scientific journals of interest to fish technologists. The table of contents of the "Journal of Food Technology" can be read at the home page of the Institute of Food Technology in the USA. The Elsevier Science Publisher has made it possible to read the table of contents of more than 1000 Elsevier Scientific Journals. This service is updated weekly and is free of charge as are most of the other services mentioned here. These services are of particular interest to the large number of scientists and technologists with poor or slow access to scientific literature.

Discussion groups is another service made available through Internet and Email. A number of discussion groups are relevant for the fish scientists and technologists of the region. These are described in the home page as well as procedures on how to join these groups. One example is a new discussion group called "FishTech-L" which has been set up recently by FAO. The group is intended for people with an interest in tropical fish technology. When a message is sent by one member of the group, it is automatically sent to all the members. People can then reply, send comments etc. All discussion goes through Email messages.

The Asian Fish Technology site is updated on a regular basis and suggestions for its improvement and possible new topics to be included are welcome. All the institutes and organisations of the Asia-Pacific region are also strongly encouraged to send information about their activities, publications and meetings to be included in the home page.

This site should be considered as an interactive forum where fish technologists of the region can not only access all kind of relevant information but also provide information to be shared by the community. Without this collective effort, the site will not become the forum it is intended to be and networking among the institutes of the region will still be limited.

LIMITATIONS AND POTENTIAL FUTURE USE

Besides all the excitement and development of the Internet worldwide, it must be noted that the development of this technology is still very slow and limited in a number of developing countries. The Internet is present in a large number of countries but only 12 of the 54 African nations are connected. However, in Asia, most of the countries are connected or in the process of being connected.

Direct access to the Internet for the large part of the population is still an utopia in most of the developing world. To have access to Internet, a telephone line is required. However, 75% of the worlds population have to share 25% of the telephone lines available and it should be remembered that in 1995, more than half of the worlds population had never used a telephone (Schiller 1996).

Access to the Internet in Universities, research institutes and organisations is much more common. Already, in several universities throughout Asia, each student and staff member is provided with an Email address and access to Internet. This makes the use of Internet for research and academic purposes very promising. In the Asian Fish Technology home page, we are making what we could already call a traditional use of the Internet. A number of future possible uses are already technically available and only await popularity and dissemination.

Online conferences and meetings can be arranged. The present meeting could have had an online part where participants who, could not attend for reason of distance, cost or time could have had the opportunity to participate, present papers, and enter into discussions with their colleagues. The advantages and disadvantages are numerous and will probably be more and more debated in the years to come.

Access to the table of contents of new issues of scientific journals and literature search in libraries all over the world are services already accessible on the Internet. The next step has been taken and the first journals are now publishing directly on the www (Blanchfield 1996; Bungay 1995). One of them is the "*Journal of Emerging Infectious Diseases*" which is published on the Internet site of the US Center for Disease Control. The full text of any papers in current and earlier issues can be accessed and downloaded (Blanchfield 1996). These include important papers on food-poisoning outbreaks and emerging foodborne pathogens. Conventional journals will soon be in competition with electronic hypertext journals that deliver a superior product at a much lower cost (Bungay 1995). These are only a few examples of the potential use of this technology for the research and academic community.

CONCLUSION

The Internet and its use in promoting networking among scientists and fish technologists has been described. One of the main advantages of the Internet is that it can facilitate access to information worldwide. Therefore, it is our belief that the use

of the Internet will have its biggest interest in developing countries where traditionally, access to scientific information is difficult and often expensive. The success and expansion of a forum like the Asian Fish Technology home page should therefore be assured if the fish technology research community of the region understands its potential and makes use of it in an interactive way.

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START SPREADING THE NEWS

By Stephen Thrower, Alan Snow and Beverley Austin[1]

Abstract

The business environment in this and coming decades will be one of increasing uncertainty. Consumer preferences are frequently changing and markets are very volatile. At the same time, development of advanced communication systems has made the "global village" a reality and anyone trading in seafood faces competition from around the world.

The enterprises that will survive in this environment will have to be highly flexible in the products they sell, the markets they access and the technology they use. To chart a course through this maze of uncertainty will require a constant supply of information that is current and appropriate. This paper will consider how to satisfy that need. It will discuss the ways that the Australian Seafood Extension and Advisory Service (AUSEAS) at the Centre for Food Technology manages and disseminates its products to a wide range of clients. Topics covered will include: the acquisition, storage, retrieval, translation and dissemination of information in a manner that will assist companies to thrive in the 21st century.

Keywords: Australian Seafood Extension and Advisory Service; AUSEAS; Information transfer.

INTRODUCTION

Anyone selling seafood today is trading in a global market which is facilitated by communications that have never been faster and transport systems which are becoming ever increasingly more efficient. This has made the "global village" a reality.

Seafood can be shipped across the world in a very short time. Markets from all over the world including Japan handle live fish, prawns and lobsters caught in Australian waters. Provided the price is right, fresh chilled fish can be shipped to almost anywhere in the world by fast efficient air freight, and arrive in good condition.

The enterprise that will survive in this environment will have to be highly flexible in the products they sell, the markets they access, and the technology that they use. To chart a course through this maze of uncertainty will require a constant supply of information that is both current and appropriate.

The four keys to doing successful business in the 1990's and beyond, will be:

- vertical integration to ensure that a company captures all the profits from every stage;
- access to prompt and relevant information;
- successful adoption of new and appropriate technology;
- flexibility to be able to switch products to exploit new niche markets.

The focus will be on service and satisfying customers needs to foster loyalty in a diverse market place where competition is fierce.

This paper will discuss the ways that these four requirements can be met. It will discuss how the AUSEAS at the Centre for Food Technology manages and disseminates its information products to a wide range of clients.

FISHING INDUSTRY- 2001

So what will the industry be like in the next century? The fishing industry in the year 2001 will undoubtedly look different to what it does today. Seafood development in the next five years will be highlighted by the following trends.

- Quality Assurance Systems will be a must for all sectors of the industry.
- Global seafood production will increase through further development of aquaculture systems.
- Biotechnology applied to aquaculture will provide a range of species with enhanced attributes.

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- There will be a wider range of new and innovative seafood products on the supermarket shelves through consumer preference for convenience foods and single serve processed foods.
- Information on food safety and proper seafood handling procedures will become more important for both processors and the community.
- Consumers will demand more information on nutrition and will call for functional foods.
- There will be a greater demand for new and innovative packaging systems and materials.
- Total utilisation of the seafood catch will be a priority for producers as they strive to maximise income through waste reduction.
- The development of nutraceuticals or functional foods from by-products will become more common as processors move to fully utilise the catch.

The demand for technical information from all sectors of the industry and the community will increase as the industry changes to accommodate these changes.

CASE STUDIES

The three case studies which follow are examples of the types of enquiries which AUSEAS handles. Although some of the information included in these case studies may be slightly exagerated they are typical of requests that have been received by AUSEAS and will continue to be received over the coming years. Each response given to clients have been customised to meet the individual needs of each client.

Case No 1 - Salmonella Sam

Salmonella Sam is a former public sector employee whose position was made redundant. He received a very healthy lump sum payment as he was on a good salary being a member of the SES. He decided to purchase a small cafe and takeaway food business which sold seafood, burgers, etc. He had no previous knowledge of food handling other than as a consumer.

He was using ineffective refrigeration, was storing food such that the juices from meat were dripping into the plates of raw fish, and was in general not using proper food handling procedures. He soon ran into food spoilage problems.

He was in danger of being shut down by the authorities resulting from a number of complaints and visits from Environmental Health Officers. He finally contacted AUSEAS for information as to what he was doing wrong and what he must do to improve his seafood handling procedures.

Our response was to visit the premises and assess the situation, a presentation in both written and oral form on changes that need to be made immediately, and provision of an information pack covering hygiene, food safety and spoilage, and some ideas for alternative presentation. We also recommended that he attend one of the Centre's Food Hygiene training courses.

Case No 2 - Enterprising Eunice

Enterprising Eunice has completed her MBA at Bond University and has made a small fortune in property development at the Gold Coast.

She has decided to turn her flair for accumulating wealth to something different and has been approached to jointly develop and market the "cubic oyster"

The advantage of the cubic oyster is that you will not need bags or buckets which will greatly facilitate storage, packing, and presentation. The cubic oyster will also be presented in a range of natural colours (blue, pink, green, etc) and get away from the natural dowdy grey colour.

Before Eunice enters into a joint venture to develop this product, she contacts AUSEAS with a request for potential markets, exporters, wholesalers and information on the process of developing the cubic oyster.

AUSEAS' response will be to provide her with enough data to satisfy the bankers and also information on additional sources as funding such as NSC and QIDC. We also recommend that she contact well known marketing consultants Dodgy and Sons.

This information will assist her to develop her business plan for this new and revolutionary product.

Case No 3 - Nutritional Neville

Neville has a number of health complaints. He suffers from chronic migraines, crippling arthritis, asthma, high cholesterol and a number of other associated health problems. He regularly reads medical literature on his visits to his doctor's surgery and has often read of both the health benefits and the health problems of eating seafood.

He contacts AUSEAS for information as to whether he can prolong or shorten his life expectancy by eating seafood and which seafood he should both eat or avoid.

AUSEAS maintains a library that has an extensive collection of literature on these subjects. We are able to use this literature to supply him with authoritative reference material on the valid health claims, on suitable species, and appropriate seafood cooking methods.

THE CLIENTS

Requests for information from AUSEAS will come from many sectors of the industry. The information needs and complexity will also vary. The major clients of AUSEAS and their information requirements are discussed below.

The catching sector

People directly involved with harvesting fish stocks in Australia have usually invested a considerable sum in a boat, licence fees, equipment etc. Some have risen "through the ranks" from deckhand to skipper. Such people have learned their skills from other fishers. Some of these practices are sound, but others are poor sometimes resulting in sub-standard products. Other fishers have undergone some type of formal training.

The enquiries received from the catching sector are varied but the following are an example of the most frequent enquiries:

- trouble shooting enquiries received after a customer has registered a complaint;
- on-board preparation and/or storage;
- different regulations pertaining to various markets;
- diversification into new fisheries.

The best way of providing information to these clients is in a hands-on situation preferably in a real life situation. For example prawn cooking workshops have been conducted on the deck of a trawler using a commercial cooker. Obviously this is not usually possible in a country the size of Australia, so the client is provided with a good oral presentation, usually by phone, backed up by the provision of written material which incorporates a number of diagrams or photographs.

There is a considerable advantage in developing interactive multimedia packages for the clients. These are self paced learning, better graphical and video presentation, and access from remote sites.

The processing sector

Seafood processors come from many backgrounds. Some have a similar long term experience of on the job learning to fishers, whilst others come from different industries as varied as the meat industry and the army. Considering the size of the industry there are relatively few qualified food technologists employed.

Frequent enquiries from the processing sector are:

- storage and shipment of live seafood;
- trouble shooting when customers return product of inferior quality;
- use of packaging systems for fresh or chilled product;
- diversification into new products and markets;
- new or improved products or process development.

The services to processors consist of two main categories - quick one-off answers; and researched information packages. Although the processing sector is offered enterprise based training for processing staff, there has resistance to allowing the amount of time necessary for attendance.

There is considerable scope for providing market intelligence information and new product information to processors.

Aquaculture

Aquaculture is the fastest growing sector of the fishing industry. Projections are that production from aquaculture will increase by 50% by the year 2001. The aquaculture industry attracts a wide spectrum of investors with little or no knowledge or experience of seafood. The range of clients include farmers, developers, teachers and firemen.

Providing customised and relevant information to this industry is a major challenge. Information including startup costs, feeds, and markets can be readily supplied. Whilst the AUSEAS area of expertise covers only the postharvest aspects, we are able to network clients with other relevant experts.

Finance sector

Financial institutions such as banks often approach AUSEAS to provide independent advice about information presented to them in business plans etc. Some institutions have made funding contingent on the provision of technical information from AUSEAS. The information provided assists financial institutions to make decisions as to the viability of a proposal.

It is very important in these enquiries to confine comments to strictly technical matters and to give advice that can be supported by published material.

Insurance assessors

Seafood is one of the most perishable of foods and the consumer preference for live and fresh product means that problems occur during transport, and become the subject of legal claims.

AUSEAS is approached by insurance assessors and lawyers representing parties in such disputes. The form of service provided varies from giving an opinion based on data supplied, to product examination and analysis. Usually this is supplied in a written report, although, on occasions, evidences is given on the witness stand.

Consultants

As a major source of information and advice, AUSEAS is frequently approached by consultants from many fields. In general most consultants are supplied with technical material with need for little interpretation.

In some cases, professionals such as engineers who have little knowledge of fish, seafood or the disciplines of food technology request information and as such these enquiries require a component of interpretation and advice as well as the information itself.

AUSEAS is also ready to work in collaboration with consultants. Such projects may be initiated by either side. The role of AUSEAS is to put clients in touch with the best available expertise. We often refer clients to consultants, and so maintain a database of experts.

Education

AUSEAS provides information to both providers and users of educational services. These include teachers, and university students at post-graduate and pass levels as well as TAFE and matriculation level. As staff of the Centre for Food Technology, AUSEAS officers also contribute to delivery of short courses for personnel in the food industry on subjects such as food hygiene.

Traders

Enquiries are often received from importers and exporters with enquiries as diverse as:

- government regulations;
- market access and identification;
- packaging;
- troubleshooting when problems occur;
- suppliers of product; and
- information on potential markets.

The response to these enquiries is to either provide a quick verbal answer, provide an information package, or refer the client to the relevant authority.

The community

Members of the community often have specific requests that need to be addressed. These requests cover topics as broad as nutritional information, seasonality of fish, and where to go to get further information. Since these people do not expect to pay for the information, the response is usually confined to a telephone conversation.

FUTURE DIRECTIONS IN INFORMATION SERVICE

People from each of the groups addressed above are current clients of AUSEAS and will be for many years to come. The changes that are expected to develop in the fishing industry over the next decade will result in an increase in the role of information providers such as AUSEAS.

The topics

In general, the types of requests that can be expected over the coming years can be grouped as information on:

- *aquaculture systems* - startup costs, feeds, likely markets, and other providers of specialist information who can assist in site selection, preparation, and operation;
- *food safety and storage* - proper seafood handling, causes and prevention of seafood spoilage, and toxins encountered in seafood;
- *Quality Control Systems* - HACCP, assistance in developing correct procedures, and other sources of specialist information;
- *nutritional and health aspects* - to satisfy requests from both the public and the catering industry.

Information and assistance:

- in the development of new value-added products. Assistance would normally be in terms of published market information, formulations, and manufacturing procedures;
- to processors who are experiencing problems or are contemplating new products or procedures. This information would include sources of new equipment.

Mode of delivery

AUSEAS currently uses a number of information sources to serve customer's needs. The in-house database holds over 6 000 publications in-hard copy form. AUSEAS also has access to electronic information sources such as CD-ROMS, on-line services, and the internet.

For the most part information sent to clients is extracted from publications in the public domain. AUSEAS task is to find the most useful material, and "translate" and present it in a form that satisfies the clients' needs.

In addition to published material, the AUSEAS database holds information that is not freely available which has been obtained from a number of sources. As with published material, this information is interpreted into a form that is applicable to the clients' problems. Obviously information obtained from consultancy work is often of a confidential nature and is not available for dissemination.

A major source of information for AUSEAS is an extensive network of experts in most areas of knowledge pertaining to seafood. This includes scientists within Australia and overseas, contacts in the fishing industry itself, and consultants in those agencies that service the industry. AUSEAS also provides a range of publications for sale including directories, manuals on processing etc, and research reports.

Services

The range of services that AUSEAS will provide to meet the challenges of the future are many and varied.

- *Information Packages*

AUSEAS will continue to provide information to clients in Information Packages which will contain both current literature and abstracts of information than can be sourced from overseas journals. These packages will also be used to disseminate current research findings.

- *Telephone Service*

AUSEAS will continue to provide a telephone service where simple enquiries or requests can be answered quickly. AUSEAS maintains a register of experts to assist in answering difficult enquiries by referring the matter to an expert in the area.

- *Consultancies*

AUSEAS will often undertake or coordinate a consultancy and, where required, will refer work or involve people in other sectors of the fishing industry. This may often require some original research to be undertaken.

- *Publications*

The range of saleable publications that AUSEAS will continue to offer includes books, Newsletters and Research reports. AUSEAS will in the future be producing information on CD-ROM for use by the industry.

- *Internet Access*

Access to the internet is to be provided by the near future. The type of information that "surfers" will be able to access will be:

- the list of saleable publications that AUSEAS has on offer;
- the list of services that AUSEAS can provide;
- telephone, fax, and electronic mail contact addresses;
- the ability to search the AUSEAS database and retrieve basic information.

- *Training*

AUSEAS has often received requests to coordinate or provide information for seafood related courses. It is anticipated that AUSEAS will play an active role in the provision of training in the future. However, it is believed that there will be a role in brokering of training or coordinating training events and seminars.

CONCLUSION

The wide variety of topics and speakers on this programme are testimony to the dynamism of the seafood industry. In this room, we have had a microcosm of world fishing. We know that global fishery resources are in serious decline. We can no longer tolerate wastage of any of these precious resources. Modern telecommunications gives us the opportunity to form effective networks for technology transfer. By combining our talents and sharing our experiences, we can generate the information the industry needs to make total utilisation of the catch not a cliche but a reality.

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