Dried WA Seafood Products for the Asian Market: A Pilot Study

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Non-Technical Summary

2009/773: Dried WA Seafood Products for the Asian Market: A Pilot Study

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PROJECT OBJECTIVES

1 Assess the technical viability of producing dried seafood products from a variety of WA seafood products.

2 Establish quality assured processes to produce market ready dried WA seafood products.

In 2009 Kingsun Bioscience Company, an international company with interests in the Japanese and Asian markets expressed an interest in investigating the possibility of drying WA seafood products for sale on the Asian market. WA seafood products of interest were those from sustainably managed fisheries with selection supported by market research.

Kingsun Bioscience Company Limited has the exclusive license to commercialise this technology outside Japan. The technology involves production of a vacuum state. In this vacuum, evaporation can be achieved at ambient temperatures. A significant advantage of ambient air drying is that the structure of proteins remains intact and is not denatured by heat. Furthermore, the flavour profile of the seafood is not compromised by a high temperature cooking process. Previous studies have shown that the colour, shape and active nutrient components of plant and animal products are retained during this innovative drying process.

Kingsun Bioscience Company Ltd provided a pilot (50L) dryer which was transported to Western Australia and installed at Australian Centre for Applied Aquaculture Research, Challenger TAFE Fremantle. Scientific assistance in installation, method development and a liaison officer (Dr Guan Tay) was provided by Kingsun Bioscience.

Successful installation and commissioning of the machine took longer than expected due to the late arrival of the dryer, significant electrical and plumbing work being necessary, and registration/certification of the machine being quite onerous. However the dryer was finally fully operational in February 2012 and since then a number of dried products have been produced and analysed.

The project has demonstrated that a range of shelf-stable, bacteriologically and compositionally food safe dried products could be produced in the dryer. Generally fish frames and waste products were the experimental products. The low temperature resulted in oil/meal products with possible use in poultry feed supplements, food flavouring and for further extraction of fine chemicals for example astaxanthin. High protein food supplements may be another potential opportunity. Costs of the power used to produce the products was estimated.

Some whole products (eg abalone, scallops and pearl meat) were also dried successfully.

Commercialisation protocols for longer term trials have been discussed with the Curtin University Commercialisation team along with the Kingsun Bioscience and Seafood CRC representatives. The owner of the dryer remains engaged and seems content for the dryer to remain in Western Australia

A number of commercialisation options have been identified and there is interest from a number of industry partners to continue trials. This interest has been intensified by an article in SEAFOOD MAGAZINE, in which up to 10 phone enquiries were received. These trials will be conducted in the future under individual company specific arrangements.

OUTCOMES ACHIEVED

1. Installation, registration, commissioning and successful operation of the 50kg pilot Biolite Dryer in Western Australia.
2. Demonstration of technical viability and estimation of production costs to produce dried seafood products from a number of WA seafood processing waste sources.
3. Commercialisation options identified for dried seafood products from processing waste.
4. Commercialisation options identified for dried whole WA seafood products.

LIST OF OUTPUTS PRODUCED

1. 3 dried whole seafood products with relevance and likely acceptability to the Asian market from WA seafood.
2. Dried material from 6 seafood processing waste streams for future product development.
3. Operational guide for use of the Biolite dryer.
4. Food Science Honours graduate (Karl Hansal) with experience in drying seafood. Karl currently works for Simplot.
5. Generic Economic Framework for assessing the likelihood of profitability for exporting dried seafood products from Australia.
6. Presentations to relevant industry stakeholders, including CRC participants and WAFIC members.
7. Articles in relevant magazines/publications (including FISH, Curtin R and D Now and Seafood Magazine)
8. Journal article submitted for possible publication in peer reviewed journal.

Glossary

Ash - the mineral content of a food product as measured by the residue remaining after a sample of known weight is incinerated.

Bacterial Count – as pertains to this report, the term bacterial count is used to represent viable (live) bacteria grown on non-selective media at a moderate temperature.

Coagulase Positive Staphylococci (CPS) – Staphylococci possessing the coagulase enzyme that catalyses the coagulation of blood. Coagulase positive staphylococci in foods are predominantly *Staph. aureous* and as a result, CPS is used to indicate the presence of this pathogen within food in Australia.

Colony Forming Units (CFU) – each colony of microbial growth on media is assumed to have generated from one viable microbial cell. Bacterial counts are typically expressed as CFU/g based on this assumption.

Enterobacteria – bacteria, generally Gram negative rods, whose normal habitat is the gastrointestinal tract.

Fat – the total lipid content of a food sample including saturated, monounsaturated and polyunsaturated fats.

Free on Board Price (FOB) - of exports and imports of goods is the market value of the goods at the point of uniform valuation, (the customs frontier of the economy from which they are exported). OECD define FOB as equal to CIF price less the costs of transportation and insurance charges, between the customs frontier of the exporting (importing) country and that of the importing (expoting) country.

Heat Resistant Bacteria – bacteria able to resist a standard treatment. Most commonly a measure of thermophillic microorganisms (whose optimal growth is >45ºC) and spore forming bacteria (able to regenerate after heat treatment).

Isolated Amino Acids – amino acids, the building blocks of peptides and proteins, isolated during analysis of food.

Moisture – water content of a food as measured by standard drying protocol.

Protein – total protein content of a food as measured by standard proximate analysis.

Salmonella – most species of Salmonella are able to cause food infections. Gastroenteritis symptoms are typically noted

Standard Plate Count – a non-selective measure of bacterial levels within a sample giving a general indication of food safety and expressed in colony forming units per gram (see above).

Water Activity (a_w) - an expression of the availability of water and water requirements for microbiological growth. a_w is calculated as the water vapour pressure of a substance divided by the vapour pressure of pure distilled water (1.0) (VanDemark and Batzing 1986).

1. Introduction

World demand for fisheries products have been steadily increasing each year and seafood processors are searching for new ways to increase production efficiency whilst minimising waste output. Dried seafood products can remain shelf-stable for up to a year or more at ambient temperatures, under the correct packaging/storage conditions (Potter and Joseph 1995), thereby helping to ease logistical and storage pressures whilst maximising the potential for product utilisation before spoilage takes place. Export potential can also be enhanced as a result of extended shelf life and storage considerations associated with dried seafood products.

Many dried seafood products are considered delicacies and can attract extremely high premiums. However, traditional drying methods for seafood products are highly labour intensive, taking weeks or months to complete (Steinberg 2005). Advances in drying technologies has made production of dried seafood products a potentially viable processing option in a developed economy such as Australia where traditional drying methods may be considered too inefficient. Mechanical dryers can be used as an alternative to sun-drying as they dry products quickly, and under conditions less susceptible to undesirable environmental influences such as pests and harsh weather (Greensmith 1998).

East Asia has a strong influence on the global demand for seafood (Clarke 2000). Australia already exports significant quantities of seafood products to Asian markets, and is highly regarded by overseas markets as a safe and premium-quality supplier of seafood (Naidoo, Slattery, and Bremner 1996). Yet very little dried seafood is produced within Australia, priming domestic producers to explore Asian markets where local competition is low and consumer demand outstrips supply. The dried fish market in Hong Kong for instance is known to be stable with regard to levels of domestic consumption of dried fish, fillets, maws and other dried seafood products (Clarke 2004). Between the years 1996 and 2000 more than 2,000 metric tonnes of dried fish were imported from Mainland China, Vietnam, India, Bangladesh, Indonesia, Kenya and Thailand (Clarke 2004).

Drying undervalued or underutilised local seafood stocks as a means of extending existing product lines, whilst entering new markets provides an attractive opportunity for West Australian seafood processors. The proximity of East Asian markets offers an advantage to Australian producers as does the premium quality of Australian seafood products. Investigations into arsenic levels in dried seafood in Hong Kong revealed levels above the maximal permissible concentrations in all dried squid samples tested (Man and He 2000). The microbiological quality of dried seafood products has also been studied particularly with regard to enteric organisms. Imported dried anchovy has been associated with a salmonellosis outbreak in Singapore, cuttlefish chips with salmonellosis in Japan and salted dried fish with Salmonellosis in the United States (Ling and others 2002). Further, an Indian study of traditionally salted dried fishes revealed alarming levels of faecal coliforms and *Vibrio spp*. (Logesh and others 2012). Such unsatisfactory results should be avoided with the use of Australian quality products in the drying process.

In 2009 Kingsun Bioscience Company, an international company with interests in the Japanese and Asian markets expressed an interest in investigating the possibility of drying WA seafood products for sale on the Asian market. WA seafood products of interest were those from sustainably managed fisheries with selection supported by market research.

This project used Intellectual Property (IP) owned by Biolight Company Limited for an innovative ambient temperature vacuum drying process. Kingsun Bioscience Company Limited has the exclusive license to commercialise the technology outside Japan. The technology involves production of a vacuum state. In this vacuum, evaporation can be achieved at ambient temperatures. A significant advantage of ambient air drying is that the structure of proteins remains intact and is not denatured by heat. Furthermore, the flavour profile of the seafood is not compromised by a high temperature cooking process. Previous studies have shown that the colour, shape and active nutrient components of plant and animal products are retained during this innovative drying process.

Kingsun Bioscience Company Ltd provided a pilot (50L) dryer which was transported to Western Australia and installed at Australian Centre for Applied Aquaculture Research, Challenger TAFE Fremantle. Scientific assistance in installation, method development and a liaison officer (Dr Guan Tay) was provided by Kingsun Bioscience.

Various seafood products were then assessed for:

- Suitability of seafood species for development of dried product
- Profile of drying required to ensure optimised product quality
- Shelf life studies
- Chemical composition, physical characteristics, sensory characteristics and microbiological safety analysed in comparison to existing Asian products (to ensure food safety/quality standards are met).

It was proposed that if the pilot trials indicated a commercially viable product could be produced, operations could be expanded to develop hubs in regional areas and add value to traditionally undervalued fisheries.

1.1 Need

There is a demand for dried seafood product for the Asian market (Steinberg 2005). Development of such a suite of products would increase the market opportunities available to WA seafood producers, expand the types of seafood that can be produced in a commercially viable manner and counteract the challenges of distance by extending shelf-life. Regional development opportunities for seafood processing capability may also be realised.

1.2 Objectives

1. Assess the technical viability of producing dried seafood products from a variety of WA seafood products.
2. Establish quality assured processes to produce market ready dried WA seafood products.

2. Methods

The study was divided into four distinct sections:

1. Development and application of an economic framework model to assess the opportunities for dried seafood products to Asia from Western Australia
2. Preliminary Drying Trials Using Vacuum Drying and Freeze Drying to Create Dried Seafood Products for the Asian market (Honours project – Karl Hansel)
3. Installation and Commissioning of Biolite Dryer
4. Drying trials

2.1 Development and application of an economic framework model to assess the opportunities for dried seafood products to Asia from Western Australia.

Initially a preliminary feasibility study was completed to assess which dried products would be competitive on the Asian Market, at what price points and what would be the likely competitive effects a new product would face. This preliminary study, summarised as a report entitled "Development and application of an economic framework model to assess the opportunities for dried seafood products to Asia from Western Australia" was conducted by Seafood Services Australia with the input of the Asian based collaborative partners for the project. This study was conducted to help inform the choice of pilot species for the experimental part of this project. The final report is attached as Appendix 3.

2.2 Vacuum Drying and Freeze Drying to Create Dried Seafood Products for the Asian market

Part of the project funding was used to support an Honours student, Mr Karl Hansal, at Curtin University in carried out under the Food Science Honours guidelines. The title of the thesis, submitted as a journal article, was "Using Vacuum Drying and Freeze Drying to Create Dried Seafood Products for the Asian market". A modified version of the article developed by Karl has now been submitted for peer review to the Journal of Food Science. Results of the Honours project are included in the Results section.

2.2.1 Traditionally processed reference samples

Dried scallop and pearl meat sold in Asian markets were purchased for comparative analyses. The average weight, length and width of samples was calculated based on the samples available (using a minimum of 6 representative samples for each group), and were viewed as approximate representations due to variability of surface structure and size of individual samples.

Scallop adductor muscle of the saucer scallop (*Amusium balloti*) was purchased block-frozen in 1kg packs from a local retailer. The scallops were sourced from a commercial operation in Shark Bay, Western Australia and were harvested from the season beginning April 2010. Pearl meat adductor muscle of the silver-lip pearl oyster (*Pinctada maxima*) was obtained directly from a commercial pearling operation located in Broome, Western Australia and 130 were harvested during the season beginning July 2010. Block-frozen packs of 0.5 kg were purchased and sent via air-freight to be received at the Perth airport depot. All frozen samples were stored at -28 °C prior to further use.

2.2.2 Pre-treatment method development

Traditionally prepared products (exact methods unknown) were purchased locally and from overseas and used as references for the desired sensory qualities to be re-produced using vacuum drying technology. Freeze dried scallop and freeze dried pearl meat products are virtually non-existent on the current market, so fresh equivalents were used for sensory reference quality in pre-treatment development. Ready-to-eat freeze dried products were created by poaching samples before drying; so that once rehydrated the samples would resemble freshly poached products, such as may be prepared at home or at restaurants from a fresh product.

Vacuum and freeze dried samples were dried to a final moisture content corresponding with a final water activity reading of < 0.6 to promote long term shelf-stability by inhibiting the growth of spoilage bacteria and mould at ambient temperatures (Hall 1997).

In determining the most suitable pre-treatment to use for the study, samples from each trial were consumed and assessed by the investigator; with assistance from an experienced culinary Chef. The final pre-treatment and drying parameters selected for product processing and analysis are provided grey in Table 1 and Table 2.

2.2.3 Vacuum dried Scallop

Pre-treatments for boiled-dried scallop as outlined by Tanikawa, Motohiro, and Akiba (1985) and Marquez-Rios and others (2009) were trialled. The products created using these pre-treatments were compared, and the drying parameters adjusted according to the final sensory outcomes. For each sample 0.5 L of water containing the required quantities of salt and/or sugar was brought to boil, the scallops were immersed in the solution and cooked according to times outlined in Table 1. Samples were placed into the dryer immediately after the boiling process. Samples were suspended on plastic netting draped over plastic containers to maximise air-flow around samples during drying. The temperature and pressure inside the chamber were set according to the desired drying parameters.

2.2.4 Vacuum dried Pearl Meat

Initial pearl meat trials followed identical treatments used for scallops. The cooking step was eliminated after further trialling, and raw samples were pre-dried in an oven at 105 °C as described by (Yoneda and others 2005), and based on the sensory result this was the only treatment selected before drying (Table 1).

Table 1 Pre-treatments trialled for vacuum dried samples

Sample	Pre-heat [°C/Time (mins)]	Cook time (mins)	Salt/Sugar concentration (%)	Temperature (°C)	Pressure (kPa)
Scallop	N/A	5	5/3	50	33.86
Scallop	N/A	10	5/3	50	33.86
Scallop	N/A	25	5/3	50	33.86
Scallop	N/A	25	N/A	60	33.86
Scallop	N/A	25	10.04/0	50	33.86
Scallop	N/A	25	10.04/0	60	50.80
Scallop	N/A	25	10.04/0	65	50.80
Scallop	N/A	25	10.04/0	70	50.80
Scallop	N/A	25	10.04/0	65	16.93
Pearl	N/A	25	10.04/0	65	50.80
Pearl	N/A	5	10.04/0	65	50.80
Pearl	N/A	2	2/0	65	50.80
Pearl	105°C/50	0	N/A	65	50.80

2.2.4 Freeze dried Scallop

Samples were cooked in 0.5 L water at 2% salt concentration for the required time (Table 2). After cooking samples were removed and left to drain for 5 min before being pat dried and re-weighed. Samples were then individually vacuum packed and blast-frozen at -40 °C for 3 hours at 175°C and stored at -28°C prior to freeze drying. Frozen samples were placed into plastic containers and transferred into the freeze dryer (Martin Christ Freeze Dryer, model alpha 1-2 LD plus). Due to competitive and shared usage of the freeze dryer, the temperature and pressure settings could not be altered, and samples were dried using a primary drying cycle only. Samples were dried to a water content corresponding with a water activity reading of <0.6 and moisture content < 10%.

2.2.5 Freeze dried Pearl Meat

Samples were cooked in 0.5 L water at 2% salt concentration for the required time (Table 2). After cooking samples were individually vacuum packed and blast-frozen at -40 °C for 3 hours and stored at -28 °C prior to freeze drying. Frozen samples were placed into open plastic containers and transferred into the freeze dryer (Martin Christ Freeze Dryer, model alpha 1-2 7 LD plus). Samples were dried in the same conditions as freeze dried scallop samples to a water content corresponding with a water activity reading of < 0.6 and moisture content < 10%.

Table 2 Pre-treatments trialled for freeze dried

Sample	Cook time (mins)	Salt/Sugar concentration (%)	Temperature (°C)	Pressure (kPa)
Scallop	5	2	-52	0.05
Scallop	5	2	-52	0.05
Scallop	2	2	-52	0.05
Scallop	4	2	-52	0.05
Scallop	3	2	-52	0.05
Scallop	3.5	2	-52	0.05
Pearl	3.5	2	-52	0.05
Pearl	3	2	-52	0.05
Pearl	2.5	2	-52	0.05

2.2.6 Experimental process

A 1 x 2 factorial study was conducted for the final products created using the selected treatments in Table 3 and Table 4. The pre-treatment selected for each sample group had two levels (3 hour acid immersion and no immersion) as seen in Figure 1. Acid immersion treatment of samples was based on a method trialled by Marquez-Rios and others (2009).

Each final experiment was replicated three times for all scallop and pearl meat sample groups. Samples were subjected to identical processing treatments unless otherwise stated. Proximate and sensory analyses were conducted to assess the overall acceptability of the products produced.

To prepare samples for processing the block-frozen scallop and pearl meat were thawed overnight in their original packaging at 1 °C before being separated into vacuum sealable bags. Samples were then vacuum packed, blast frozen, and stored at -28 °C prior to pre-treatment processing.

Prior to pre-treating, samples were thawed at 1 °C over 18 hours, patted dry with a paper towel, and the fresh weight recorded. Samples acid treated were placed into a 0.1 M citric acid solution (pH 3) at 4 °C for 3 hour, with a sample/solution weight ratio of 1:2. Samples not subjected to the acid pre-treatment underwent identical thawing and weighing processes.

After the acid treatment (or thawing for samples forgoing acid immersion), samples were processed according to the optimal parameters selected in Table 1 for vacuum dried samples and Table 2 for freeze dried samples.

Samples were placed into the designated dryer immediately following the completion of the processing treatments. When the required dried weight was reached for each sample, it was removed and individually vacuum packed for storage at 0 °C prior to further analysis.

Colour

Colour densities were measured using a Minolta spectrophotometer CM-508i and results were quantified using the CIE L* a* b* 3-dimensional scale. Readings were taken at the surface of each dried sample and the Minolta was programmed to take the average of three readings for each test. Readings for each sample were taken 3 times and the average recorded as a representation of surface colour.

Texture

Texture analysis using the TA-XT2i texture analyser (Stable Micro Systems Ltd, Surrey, England) fitted with a 6 mm diameter spherical probe was used to measure the hardness of all dried samples at 5% strain using a 25 kg load cell at 2 mm/sec. Only whole samples were used to measure hardness. Triplicate readings were taken and the mean recorded for each sample.

Water Activity

Water activity was measured using an AquaLab Water Activity Meter (Decagon Devices, Inc).

Moisture content

Moisture content was measured for all samples using the standard method for loss on drying (moisture) in meat 950.46 (AOAC International 2008).

Proximate analysis (dried samples)

Ash

Dried samples from moisture content analysis were used to determine the ash content of samples. Ashing was conducted according to the standard method for ash determination of seafood 938.08 (AOAC International 1938) using Approximately 3 g of dried sample, the dried material was charred for 24 hrs at 550 °C and left to cool for 3 hrs in desiccators.

Protein

Protein content was determined by using the standard Kjeldahl method 955.04 for total nitrogen content as described by the AOAC International (1955), which is used to determine the protein content of samples. The BÜCHI distillation unit K-314 and BÜCHI digestion system K-437 (BÜCHI Labortechnick AG, Switzerland) were used for the experiment. The percentage of protein in each sample was determined from the total nitrogen content using a protein conversion (f) factor of 5.82 for seafood (Owusu-Apenten 2002).

Fat

Crude fat content of samples was determined by the standard method of acid hydrolysis 948.15 as described by the AOAC International (1948). A BÜCHI Soxhlet Extraction Unit E-812/816 SOX (BÜCHI Labortechnick AG, Switzerland) was used.

Carbohydrates

Total carbohydrate content (crude fibre + nitrogen-free extract) was determined by subtractive difference upon completion of all other proximate analyses.

Heavy metals

Cadmium, Lead and Arsenic were analysed for each sample group. Approximately 1 g of sample was digested using concentrated HNO3 and diluted to 20 mL in volumetric flasks for analysis. Cadmium and lead were analysed by the flame spectrophotometry method 973.34 as described by AOAC International (1974). Arsenic was analysed using hydride generation atomic absorption spectrophotometry as described by Fabiyi, Sileo, and Aremu (2008).

Processing yields

To achieve the optimised final moisture content for each sample a drying model was created according to the drying parameters used and the target water activity of < 0.6 for food safety and product quality purposes. Freeze dried products require a final moisture content of < 10% to retain original textural quality upon rehydration (Crapo and others 2010) and at these moisture percentages the water activity can be much lower than 0.6. A drying model was formulated and used for determining the target dried weight of each individual whole sample. The initial moisture content of samples was used to determine the target dried weight based on the optimised final moisture content for each product type. The drying model is represented by the following equation:

$$Wd = [Wf - (Wf * \{ \%MCf / 100 \})] * [1 + (\%MCd / 100)] \quad 11$$

Where:

Wf = Weight of fresh sample (grams)
%MCf = Percentage moisture content of fresh sample
%MCd = Percentage moisture content of dried sample
Wd = Weight of dried sample (grams)

The final yield of each dried sample was determined by calculating the percent difference for each sample prior to and after drying.

Focus group sessions

Untrained participants from Asian (specifically Chinese, Japanese or south-east Asian) backgrounds were asked to take part in the focus group sessions. The selected participants were chosen as representative target consumers who were likely to have experience eating and/or preparing dried seafood products in traditional cuisine. Two separate 6-person focus groups (Ethics approval by Curtin University ethics council, code: SPH – 26 – 2010) were conducted according to guidelines outlined by Krueger and Casey (2000) set up to test for the acceptability of the samples created. Participants were required to assess the overall acceptability of each sample using a labelled hedonic scale (LHS), and in-depth discussions between the tasting of each sample group was recorded to determine overall trends and differences in opinion.

Preparation of products for sensory analysis

Each sample assessed by participants was represented by a random 3 digit number, with care taken to select numbers that were not auspicious / inauspicious in Chinese culture. Sample codes were used so that each participant could not identify the purchased samples from the samples created in the lab, therefore minimising the potential for bias acceptability results.

In addition to the samples created using freeze drying and vacuum drying, two traditionally dried Asian scallop variants and one traditionally dried pearl meat variant were purchased and used for comparison. To assess the acceptability of each sample a 20 cm long labelled hedonic scale printed on A4 paper was given to each participant. Participants were instructed to draw a horizontal line through the section of the scale that best represented their personal level of acceptability. A fresh labelled hedonic scale was given with each new sample so that participants could not view their previous ratings. After each sample group was tasted, and results recorded, an in-depth discussion was held; focussing on the group"s opinions and feedback regarding the sensory characteristics of samples and how their acceptability ratings reflected these opinions.

Rehydration and cooking of samples

Equal amounts of each scallop and pearl meat sample were weighed out for sensory tests. Each sample was rehydrated for 24 hrs in tap-water with a sample/water weight ratio of 1:2. A single cube of stock powder (Massel's salt reduced chicken-style stock cubes) was added to 0.5 L of boiling water and stirred for 2 mins. The stock acted as a standardised carrier for each sample and was selected due to its light flavour and salt content so that the sensory quality of samples was not overwhelmed. Samples were broken up into smaller meat fragments, replicating traditional cooking methods, and then added to the liquid to create individual master stocks which would be further divided between focus group participants. Whole freeze dried samples followed the same preparation process, however as no further cooking was required for the freeze dried samples they were simply added to the boiled master-stock in a single thermos flask for each sample.

Sample service

Each sample was served in individual white 150 ml ceramic bowls for tasting; with traditional white ceramic Chinese spoons and a napkin for each participant. For traditional and vacuum dried samples each participant received 1 ladle of stock (125 mL) containing equal amounts of broken up scallop fragments for scallop samples, and sliced pearl meat pieces for pearl meat samples. Prior to service each sample was microwaved for 40 sec on high to ensure even heating throughout the stock and a service temperature > 60 °C. For freeze dried samples the process was identical, with each service bowl served containing a whole rehydrated sample to taste.

Statistical Analyses

SPSS (version 18.0) and Microsoft Excel (2007) software were used for all statistical analysis conducted for this study.

2.3 Installation and Commissioning of Biolite Dryer

There was a significant delay in the Biolite dryer being delivered from Japan. The machine arrived in July 2011 and was installed at the Australian Centre for Applied Aquaculture Research (ACAAR) , Challenger TAFE, Fremantle (see Figure 1).

Figure 1: Biolite Dryer installed at Australian Centre for Applied Aquaculture Research

Agreements have been signed between CESSH and ACAAR and between Curtin University and Biolight Pty Ltd in regard to the use and installation of the machine. Initial commissioning of the machine was supervised by the inventor Dr Fukimoto in September 2011 (see Figure 2).

Figure 2: The dryer installation team. Inventor Dr Fukimoto is standing second from left.

Following the visit from Dr Fukimoto, there were further installation / technical issues which were resolved by February 2012. Since that time the machine has been fully operational with an Operations Manual produced (see Appendix 2), inspections and appropriate certification documentation finalised by boiler inspector Andrew Holden and the dryer registered with Worksafe and other appropriate authorities.

2.4 Drying trials

The Biolite Dryer, delivered in June 2011, differed from the model viewed by Karl Hansal in Japan. The delivered model had a milling/crushing/rotating insert rather than the shelf insert as expected. The rotating capacity of the dryer had implications for its use on premium whole product. If the machine was rotating, whole product would be damaged. The original target products, pearl meat and scallops, which had been the subject of Karl Hansal's work in the smaller dryers, were re-evaluated whilst a better understanding of the capabilities of the rotational model, particularly as regards a whole product was gained. Subsequently, and at the instigation of the project partners Guan Tay and Dr Ding Qing, the focus products became seafood waste products including

- fish frames (including Atlantic salmon, barramundi, sardines and mixed frames);
- octopus waste;
- shark cartilage;
- underutilised by catch species (including rosy threadfin bream and escolar species) and;
- Atlantic salmon heads and skins (as alternate waste products).

Drying trials were also eventually carried out on oyster, abalone and pearl meat.

Drying trials in the actual Biolite dryer were completed using the operational protocols described in the Operations Manual (see Appendix 2). Samples were periodically removed during operation of chemical and microbiological analyses. Electrical use was recorded to help calculate production costs.

2.4.1 Analyses of Dried Products

Analyses selected for the products dried using the Biolite dryer differed from those used in the preliminary Honours study of vacuum and freeze dried whole product. While proximate analysis was repeated, colour and sensory analysis could not be meaningfully conducted in the absence of an acceptable and comparable dried seafood product in the marketplace to benchmark results against. Additional analyses were carried out to establish microbiological parameters and shelf life of the dried products. The methods used are detailed below:

Moisture Content

Moisture content was measured for all samples at Curtin University using the standard method for loss on drying (moisture) in meat 950.46 (AOAC International 2008).

Water Activity

Water activity was measured using an AquaLab Water Activity Meter (Decagon Devices, Inc).

Ash

Dried samples from moisture analysis were used to determine the ash content according to the standard method for ash determination of seafood 938.08 (AOAC International 1938). Approximately 3 g of dried sample was charred for 24 hours at 550 ¡ÆC, left to cool for 3 hours in desiccators and then weighed to calculate ash content.

Protein

Protein content was determined by using the standard Kjeldahl method 955.04 for total nitrogen content as described by the AOAC International (1955). The BUCHI distillation unit K-314 and BUCHI digestion 245 system K-437 (BUCHI Labortechnick AG, Switzerland) were used for the experiment. The percentage of protein in each sample was determined from the total nitrogen content using a protein conversion (f) factor of 5.82 for seafood (Owusu-Apenten 2002).

Fat

Crude fat content of samples was determined by the standard method of acid hydrolysis 250 948.15 as described by the AOAC International (1948). A BUCHI Soxhlet Extraction Unit E-812/816 SOX (BUCHI Labortechnick AG, Switzerland) was used.

Fatty Acids

Fatty acid profile were performed after a total lipid extraction as per above followed by saponification and methylation of the fatty acids in the presence of a catalyst to form fatty acid methyl esters which are then profiled using Gas Chromatography with Flame ionisation detection (GCFID). This was performed on an Agilent 7890A GCFID using dean switch technology to resolve closely eluting isomers.

Heavy metals

Cadmium, lead and arsenic were analysed for some samples. Approximately 1 g of sample was digested using concentrated HNO_3 and diluted to 20 mL in volumetric flasks for analysis. Cadmium and lead were analysed by the flame spectrophotometry method 973.34 as described by AOAC International (1974). Arsenic was analysed using hydride generation 260 atomic absorption spectrophotometry as described by Fabiyi, Sileo, and Aremu (2008).

Microbiological Assessment

Samples were subject to microbiological testing at NATA accredited laboratories (PathCentre, Promicro and Silliker). Samples were tested immediately after production with additional shelf life analysis conducted after 6-12 months of chilled storage. Analyses included a Standard Plate Count, Coagulase Positive Staphylococci and *Salmonella spp*..

3. Results

3.1 Development and application of an economic framework model to assess the opportunities for dried seafood products to Asia from Western Australia.

A preliminary feasibility study was undertaken to assess which dried products would be competitive on the Asian Market, at what price points and what would be the likely competitive effects a new market would face. This preliminary study and compilation of the associated final report, including a framework to assess the economic viability of drying the various different products in the project, was undertaken by Seafood Services Australia and was intended to inform the choice of pilot species. The objectives of the report are summarised below.

- Consolidate an agreed seafood species price list. Calculate cost plus pricing for agreed seafood species.
- Calculate demand based pricing for agreed seafood species from Japan and Hong Kong.
- Complete final report.

The final summary page of the report is reproduced below and the report is attached as Appendix 3.

3.1.1 Summary of Economic Feasibility for the Production of Dried Seafood for the Asian market

The results suggest that based on the Free on Board (FOB) Australia cost of production calculation not all Australian dried seafood products may be economically viable for exporting (see Tables 3 and 4).

To calculate the FOB Australia cost of production (raw material, labour, packaging, energy, plant, etc.) for each seafood species, the following steps are to be followed:

i. the raw material costs before drying is divided by the dry recovery rate
ii. this results in a value for the raw material cost after drying.
iii. add assumed labour and material cost for producing the product to the cost after drying ,
iv. add plant and administration overhead cost for operating the drying process to the cost after drying
v. add an assumed profit margin of 25% to actually yield profit through producing the dried seafood product
vi. all the values summed up, result in the FOB Australia cost of production

The FOB calculation is then used as the basis to calculate the likely retail costs based on the need to:

i. add freight and insurance, including all additional costs involved in getting the product to the customer, for example sea freight/ air freight charges to wharf/airport, sea/air documents fees e.g. airway Bill, B/L, Transport contingency.
ii. add importing costs including a 10% margin on the previous value and potential marine insurance premium costs
iii. add potential import duties/taxes as appropriate for the Japan market (calculated as percentage of CIF price, plus customs clearance fees, delivery charges)
iv. add wholesaling costs, including an assumed 30% margin
v. plus retailing costs (expressed as 20% margin)

Based on the above calculations it is then possible to assess economic feasibility of production based on the calculated retail costs and the actual costs from the Asian markets.

Table 3 Economic feasibility for Hong Kong market

Product	Estimated FOB Australia cost	Estimated FOB Australia price	Economically feasible
Sea Cucumber Sandfish	$135.75	$527.22	Yes
Abalone	$403.50	$467.25	Yes
Scallops	$49.57	$324.61	Yes
Squid	$53.69	$49.42	No
Cuttlefish	$65.69	$55.48	No
Prawn (e.g. Brown or coral)	$240.44	$83.20	No
Shark fin	$98.13	$195.59	Yes

Sea Cucumber Sandfish, Abalone, Scallops and Shark fin might be competitive for the Hong Kong market, as the estimated Free on Board (FOB Australia price is higher than the estimated FOB Australia cost).

Table 4 Economic feasibility for Japanese market

Product	Estimated FOB Australia cost	Estimated FOB Australia price	Economically feasible
Sea Cucumber	$135.75	$467.25	Yes
Abalone	$403.50	$324.61	No
Scallops	$49.57	$324.61	Yes
Squid	$53.69	$49.42	No
Cuttlefish	$65.69	$55.48	No
Prawn (eg. Brown or coral)	$240.44	$83.20	No
Shark fin	$98.13	$195.59	Yes

According to the above calculation, Sea Cucumber, Scallops and Shark fin may be competitive in the Japanese market based as the estimated FOB Australia price is higher than the FOB Australia cost.

Based on the report, industry support, and feasibility issues, scallops were chosen as the initial target species for the project. Pearl meat was also chosen, although not part of the economic evaluation, as industry partners were very supportive and the perceived market price was very high. The economic framework developed for the project could be manipulated based on the “real” data produced or new products (eg pearl meat) added.

3.2 Using Vacuum Drying and Freeze Drying to Create Dried Seafood Products for the Asian market

Honours student, Karl Hansal, undertook preliminary drying and sensory trials on the target species. It had been anticipated that Karl would complete seafood drying trials in the Biolite dryer. Due to time constraints however drying trials were completed using laboratory scale vacuum and freeze dryers housed within the Curtin University School of Public Health.

In order to enhance the production of market appropriate products, Karl received support to visit project partners in Japan, visit dried seafood markets to collect prices and samples, (see Figure 3), establish relationships with the project partners and examine the Biolite dryer in operation in Japan.

Figure 3: Photographs of Dried Seafood markets in Japan (Karl Hansal 2010)

The Honours results detailed below reveal that the quality and sensory characteristics of products produced were comparable to traditionally produced product.

3.2.1 Final dried test samples

Although both freeze dried and vacuum dried products were produced, it should be noted that the aim was not to compare freeze drying with vacuum drying, but to evaluate the acceptability of both product types separately.

3.2.2 Final sample yields

Final sample yields are useful in predicting the economic feasibility of commercialising products on an industrial scale. Factoring yields into processing and raw material costs can be used to determine at what cost the final products should be sold by processors to ensure viability and profitability during long-term production (Naidoo, Slattery, and Bremner 1996). Dried seafood products are sold on a by-weight basis in Asian and world markets, and it is therefore in the interest of dried seafood processors to reduce the moisture content of products to a weight that is acceptable re food safety/quality parameters but still ensures profitability.Table 5 compares the results predicted by the drying model for final mean yield percentage, moisture content, and water activity to the actual results for vacuum and freeze drying experiments.

Table 5 Comparisons of the target and actual mean yield, moisture content, and water activity of sample groups

Sample group$_a$	Mean yield (%)			Mean Moisture content (%)			Mean water activity (Aw)		
	Target$_b$	Actual	Diff	Target$_b$	Actual	Diff.	Target$_b$	Actual	Diff.
Vac scallop	20.25	20.04	-0.21	<12.50	13.56	1.06	<0.600	0.586	-0.014
Vac scallop + acid	20.25	19.17	-1.08	<12.50	12.60	0.1	<0.600	0.564	-0.036
Vac pearl	32.40	31.91	-0.49	< 20	12.94	-7.06	<0.600	0.523	-0.077
Vac pearl + acid	32.40	31.82	-0.58	< 20	17.88	-2.12	<0.600	0.706	0.106
FD scallop	19.80	18.12	-1.68	< 10	11.07	1.07	<0.600	0.284	-0.116
FD scallop + acid	19.80	19.70	-0.10	< 10	9.86	-0.14	<0.600	0.460	0.060
FD pearl	27.54	26.14	-1.40	< 10	9.83	7.83	<0.600	0.350	-0.050
FD pearl + acid	27.54	30.87	-3.33	< 10	17.53	15.53	<0.600	0.644	0.244

a Number: 3
b Using initial moisture content of 83% for scallop samples and 73% for pearl meat samples

3.2.3 Proximate analysis

Moisture content and water activity

Water activity is the focus in food drying, as it is the water activity that is responsible for predicting the stability and safety of the final product (Baker 1997). Moisture content is important in the analysis because deviations in the expected water activity can cause shifts in water activity outside acceptable ranges. Standard: 1.6.2 in The Food Standards Code (2010) defines dried meat products as having water activity readings below 0.85, a value that will inhibit the growth of *Staphylococcus aureus* bacteria which is a common food handling microbiological contaminant.

All products analysed conformed to the Food Standard's definition with water activity readings < 0.85. The water activity target of < 0.6 for this study aims to inhibit the growth of all pathogenic and spoilage microbes.

The mean water activity and moisture content results for vacuum dried scallop samples were within the mean range of the traditional samples analysed (min mean Aw = 0.424 from Trad

Aus Large, max mean Aw = 0.679 from Trad China Small) and they were successfully dried to below the target water activity readings of < 0.600. Of the traditionally dried scallop samples analysed only the Trad Aus Med and Trad China Small groups showed water activity readings above Aw = 0.600 (mean Aw = 0.610, and mean Aw = 0.680) which could make them susceptible to mould growth during long term storage at ambient temperatures (Hall 1997).

Vacuum dried pearl meat samples without acid pre-treatment were successfully dried below the Aw < 0.600 target (Aw = 0.523, std. error = 0.05, moisture content = 12.94%, std. error = 1.98) however samples subjected to the acid immersion treatment yielded a mean water activity reading of 0.706 (std. error= 0.02) and moisture content of 17.88% (std. error = 1.23) which was above the Aw < 0.600 target. The standard deviation for water activity in the acid treated pearl meat group is low, thus the optimisation process demonstrated a high precision but lack of accuracy for the target water activity in this sample group. This result suggests the initial moisture content of the samples used were higher than predicted, and therefore the samples in this group required further drying to achieve the target water activity readings.

Variability in initial moisture contents of fresh samples has resulted in the final water activity being significantly above or below the target range for some samples. During the traditional process of sun drying scallops batches are often bought inside at night time for “tempering‟, which aims to achieve an even moisture content across the entire batch (Yoneda and others 2005). If variations in fresh moisture contents cannot be avoided then a ”buffer-percentage‟ could be added to the initial moisture content accounting for samples in the positive extreme ranges, however samples at the mid to lower extremes would risk unnecessary moisture loss and over-drying.

Protein, Fat, Carbohydrate, and Ash

Table 6 Comparison of the range of proximate parameters between traditional Asian and vacuum dried scallop samples

Proximate Parameter	Traditional scallop groups min meana	Traditional scallop groups max meana	Vacuum dried scallop + acid mean valuea	Vacuum dried scallop no acid mean valuea
Moisture (%)	9.39 (Trad Aus Large)	27.81 (Trad China Small)	12.60	13.56
Ash (%)	8.26 (Trad Aus Large)	14.96 (Trad China Small)	18.10	14.38
Protein (%)	47.12 (Trad China Small)	61.97 (Trad Japan Med)	48.38	45.84
Fat (%)	1.36 (Trad China Med)	3.04 (Trad China Small)	3.21	2.11
Carbohydrate (%)	7.07 (Trad China Small)	19.41 (Trad Aus Large)	17.61	24.11

Proximate composition results may show whether the drying methods used produce any noticeable anomalies. It was expected that proximate compositions for scallop and pearl meat samples would vary significantly as suggested by Webb and others (1969), who found that significant differences existed in the proximate composition within and between three different scallop species; and attributed the variations to seasonal, regional and environmental factors. Huda and Sari Dewi (2007) found no significant differences when comparing the proximate composition of vacuum dried Shark dendeng with traditionally dried dendeng.

It was expected that vacuum drying and freeze drying would not destroy the major proximate components of samples at the temperatures and pressures used. However, the proximate comparisons between the Asian scallops and West Australian scallops can be used to make inferences in sensory qualities, final product stability and quality of the fresh product.
The species of traditionally dried scallop samples purchased for this project were unknown, and no literature exists that would suggest Australian scallop species are currently used to commercially produce traditional-style dried scallop products for export.

Protein, fat, carbohydrate and ash content can indicate the nutritional status and health of the animal at the time of death and can also reveal whether the processing/drying methods show any evidence of compositional destruction/alteration to the final product. Vacuum dried scallop samples showed proximate variables within the general range found in the Asian products (Table 6). High mean carbohydrate, and fat values for both sources of dried products may indicate that the animal did not show signs of stress at the time of death and that the animal was well fed, with non-depleted stores of glycogen and fat inside the muscle tissue (Gracey, Collins, and Huey 1999).

3.2.4 Colour

Table 7 Mean range of Lab colour scale values for traditionally dried samples compared to mean vacuum dried values

Lab colour scale variable	Traditional scallop groups min mean	Traditional scallop groups max mean	Vacuum dried scallop + acid mean value	Vacuum dried scallop no acid mean value
L*	40.67 (Trad Aus Med)	47.55 (Trad China Med)	54.47	57.10
a*	5.56 (Trad Aus Large)	8.41 (Trad Jap Med)	6.40	1.32
b*	15.50 (Trad Aus Large)	26.11 (Trad Jap Med)	26.95	21.65

It was expected that variations in drying techniques in addition to variations in species and proximate composition would result in significant variation between traditionally dried and vacuum dried scallop samples. Each traditional scallop group, though similar in colour and surface texture, were easily distinguishable visually between groups. However, despite these noticeable differences a Kruskal-Wallis test for significance (set at 5% significance level) between the traditionally dried scallops showed no significant differences between the traditional samples for the L* (p-value = 0.248), a* (p-value = 0.248) and b* (p-value = 0.082) colour scale values.

Vacuum dried scallop samples were noticeably paler and more uniform in colour than traditionally processed equivalents which appeared to have patchy surface colours with dark and light areas. Significance of L* (light) and b* (yellow) values was confirmed (L* p-value = 0.017, b* p-value = 0.026) by conducting a Kruskal-Wallis test at 5% significance, with traditional and vacuum dried scallop samples. It is reported by Conova and Dong (1998) that in the Hong Kong dried seafood markets there is a preference for dried seafood that is lighter in colour (unless the fresh product has a dark pigmentation), which suggests that the light pale colours observed in vacuum dried samples may be favourable in target markets. It is also worth noting that the surface colour of the Trad China Small samples could not be measured by the Minolta due to the small size of the product, and this sample group appeared to have a uniform and light surface colour resembling the vacuum dried samples more so than the other traditional samples, as viewed by the assessor.

The final pearl meat samples varied significantly in size (3.24mm min and 8.37mm max final dried weights), and it was observed that the largest had a much darker surface colouring than the pale smaller sample. The small sample took 9 hours to dry, while the larger sample needed 10 additional hours to reach the target weight. The significant change in colour observed suggests that further optimisation of methods need to be explored for larger samples which are susceptible to non-enzymic browning when dried at the >60 ºC temperatures used for long periods of time, affecting the quality perception for potential buyers.

Freeze dried samples from both the scallop and pearl meat groups appeared to have a very chalky, pale white colour when dried. As chemical reactions are minimised during freeze drying the natural pigmentation of the surface colour is preserved.

3.2.5 Texture

Table 8 Mean hardness range for traditionally dried samples compared to mean hardness values for vacuum dried values (n=3)

Hardness (g) (Traditional scallop groups min mean)	Hardness (g) (Traditional scallop groups max mean)	Hardness (g) (Vacuum dried scallop + acid mean value)	Hardness (g) (Vacuum dried scallop no acid mean value)
1355 (Trad China Small)	10895 (Trad Jap Med)	4513	1840

Note: Hardness is force required (grams) for probe to depress sample by 10% using a 25kg load cell at 2mm/sec

Vacuum dried scallop samples had relatively low mean texture readings when compared with the traditionally processed samples. Vacuum dried scallops shared mean readings closest with Trad China Small scallops (Table 8) and as with colour were also observed to have similar textural characteristics.

Vacuum dried pearl meat samples also scored low mean texture readings relative to the traditionally dried samples. Vacuum dried samples scoring low on textural readings may be an indication that the nature of vacuum drying does not produce products as hard as traditional drying in the sun or air. Further research should be conducted to discover how species type and drying conditions may affect the textural properties of vacuum dried products.

3.2.6 Heavy metals

For the cadmium analysis all samples were < 0.10 ppm, for lead, all samples were < 0.10 ppm and for inorganic arsenic all samples were < 0.10 ppm

Although heavy metals were detected in all samples by atomic absorption spectrophotmetry, the values were much lower than maximum residue limits found in the Food Standards code: Standard 1.4.1 for contaminants and natural toxicants (Food Standards Australia New Zealand 2010).

3.2.7 Focus group sessions

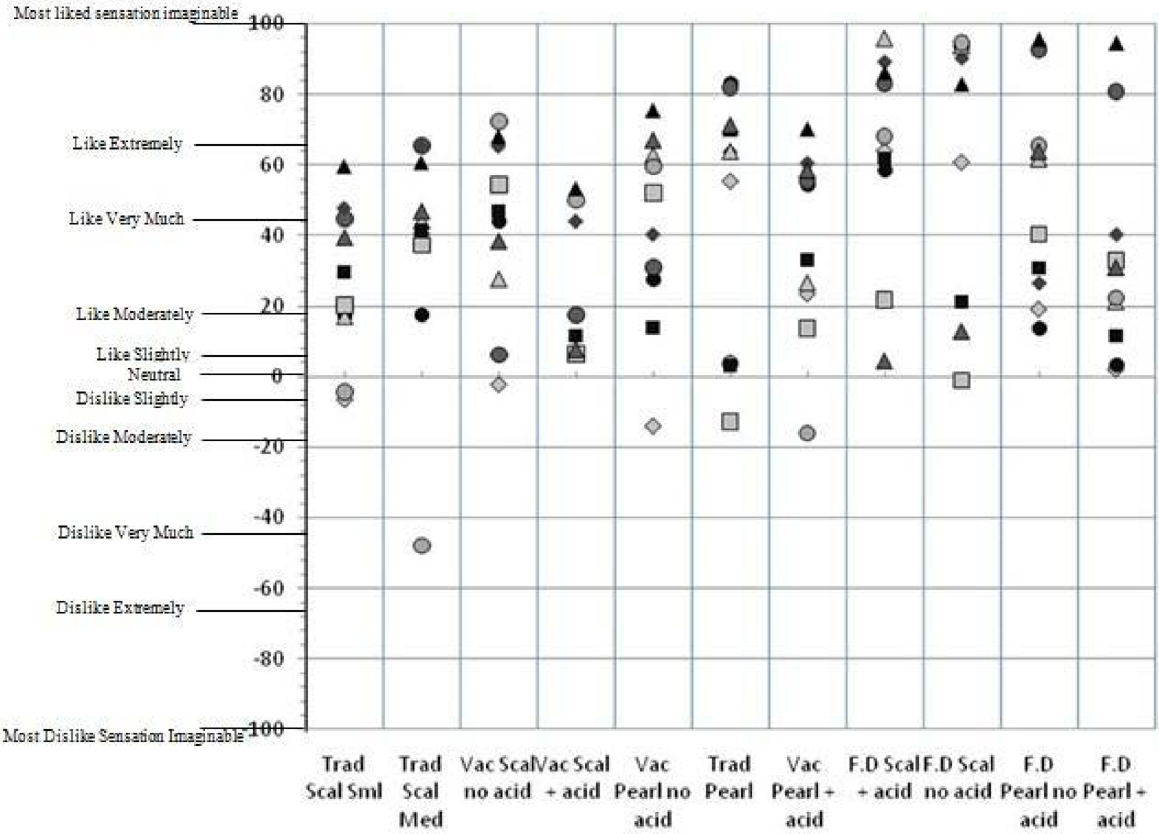

Figure 4: Graph showing sample group acceptability results with the labelled hedonic scale on the Y-axis and sample groups on the X-axis. Individual participants are represented by the different shape styles in the plot area.

(Acceptability ratings for all dried product groups using a labelled hedonic scale on the Y-axis)

Vacuum dried samples results

Results for overall acceptability of scallop samples (Figure 4) show that all samples were deemed acceptable by the majority of participants. The mean rating for vacuum dried scallop no acid was 41.12, situated between "Like moderately" (17.82) and "Like very much" (44.43) on the labelled hedonic scale. Acceptability ratings were tested for overall significance across the traditional and vacuum dried scallop samples using a Friedman"s non-parametric test. The Friedman's test showed that significant differences in acceptability of samples existed (p-value 0.005 at 5% significance) so each sample's acceptability scores were compared using the Wilcoxon signed ranks test for two related samples to determine which samples showed significantly different ratings. A significant difference existed only between acceptability ratings of the vacuum dried acid and no-acid scallop groups (p-value 0.012 at 5% significance). The Wilcoxon signed ranks Z score (vacuum dried scallop acid – vacuum dried scallop no-acid) = -2.499, confirming that the vacuum dried scallop no-acid scallop were significantly preferred to vacuum dried scallop with acid by the majority of participants.

It was found that during focus group discussions held after the first group of sample tasting (traditional and vacuum dried scallop) texture was a recurring discussion point and influenced the scores given. One participant proclaimed that the vacuum dried no acid sample had "*the most natural texture*" which prompted a higher score due to quality perception. It was agreed by all participants that saltiness was the greatest difference noticed between samples, and some participants found the saltiness overwhelming. The carrier stock used was a salt-reduced chicken-style stock which was pre-assessed to avoid noticeable saltiness, so the saltiness experienced by participants was imparted by the cooked scallop samples.

Scallop and pearl meat samples cooked in plain tap water during pre-treatment trials did not impart a strong flavour or saltiness into the cook-water, so the intense flavour produced when samples were cooked in the salt reduced stock may be an indication that extractive components in the dried scallops and pearl meat are interacting with components in the stock. Yoneda and others (2005) found that the flavour of dried scallop broth was improved when adenosine monophosphate (AMP), an extractive component of dried scallop was converted to inosine monophosphate (IMP) when mixed with chicken meat extract containing AMP deaminase. The carrier stock used in this study was chicken-derived, however it is unknown if AMP exists in the stock cubes used to account for the flavour changes noticed. This observation opens the possibility to more research in determining flavour interactions between extractive compounds found in dried scallop/pearl meat, and selected stock ingredients to improve the flavour profile of soups and broths.

Acceptability results (Figure 4) show an even spread of scores for the vacuum dried pearl meat samples. This is contrasted to the results for traditional pearl meat samples; with the majority of panellists giving high ratings and the remainder giving the samples much lower acceptability ratings. One participant remarked that younger consumers would be more open to trying new/uncommon kinds of dried seafood like the dried pearl meat, which had a unique flavour and “meaty” texture. The total sample size for this group is small, so accurate data based on panellist age cannot be conducted, however there was some agreement among the participants in regards to this comment. Mean acceptability ratings (48.35, 41.59, and 37.98) for traditionally dried pearl meat, vacuum dried no-acid pearl meat and vacuum dried with acid pearl meat showed that all three samples scored highly acceptable mean ratings. A Friedman’s test for overall significance of acceptability ratings was conducted and showed that no that overall significance existed between the acceptability of samples (p-value 0.368 at 5% significance). This suggests that both the acid and no acid vacuum dried pearl meat samples were equally acceptable to the traditionally prepared pearl meat samples for the majority of participants, regardless of whether samples were acid treated or not.

The focus group discussion following the tastings of traditional and vacuum dried pearl samples revealed that the majority of participants had not previously consumed dried pearl meat, and were inclined to compare the sensory qualities directly with dried scallop. Despite no significant difference in the mean acceptability between pearl meat samples it can be seen from Figure 4 that panellists did not give identical ratings for each sample, and there appears to be critical differentiation between the samples tasted. One panellist stated “*I think that maybe there could be a market for it (dried pearl meat), if it was cheap... cheaper than scallop!*” A few other participants nodded in agreement after this comment was made. This comment does not reflect the current market price for dried pearl meat relative to dried scallop prices, which further highlights the scarcity of dried pearl meat even within the Asian community.

It can be concluded from the acceptability ratings and statistical results that acceptable products can be created from the scallop and pearl meat groups using vacuum drying technology.

Freeze dried samples results

Participants were overwhelmingly receptive to the freeze dried samples presented. As participants were not informed that the samples had been freeze dried the group members assumed they been freshly prepared. "*Ah! Here come the fresh ones!*" said one excited group member. Comparisons were made between the acid and no acid freeze dried samples for each group. Feedback was very similar for freeze dried scallop and pearl meat, with panellists divided only by their personal preferences of the unique taste and textural characteristics of each.

A Wilcoxon signed ranks test for freeze dried scallop revealed that there was no significant difference (p-value 0.878 at 5% significance) between the acceptability ratings of the acid and non-acid samples, suggesting that both samples were equally acceptable amongst the majority of participants. A Wilcoxon signed ranks test for freeze dried pearl meat revealed that there was a significant difference (p-value 0.022 at 5% significance) between the acceptability ratings given for the acid and non-acid samples. The Z score (-2.293) shows that the non-acid treated vacuum dried pearl meat was significantly favoured by the majority of participants.

Concluding focus group discussion

The final focus group discussion held after all product groups had been tasted revealed that some panellists disliked the carrier stock used, and the majority believed the freeze dried samples should have been prepared using an alternative carrier/no carrier at all. The mood after the focus group had ended was very positive, and participants were eager to learn about how the products were made as well as future plans for the products. Participants all agreed that the majority of the products tasted would be enjoyed outside of the focus group setting.

It can be concluded from the acceptability ratings (Figure 4) and statistical results that acceptable products can be created from the scallop and pearl meat groups using both vacuum and freeze drying technology.

Concluding comments

The abstract for the Honours project is reproduced below and the full draft journal manuscript, modified to enable submission to Journal of Food Science, is available as Appendix 1. The aligned power-point Honours summary presentation delivered by Karl is attached as Appendix 4.

Using vacuum drying and freeze drying to produce dried seafood products for the Asian market

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ABSTRACT: West Australian scallop (*Amusium balotti*) and pearl oyster (*Pinctada maxima*) were sourced locally and dried using vacuum drying and freeze drying technologies. Final drying procedures were optimised, and the physical, proximate and sensory characteristics of the final products were analysed and compared with equivalent, traditionally processed samples already sold in Asian markets. Two focus groups using target consumers who were selected from traditional Asian backgrounds were asked to assess the overall sensory acceptability of the vacuum dried

and freeze dried products alongside traditionally processed equivalents via a blind tasting of coded samples. Physical and proximate analyses showed that the vacuum dried samples were within the ranges of Asian samples and the sensory analysis revealed that all West Australian products created were acceptable to the panellists, comparing equally with the traditionally processed equivalents. Freeze dried products scored high mean acceptability ratings, with participants believing the samples were freshly cooked. The potential for economically feasible production of dried shellfish products from locally sourced species has been trialled and it has it been demonstrated that safe, consumer accepted products can be created from local seafood species, comparing favourably with traditionally dried equivalents in physical, proximate and sensory acceptability tests.

Karl is currently employed at Simplot in Melbourne, but maintains close contact with CESSH.

3.3 Drying trials in Biolite Dryer

3.3.1 Initial Drying Trials

The products of preliminary trials conducted on Atlantic Salmon frames are displayed in Figure 5. Notably, significant oil was extracted from the dried Atlantic Salmon.

Figure 5: Before and after photos of dried Atlantic Salmon frames from preliminary trials.

The results of analyses of product from these preliminary trials are shown in Table 9.

Table 9: Results from Preliminary Drying Trials

	Dried Atlantic Salmon	Dried sardines	Dried prawns
Moisture (%)	1.0	7.1	13.2
Fat (%)	49.5	6.5	4.1
Protein (%)	36.5	71.4	64.6
Ash (%)	11.5	14.8	14.3
Standard Plate Count (CFU/100g)	<200	600	18000
Coagulase Positive Staphylococci (CFU/100g)	<100	<100	4500
Salmonella (CFU/25g)	Not detected (ND)	ND	ND

Drying of the Atlantic Salmon frames was particularly effective with moisture levels of 1% achieved. Dried sardines also reached target levels of below 10% moisture. Bacterial levels were low in dried Atlantic Salmon fish frames and whole sardines but high in dried prawns. The high bacterial counts in prawns were thought to be the result of poor handling. The high *Staphylococcus* counts in the prawns support the view that handling was an issue for prawns and Staphylococcal contamination is typically related to human handling and hygiene. No *Salmonella species* were detected in dried Atlantic Salmon, sardines or prawns. These microbiological results show that the Biolite dryer could produce microbiologically safe and superior products as compared with some traditionally dried products where enteric bacterial contamination has been noted, particularly those in developing nations (Logesh and others 2012, Ling and others 2002).

Additional detailed compositional data from the original dried products and the oil is shown in Appendix 5. While the level of extracted oil in the Atlantic Salmon frames was high at 49.5%, much of the oil was likely to be oxidised and saturated and therefore of lower value. The drying of high oil species therefore requires further investigation. Extracted oil has the potential to be a valuable commercial biproduct of drying oily fish once the process is modified to improve the quality of extracted oil.

To establish shelf-life of the original dried products they were retested eight months after initial production. Results of these shelf life analyses are presented in Table 10. Samples had been stored at ambient temperature.

Table 10: Eight Month Shelf-life studies on Preliminary Dried Samples.

	Dried Atlantic Salmon	**Dried Sardines**	**Dried Prawns**
Moisture (%)	1.9	9.6	19.9
Standard Plate Count (CFU/100g)	<100	<100	10000
Coagulase Positive Staphylococci (CFU/100g)	Not detected (ND)	ND	ND
Salmonella (CFU/25g)	ND	ND	ND

The results of shelf life analyses revealed no elevation of Standard Plate Counts over the eight month storage period. Additionally, no Coagulase Positive Staphylococci or Salmonella were detected in any of the three species tested. It was clear from the results that the both moisture levels and microbiological quality were relatively stable over the storage period.

Following the initial trials and the further modifications to the machine the PI, Doctor Janet Howieson, collaborated with the WAFIC CRC Extension Officer, Neil McGuffie, to seek expressions of interest for further trials of dried product from various WA industry representatives. The EOI documentation can be seen in Appendix 6, and the result was a schedule of testing of various WA seafood products. The results from the drying of these products including various species fish frames, shark cartilage, sliced abalone and pearl meat, whole Australian Salmon and Escolar, are reported below under the headings of seafood processing waste and dried whole products.

3.3.2 Drying trials with seafood processing waste products.

Fish caught and processed in Western Australia produce a potentially viable waste product. Fish waste accounts for approximately 20% to 60% of whole fish and is predominantly disposed of, at cost to the processor. In order to understand the potential of fish waste to be turned into a variety of secondary products, a cross section of fish waste was dried. Data obtained from drying different sea food wastes is reported below.

The drying trials were conducted under standard protocols conditions according to the Operations Manual (Appendix 2). Detailed individual drying data is presented in Appendix 7.

Drying Curves

Data consolidation of drying for the different seafood processing waste tested can be found in Table 11. The most significant data is the beginning weight of the sample, the percentage of loss through drying and the time taken. The time to dry a sample is directly proportional to the starting weight of the sample.

Table 11: Drying data consolidation for each of the processing wastes tested.

Sample	Starting Weight (kg)	Liquid Recovered (Litres)	Solids/Oils Recovered (kg)	Loss (kg)	Sample Loss (%)	Energy (kwh)	Time to Dry (hrs.)
Salmon (Atlantic) (1)	27.71	15.9	11.6	0.21	57%	320	3:45
Salmon (Atlantic) (2)	23.16	13.5	9.61	0.05	58%	289	4:08
Sardine Frames (1)	18.21	12.3	6.135	0.225	68%	309	5:09
Rosy Threadfin Bream	10.07	5.8	6.135	1.865	58%	181	3:28
Shark Cartilage	9.145	5.85	6.135	2.84	64%	205	3:39
Octopus Heads	5.255	3.65	1.34	0	69%	165	3:21
Sardine Frames (2)	40.82	29.40	11.64	0.22	72%	537	7:36
Barramundi Frames (1)	3.94	2.30	1.55	0	58%	126	2:28
Mixed Fish	6.765	4.50	2.33	0.065	67%	171	3:30
Barramundi Frames (2)	14.02	7.75	6.27	0	55%	230	3:19
Australian Salmon	9.18	6.00	3.63	0.45	65%	203	2:34
Salmon (Atlantic) (3)	10.81	6.65	4.01	0	62%	192	3:04
Escolar	16.07	9.70	5.87	0	60%	264	4:27
Salmon (Atlantic) Heads	8.96	5.90	3.56	0.5	66%	183	2:49
Salmon (Atlantic) Skins	4.695	2.50	1.92	0	53%	127	2:20

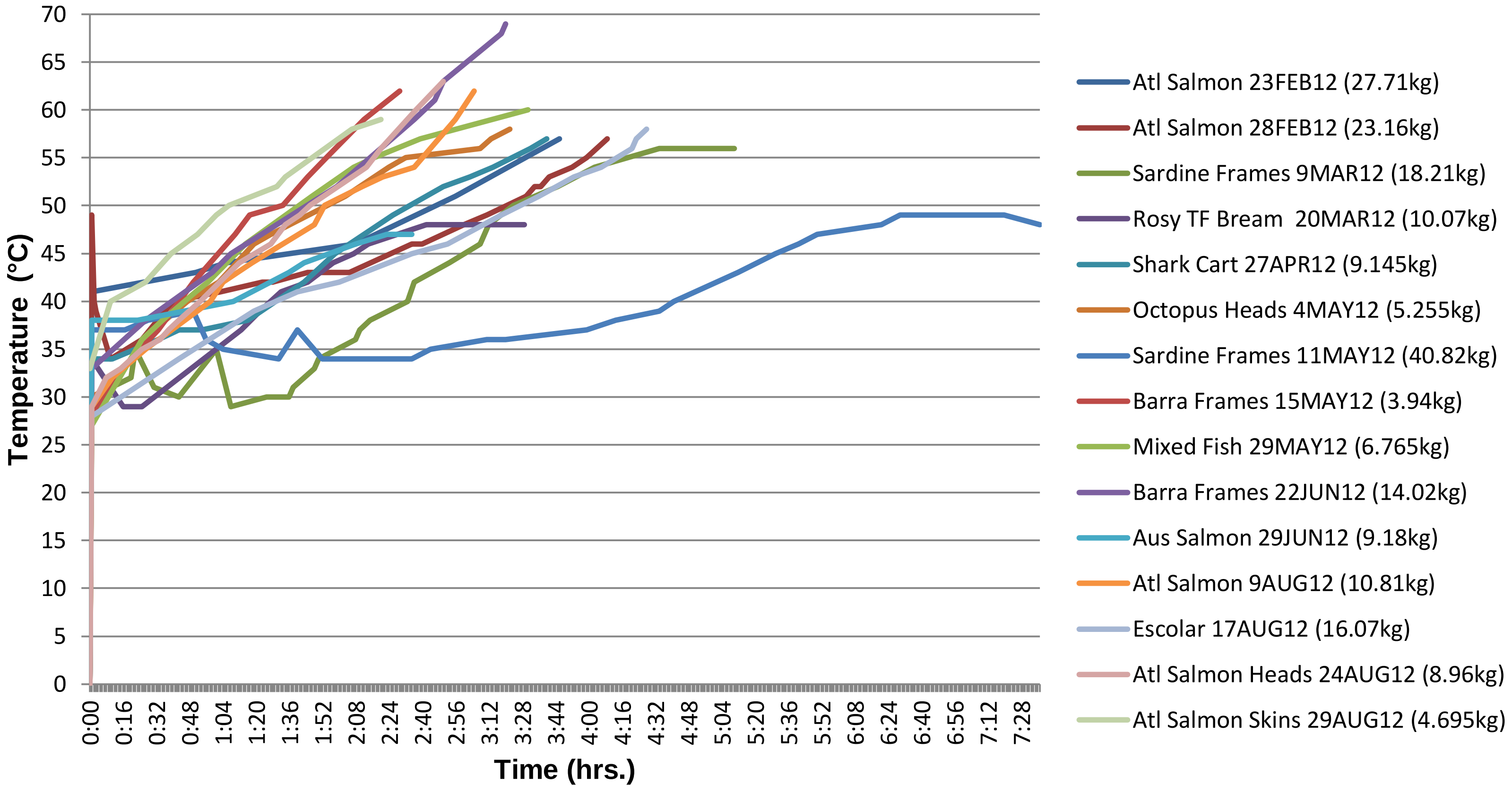
A drying curve summary of the different species of fish being dried can be found in Figure 6. The drying curve for each species shows slight variation. The weight of the sample being dried was the predominant and most accurate indicator of drying time as well as the final maximum temperature of the finished product.

The positive correlation between volume and the time required to dry was clearly demonstrated by the data collected. The drying trial with the lowest volume was carried out on 3.94kg of Barramundi frames and required 2.5 hours of drying time. Conversely, the largest consignment dried was sardine frames (40.82kg) which required approximately 8 hours of drying time.

Drying time was also influenced by the oil content of the fish. Oily fish such as Atlantic Salmon having a high oil to moisture ratio require less drying time than fish with a low oil to moisture ratio. Fish such as shark and Australian Salmon with relatively higher oil to moisture content require greater drying times.

Most samples dried well, with the exception of the octopus heads (~30%). It was thought that the difficulty in drying octopus heads was due to the external skin structure of the waste product trapping moisture internally. The dryer was not effective in breaking down the external tissue of the octopus.

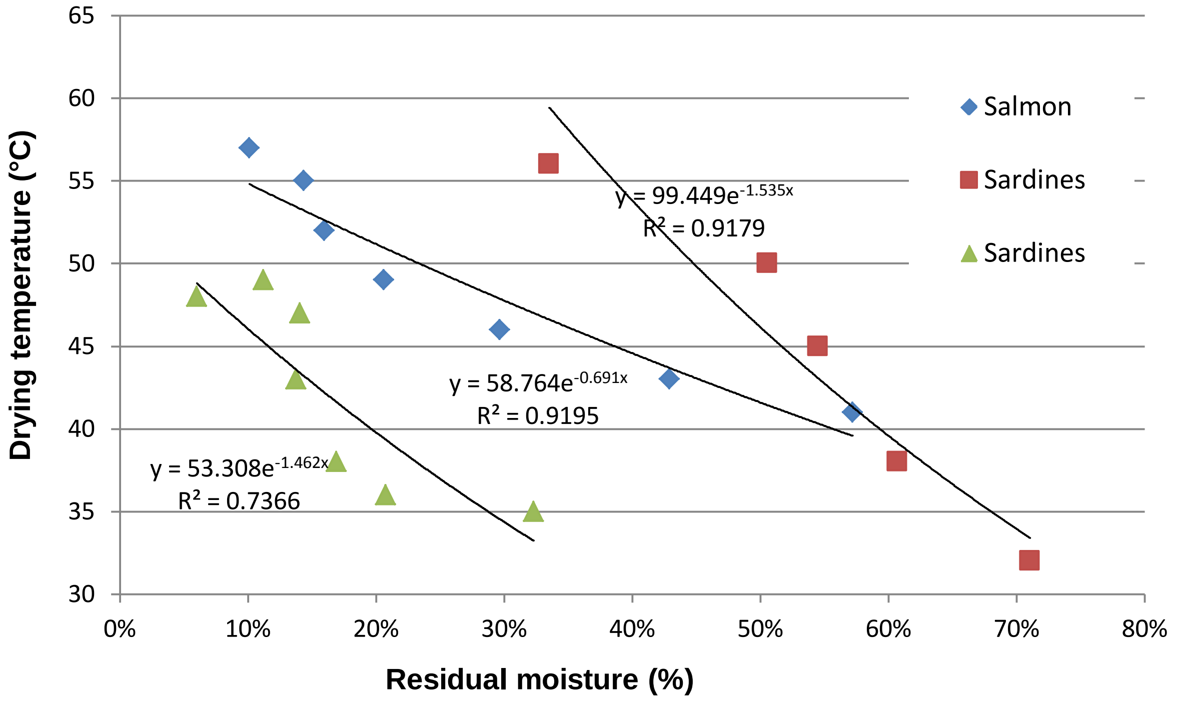
Figure 6 Time Taken to Reduce Moisture to <5% for Selected Waste Products



Moisture of Finished Product

Drying times were also governed by the desired final moisture content of the final product. Lower residual moisture levels require increased drying times. Higher temperatures could be employed within the drying process to achieve lower residual moisture levels in a given time frame. Figure 7 shows the linear relationship between residual moisture and temperature of drying.

Figure 7 Residual Moisture Content and Drying Temperature



3.3.3 Energy Use During Drying.

Energy use during drying is an important commercial consideration. Throughout the drying trials a comprehensive log was kept on the energy required to dry any given sample. The data in Figure 7 demonstrates that the amount of energy used was proportional to the weight of the starting material. Logically, larger samples contain more moisture and require longer drying times and / or temperatures consuming more energy. Preliminary energy costs calculations are shown in Table 12.

Figure 8. Energy usage and starting material weight.

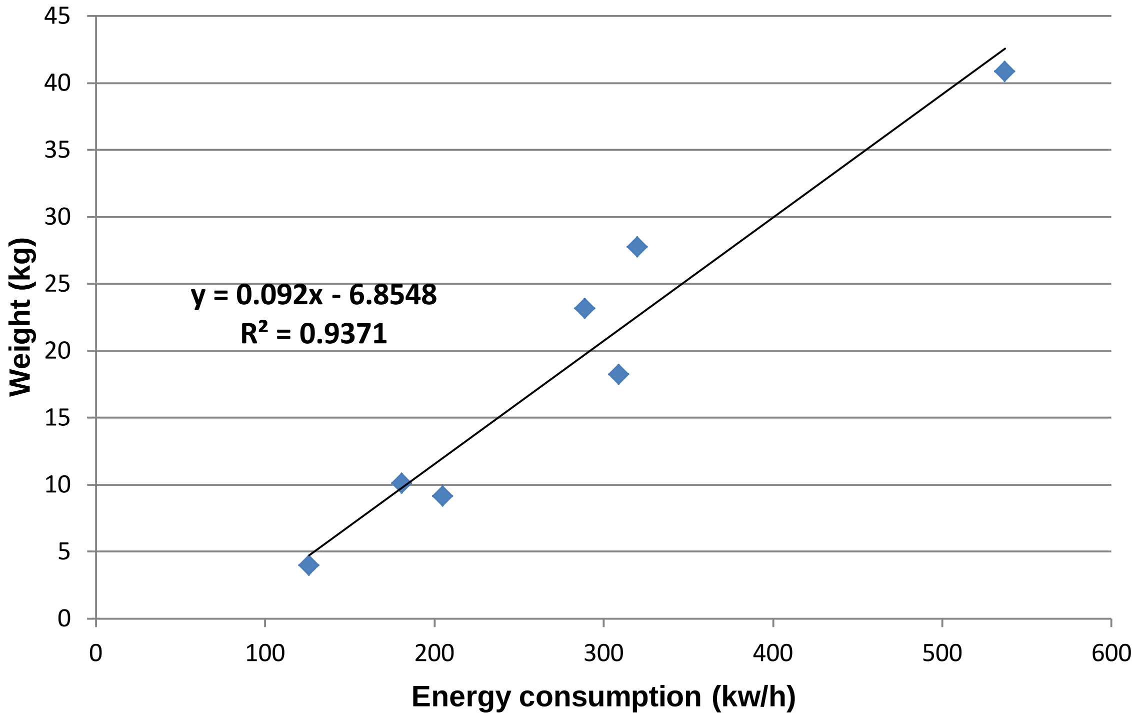


Table 12: Energy and Weight Calculated Costs (50kg Biolite Dryer)

Weight (kg)	Energy (kwh)	Cost (@0.22c/kw)
10	183.20	$40.30
20	291.90	$64.22
30	400.60	$88.13
40	509.29	$112.04
50	617.99	$135.96

3.3.4 Summary of drying trials

A summary table of the various parameters of the dried products trials is shown in Table 13 with more detailed results shown in Appendix 5. Compositional and shelf-life data are included where appropriate. Heavy metal and fatty acid analyses were conducted on selected samples.

Table 13: Summary Table of Drying Trials with Seafood Processing Waste

	Dried Atlantic Salmon frames	**Dried sardines (whole)**	**Dried sardine (frames)**	**Dried barra (frames)**	**Dried Aust salmon (Headed and gutted)**	**Dried Escolar (whole)**	**Dried prawns**	**Rosy Thread fin Bream**	**Shark cartilage**
Moisture (%)	1.0	7.1	5.73	7.4	20.9	7.7	13.2	10.74 (35.8)	11.64
Fat Folch (%)	49.5	6.5	11.3	38.2	9.6	43.9	4.1	2.9	ND
Protein (%)	36.5	71.4	53.1	36.7	64.1	41.1	64.6	50.4	ND
Water Activity	0.579	ND	0.705	0.519	0.787	0.521	0.628	0.894	0.837
Ash (%)	11.5	14.8	15.8	14.5	5.0	4	14.3	13.2	ND
Standard Plate Count (CFU/g)	<200	600	<200	<200	<200	<200	18000	2.1×10^7	ND
Coagulase Positive Staphylococci (CFU/100g)	<100	<100	ND	ND	ND	ND	4500	ND	ND
Arsenic (mg/kg)	0.6	ND	10	0.6	ND	ND	ND		ND
Cadmium (mg/kg)	<0.001		0.4	<0.001	<0.01	1.2	ND	0.39	ND
Mercury (mg/kg)	0.04	ND	0.1	<0.01	ND	ND	ND	ND	ND
Lead (mg/kg)	0.012	ND	0.4	0.1	<0.01	0.012	ND	<0.01	ND
Omega 3 oils (g/100g)		2.16	1.10	5.39	2	2.2	1.01	ND	ND

ND: Not done

Microbiologically samples were of good quality with the exception of Rosy Threadfin Bream and prawns. The high water activity measured in Rosy Threadfin Bream may explain high bacterial counts with more water available within this product to support microbiological growth. The prawn sample contamination with *Staphylococcus* was thought to be due to poor handling probably on thawing.

Individual Samples

Before and after photos of the samples subject to drying in the Biolite dryer are shown in Figures 9-16. Duplicate samples such as Atlantic Salmon and Sardines are represented by single photos.

Before

After

Figure 9: Atlantic Salmon frames.

Before

After

Figure 10: Sardines.

Before

After

Figure 11: Shark frames.

Before

After

Figure 12: Barramundi frames.

Before

After

Figure 13: Australian Salmon.

Before

After

Figure 14: Escolar.

Before

After

Figure 1 Mixed fish.

After

Figure 16: Octopus heads (no before sample taken).

3.3.5 Atlantic Salmon Waste Additional Studies.

An additional investigation was carried out in response to the large amount of oil biproduct generated from drying of the Atlantic Salmon frames. Fish meal and fish oil produced from the Atlantic Salmon waste are shown in Figure 17.

Figure 17: Products from dried Atlantic Salmon Waste.

Oil from the Atlantic Salmon frames was analysed separately. The fatty acid results are shown in Appendix 5.

In a further trial the dried Atlantic Salmon frames were “pressed” in an olive oil press to assess likely recoveries of oil from the dried product. From an initial 4.01kg of dried product, 0.513kg of oil (12.8%) was recovered, 3.392 of solids were recovered (84.6%) and 0.105kg (2.6%) was lost. Some of the pressed oil was then sent to Japan for analyses.

Preliminary result from drying of Atlantic Salmon frames were discussed with major Atlantic Salmon producers. The comment was that the heads and skins were better options for drying trials as several options had been developed for fish frames. As a result of these discussions drying trials were conducted on Atlantic Salmon heads and skins. These results are shown in Table 14.

Table 14: Results from drying trials with Atlantic Salmon frames, heads and skin.

	Frames	Heads only	Skin only
Moisture (%)	1.0	8.9	10.1
Fat (%)	49.5	40.5	39.3
Protein (%)	36.5	44.8	54.9
Ash (%)	11.5	4.7	4.3
Standard Plate Count (CFU/100g)	<200	<200	<200
Coagulase Positive Staphylococci (CFU/100g)	<100	ND	ND
Water Activity	0.579	0.568	0.639
Arsenic (inorganic)	0.6		
Cadmium (mg/kg)	<0.001	1.2	<0.01
Mercury (mg/kg)	0.04		
Lead (mg/kg)	0.012	0.014	<0.01

3.3.6 Drying trials with whole/sliced products

Sliced abalone, pearl adductor muscle and whole un-shucked and shucked oysters were dried in the biolite dryer at the request of WA industry partners. The revolving action of the dryer was stopped to prevent mechanical destruction of the products, and the products were placed on a shelf inserted into the dryer.

Satisfactory results were not achieved with drying of whole oysters; the peripheral tissue of the oyster began to burn/cook before the moisture from the internal tissue could be drawn out. The dried oysters produced were dry on the outside but still moist in the middle. The sliced abalone dried well but was very tough (Figure 18). As with the oysters, dried pearl meat slices began to cook on the periphery as temperatures rose. Thinner slices of pearl meat may be more effective (see Figure 18). With sufficient commercial interest these trials can be repeated with different combinations of time and temperature.

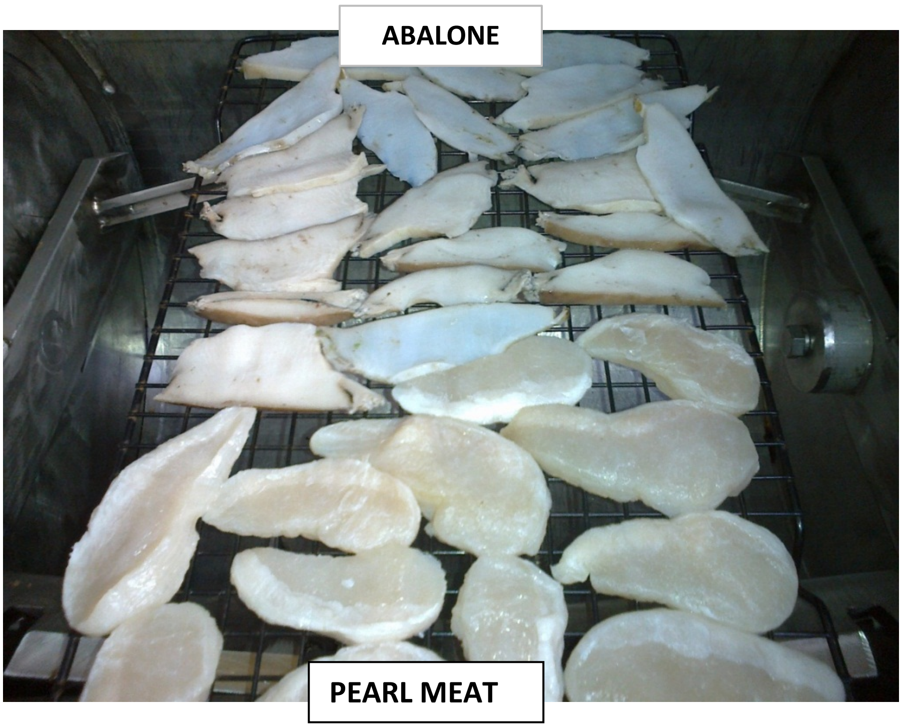


Figure 18a: After Drying of Sliced Abalone and Pearl Meat Adductor Muscle.

Figure 18b: After Drying of Sliced Abalone and Pearl Meat Adductor Muscle.

Based on the variable results using the Biolite dryer in Western Australia, whole abalone was transported to Japan to be dried in the equivalent shelf dryer operational there. The subsequent product was well received (see Figure 19) and therefore whole abalone, oysters, pearl meat adductor muscle and scallops have been transported to Japan for drying in that particular customised machine. These trials are ongoing and results from these trials will be reported separately.

Figure 19: Whole Abalone dried in the Japan based shelf dryer.

3.4 Economic evaluation and Industry liaison activities to investigate possible future commercial arrangements

3.4.1 Introduction

The project involved the assessment of a proprietary low temperature drying technology. Traditionally, high temperature drying in ovens destroys the long chain nutrients and can have a marked effect on the appearance, flavour and texture of the products produced. The low temperature drying technology allows seafood products to be treated mildly, potentially preserving the nutrition content of the dried product. Figure 20 summarises the three outputs of the drying phase; a cake (fish meal); lipids (oil) and water which contains soluble compounds.

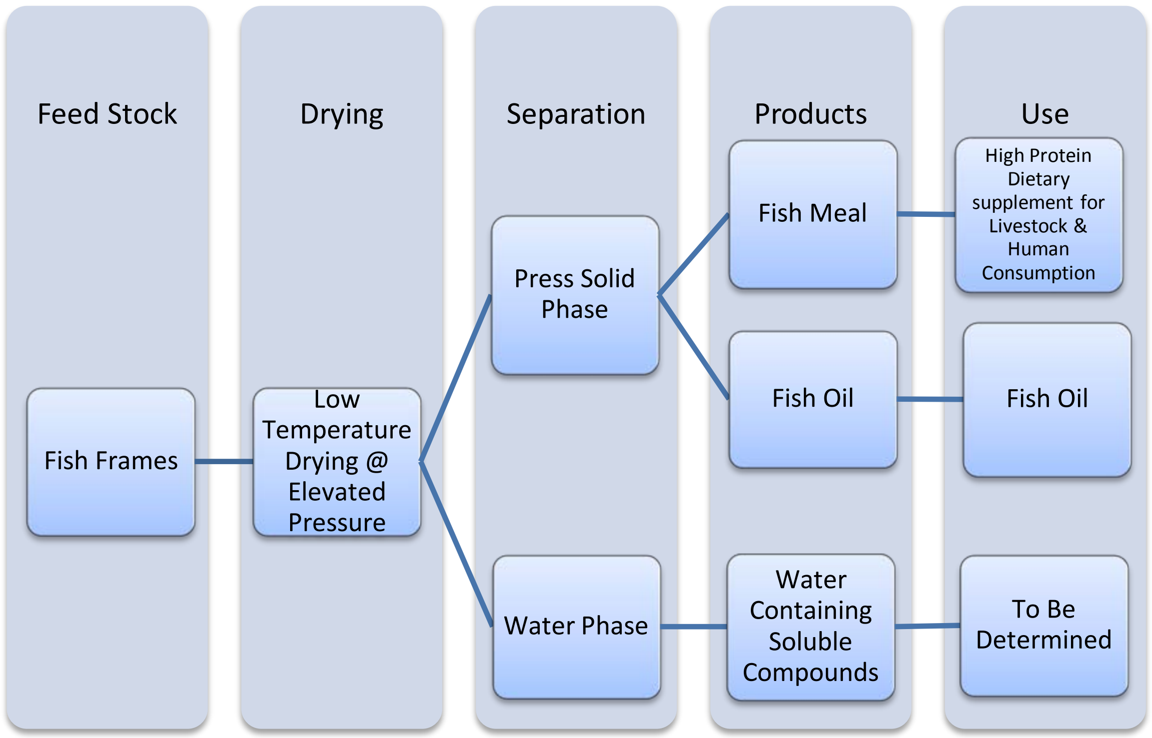


Figure 20: The low temperature technology separates water from the dried product

3.4.2: Commercial Opportunities from Dried Products from Seafood Processing Waste

At the present (high end) estimated costs of production for meal and oil from the dryer are estimated to be $3600/tonne based on Australian power costs. This cost of production is too high for viable commercial use of the meal and oil in aquaculture feed (market price of fish oil $1500 per tonne and fish meal $1200-1800 per tonne) (Tay, pers comm). Other possible commercialisation options are described below:

a. High protein supplements for humanitarian situations

The United Nations World Food Program (WFP) is the global procurement and distribution process for the majority of humanitarian / emergency food relief globally. In 2011 it purchased 2.4 million metric tonnes of food costing US$1.23 billion dollars. A high percentage (86%) of the food purchased were staples such as wheat, rice, lentils, chickpeas, sugar, maize and sorghum. WFP also brought some specialised highly fortified supplementary food (350,000 metric tonnes valued at US $317.5 million). Examples of such fortified supplementary foods are shown in Appendix 8. An example is high energy biscuits, these cost around $1200/tonne of the packaged product. The formulation of supplementary foods is based on providing energy to sustain people. The percentage fat and protein in the products listed in Appendix 8 (13%) are low compared to the nutritional profile of fish meal provided in the current research (see Table 15).

Table 15: Examples high energy food for from WFP compared with dried fish meal.

Food **Composition**	**Fortified Blended Food (packaged)**	**Ready to use food**	**High energy Biscuits (packaged etc)**	**Compressed food bars (packaged etc)**	**Vacuumed dried fish meal (not processed)**
Price (per tonne)	$9720		$1200	$3210	$3600 (max)
Energy	380Kcal	534 Kcal	450 Kcal	500 Kcal	Not known
Protein	18%	13%	13%	16%	30-45%
Fat	6%	12.5%	15%	18%	11.3-49.5%

Higher fat and protein diets are more effective in reducing malnutrition in children less than two years of age. To increase protein levels in WFP target diets skim milk powder is added. Skim milk powder is (by weight) 36% protein, 52% carbohydrate and provides calcium (1.3%) and potassium (1.8%). The cost of skim milk powder is just over AUD $3000/tonne.

The dried fish meal product has potential as an additive to the highly fortified supplementary food products to increase protein levels in the WPF diets. Fish meal has a higher protein level than skim milk powder and may be a cost effective way to increase protein content in diets specially formulated for children. Further research is required to fully understand digestibility and palatability of the diet if the fish meal product is used. This area of development of a biscuit incorporating the dried fish meal and investigating the resulting digestibility/palatability will be the subject of a Masters of Food Science Project in 2013.

One important element in accessing the market is the WFP policies on procurement. The WFP's general policy is to purchase from pre-qualified suppliers through a competitive bidding process. Before issuing a tender, careful consideration is given to the location of the most advantageous place to buy, relative to the area of need. When all conditions are equal, preference will be given to purchasing from developing Countries. Currently, the majority of the highly fortified supplementary diets are produced in Asia.

b. Dashi: fish stock powder

Dashi fish stock powder is a class of soup and cooking stock considered fundamental to Japanese cooking. Dashi is generally produced from dried fish powders or dried seaweed powders. The traditional Japanese Naboshi Dashi is made from dried Sardines; however there are a number of different fish species used to make the dried powder. Dashi is used throughout North East Asia and there are substantial markets in Japan and South Korea.

An alternative Dashi product commonly available is dried Bonito or dried Skipjack Tuna powders. The market price for the product varies between US $780- $1500 per tonne including packaging. Packaging is in 500gm bags, with 2x500gm bags in an inner carton with 10 inner cartons per outer carton.

Dashi is a niche market in Japan. Dried sardine product from the Curtin University dryers was milled (Figure 21) and sent to Japan. Analysis within the Japanese market revealed the test Dashi (from dried Sardines) to have similar properties to the Japanese product (see Table 16).

Figure 21: Dried sardines is an ingredient that could be potentially incorporated into products like Dashi.

c High omega and protein supplement for Korean poultry industry

Although the costs of the dried seafood product from this operation exceeds those costs on the open market (eg fish oil $1500 per tonne and fish meal $1200-1800 per tonne) potential markets in the Korea poultry industry appear willing to continue discussions, based on the source of the product and the compositional analyses, particularly of the fatty acids, which were very favorable. The Korean interest in the fish meal has been principally around the use of the meal in poultry feed to increase the omega 3 levels. WA Dried sardine product is currently being trialled in the Korean poultry industry for impacts on omega 3 levels in egg production

d High protein supplements for premium pet food industry.

We have been asked to provide some product for some trials with premium pet food companies.

e High value products from Shark cartilage

We have successfully dried shark frames to produce a dried cartilage product. Further processing of this product may results in high value products being extracted. In addition dried shark fin may be an alternative product.

Table 16: Comparison of Dried WA Sardines with dried Japanese sardines (for dashi production)

Valuation item	Dried WA sardines	Raw material from Setonaikai (Seto inland sea)	Dried sardine from Setonaikai(Seto inland sea)	Raw Material from Setonaikai(Seto inland sea)	Dried Sardine Powder by Setonaikai(Seto inland sea)
		Sardine *E. Japonica*	Sardine *E. Japonica*	Sardine *E. Japonica*	Sardine *E. Japonica*
Process of manufacture	Normal temperature drier	Normal temperature drier oxygen treatment	Normal method of dried fish	normal temperature drier and oxygen transaction	Normal method of dried fish
Moisture (% or g/100)	7.1	9.1	18	0	0
Fat Folch (% or g/100)	6.5	8.5	3.4	9.4	4.2
Protein (%)	71.4				
Ash (%)	14.8				
Total extract (g/100)		32.2	14,9	35.5	18.1
IMP-Na (mg/100g)		931	633	1024	771
Isolated amino acid (mg/100g)		2942	937	3236	1142
Amino acid (mg/100g)		282	92	310	112
Bacterial count (CFU/g)	600	Below 300	140000	Below 300	140000
Heat resistant bacteria (CFU/g)	ND (Not Detected)	ND	2000	ND	2000
Enterobacter (CFU/g)	negative	negative	negative	negative	negative

f High protein supplements for survival foods.

There is a market for dried and vacuum packed complete meal solutions. The main uses are in responding to emergencies and in the camping, hiking and boating market. These vacuum packed meals are light weight and have extended shelf life, both critical factors in this market. There are a number of marketers of these products globally. The majority of the manufacturing of the products occurs in China. A preliminary investigation (Tay pers comm) of the range of meals from a number of different marketers showed a range of prawn based meals but did not reveal any fish based or fish flavoured meals.

g Premium fish oil

However, there is an option to provide premium omega 3 Oil for human consumption. Samples have been sent to a Japanese company for analyses.

3.4.3 Options for Supply of Fish Processing Waste for Drying

Atlantic Salmon Producers

Preliminary discussions with Tasmanian Atlantic Salmon producers indicate the output of salmon waste is at least 3380 tonnes annually. However, there are also skins and offal waste products that could be utilised. Producers have stated that the offal, skins and heads should be examined first and foremost, and secondly the frames which have other uses. Results of these separate waste components after drying have been communicated to Atlantic Salmon producers with no response.

Perth based processors.

One Perth based processor produces approximately 215MT of Atlantic Salmon waste each year. This represents 40% of production (ie 537.5MT/yr produced). They are charged a pick up fee from a waste carrier which includes all waste. Based on this the cost to remove offal waste is estimated at $6k per annum. Currently, the waste undergoes rendering and is made into fish meal. This is then used for an additive mainly in pet-food production and is also used in fertilisers.

Australian Seafood Co-Products Fertilisers Pty Ltd (ASCoF)

Australian Seafood Co-Products Fertilisers Pty Ltd (ASCoF) was formed to commercialise biological fertilisers based on fish waste. The collaborators in the project were particularly attracted to producing a unique biological solid fertiliser that could provide an alternative to widely used superphosphate fertilisers.

To convert the fish waste into a usable product, ASCoF required access to an industrial biotechnology technique from Pacific Biofert, a New Zealand company with expertise in bioactive fertilisers. Pacific Biofert’s unique and patented technology hydrolyses the fresh fish waste in acid and then uses advanced composting technology, including fungal inoculation, to produce solid fertiliser that is suitable for a range of applications. The biomass in this biological phosphate fertiliser makes this product suitable for both organic and bio-dynamic applications.

ASCoF previously has had commercial relationships with Incitec Pivot and Southern Soils and sold about 200,000 litres of liquid fertiliser and about 4,000 tonnes of solid fertiliser per year. This production is now in abeyance.

The company is no longer producing commercial quantities of the fertiliser. The equipment and infrastructure are however still owned by ASCoF.

3.4.4 Dried Products from Whole Fish (not currently utilised)

There may be an opportunity to produce dried products from whole fish which are caught but currently not used for human consumption. Trials have been completed on Rosy Threadfin Bream, Escolar and Australian Salmon.

High protein fish meal

Options would be similar to fish processing waste (3.4.2) except protein content for whole fish is considerable higher (~70%) and ash content lower.

Premium oil

Richard Stevens (WAFIC) discussed Australian Salmon options with Aphichai Techanitisawad, Managing Director of Anusorn Mahachai Surimi Co which processes factory by-product to meal and oil. There is a commercial dryer (low temp/low pressure) in Malaysia, but products for human consumption have not been identified. Estimates of extraction of 8-10% oil from Atlantic Salmon frames are below that achieved in this project.

3.4.5 Whole dried products

The pilot dryer currently available for drying is not optimised for drying whole product. However there is interest from WA producers should an appropriate machine be made available. This interest has been from the Abalone, Oyster and Cobbler (for stomachs) dried product.

Abalone has been sent to Japan for drying in the appropriate machine (see Figure 19). Permits have now been obtained to enable drying of Abalone (again) as well as Oysters, Scallops and Pearl meat in the Japanese machine. Samples have been sourced and were despatched in December 2012.

4. General Discussion

There were several unforeseen problems in the early stages of the project. Firstly the delivery of the dryer was delayed by 12 months, necessitating a change in the proposed Honours research conducted by Karl Hansal using funding from the project. Despite the challenges, Karl was able to complete a preliminary study on the vacuum drying of the target species and some innovative work on the freeze drying of the same products. He also visited Japan which cemented project partnerships and provided information on the operation of the dryer in its Japanese installation.

The preliminary economic assessment suggested that the target species be Scallops, Pearl Meat was subsequently added at WA industry request. However, the dryer when it arrived had a different configuration from that expected, advice was received that whole products could not be dried in this machine. This was subsequently confirmed in experimental trials with Oysters, Abalone and Pearl Meat.

Successful installation and commissioning of the machine also was longer than expected due to significant electrical and plumbing work being necessary, and registration/certification of the machine being quite onerous. However the dryer was finally fully operational in February 2012 and since then a number of dried products have been produced and analysed.

The project demonstrated that shelf-stable, bacteriologically and compositionally food safe dried products could be produced in the dryer. The low temperature resulted in oil/meal products with possible use in poultry feed supplements, food flavouring and for further extraction of fine chemicals for example astaxanthin. Costs of the power used to produce the products was estimated.

In looking towards commercial application of this technology the two broad categories of dried seafood products can be targeted: firstly traditional products such as dried fish, dried kale and dried seaweed and secondly snack foods such as roasted seaweed and shrimp (Wang and others 2011). Dried seafood snack foods, as a category, are developing very slowly despite offering superior nutrition to many cereal based snack foods. One of the major barriers to development is processing technology and knowledge and a lack of consumer awareness of the nutritional value of dried seafood products (Wang and others 2011).

A number of commercialisation options have been identified and there is interest from a number of industry partners to continue trials. This interest has been intensified by an article in SEAFOOD MAGAZINE, in which up to 10 phone enquiries were received.

Options for longer term “in confidence” trials are being discussed with the Curtin University, Seafood CRC and Kingsun Bioscience representatives. The owner of the dryer remains engaged and seems content for the dryer to remain in Western Australia. Dryer operations will therefore be continued (and funded) in the future with committed industry partners. CESSH, Curtin University remains committed to providing research backup as required. Also Curtin University student projects incorporating the dryer are in place for 2013 (Abubakary Saad Mbadjo (Masters of Food Science, research project production of high protein biscuits from dried fish frames).and likely to continue into the future.

5. Benefits and Adoption

The project has successfully demonstrated that the drying technology can be used for a range of WA seafood products. A range of commercialisation options have been identified (see Section 3.4) and discussions with future industry partners are continuing. Further trials with the dryer will be managed in individual contracts between the commercial partners in the dryer and interested producers.

6. Further Development

As described in Section 3.4, a number of commercial opportunities have been suggested and industry partners have indicated interest. Further work with the technology will be developed based on one on one industry funded partnerships.

7. Planned Outcomes

Public Benefit Outcomes

a. Options are presented for possible use for seafood processing waste.

The project has resulted in an interest in drying as an alternative to traditional means to discard waste. Both fish meal and oil can be extracted for further use at a potentially higher value. There is local and international interest in using the meal for high protein supplements as well as a range of other uses.

b. Value added opportunities for the WA seafood industry

The project has demonstrated the production of shelf-stable, food safe dried products from up to 10 different WA seafood products. Many companies are now considering dried products as part of their premium products range (eg Paspaleys Pearls) or as an alternative higher value product for waste or underutilised products (Urangan Fisheries, Fremantle Octopus Company). This technology can now be available to specific industry partners under separate arrangements.

Private Benefit Outcomes

a. Individual companies may develop commercial in confidence opportunities using the dryer.

Linkages with CRC Milestone Outcomes

Output 2.8 - Smart processing technologies and practices

Milestone 2.8.1 - Innovative technologies for controlling spoilage to enhance shelf-life and marketability identified, implemented and evaluated for five seafood products

Milestone 2.8.2 - Innovative technologies and approaches to improve processing efficiencies by recovering under-utilised product, and reducing waste trialled and evaluated for three seafood sectors

Milestone 2.8.5 - Twenty new seafood products developed, incorporating innovative processing and packaging technologies, commercially trialled and evaluated

8 Conclusion

This research has explored many aspects of dried seafood relevant to the West Australian Seafood industry. Market potential and economic feasibility has been identified in the Hong Kong market for dried sea cucumber, abalone, scallops and shark fins and in the Japanese market for dried sea cucumber, scallops and shark fins.

West Australian dried seafood products were created by developing optimised pre-treatment and drying conditions; producing safe, ready-to-eat vacuum and freeze dried products, having the potential to be implemented on an industrial scale. In this study sensory proximate composition, physical properties and food safety analyses has shown that products produced using vacuum drying technology were within acceptable ranges of results obtained from traditionally processed equivalents purchased on local and Asian markets. Sensory focus group evaluations using target consumers showed that acceptable products were created from scallop and pearl adductor muscle using vacuum drying and freeze drying technologies. The results from this project results can be integrated into economic feasibility studies. The potential has been realised for further research into drying technologies, further exploring the effects of drying conditions and optimisation methods.

Novel drying technology was introduced and installed into Western Australia. Drying trials confirmed that the quality of fresh Australian seafood was reflected in the dried products with microbiologically and chemically safe products produced. The project has demonstrated the production of shelf-stable, food safe dried products from up to 10 different WA seafood products. This technology can now be available to specific industry partners under separate "commercial in confidence" arrangements.

9 References

AOAC International (1938). Method 938.08 Ash of Seafood. Gaithersburg.

AOAC International (1948). Method 948.15 Fat (Crude) in Seafood Acid Hydrolysis Method. Gaithersburg.

AOAC International (1955). Method 955.04 Nitrogen (total) in Fertilisers Kjeldahl method. Gaithersburg.

AOAC International (1974). Method 973.34 Cadmium in Food Atomic Absorption Sectrophotometric Method. Gaithersburg.

Baker, C. (1997). Industrial Drying of Foods. London, Blackie Academic and Professional. ISBN0751403849

Clark, J. P. (2009). Freeze Drying. Case Studies in Food Engineering, Springer New York**:** 67-73.

Clarke, S. (2004). "Understanding pressures on fishery resources through trade statistics: a pilot study of four products in the Chinese dried seafood market." Fish and Fisheries. **5**: 53-74.

Conova, A. S. and -f Dong Y. (1998). Hong Kong Dried Fish Market. Dried Fish Market Investigation and Industry Demonstration Project. Alaska, University of Alaska Anchorage.

Crapo, C., Oliveira, A.C., Nguyen, P and Fong Q (2010). "Development of a Method to Produce Freeze-Dried Cubes from 3 Pacific Salmon Species." Journal of Food Science **75**(5): 269-275.

Fabiyi, F. A. S., Sileo M.A. and Aremu O. A. (2008). "Hydride Generation Atomic Absorption Spectrophotometry Method for the Determination of Arsenic at Ultramicro Levels." Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry **38**(9): 727 - 730.
Food and Agriculture Organization of the United Nations (2009). The state of the world's fisheries and aquaculture 2008. Rome, FAO.
Food Standards Australia New Zealand (2010). Food Standards Code: Standard 1.4.1 Contaminants and Natural Toxicants. Canberra.
Food Standards Australia New Zealand (2010). Food Standards Code: Standard 1.6.2 Processing Requirements. Canberra.
Gracey, J., Collins, D. and Huey R. (1999) Meat Hygiene 10th Edition London WB Saunders.
Greensmith, M. (1998). Practical rehydration. Cambridge Woodhead Publishing.
Hall, G. M. (1997). Fish Processing Technology. London, Blackie Academic and Professional.
Huda, R. A. and Sari Dewi, R. (2007). Effects of various drying methods on the quality of shark dendeng. Minden.
Krueger, R. A. and Casey M.A. (2000). Focus groups: A practical guide for applied research. California, Sage Publications.
Ling, M.L., Goh, K.T., Wang, G.C.Y., Neo, K.S. and Chua, T. (2002). “An outbreak of multidrug-resistant *Salmonella enterica* subsp. *Enterica* serotype Typhimurium, DT104L linked to dried anchovy in Singapore. Epidemiological Infections. **128**: 1-5.
Logesh, A.R., Pravink, M., Raffi, S.M. and Kalaiselvam, M. (2012). “An investigation on Microbial Screening on Salted Dried Marine Fishes.” Journal of Food Resource Science. **1**(1): 15.21
Man, C.K. and He, X.W. (2000). “Arsenic in dried seafood consumed in Hong Kong.” Journal of Radioanalytical and Nuclear Chemistry. **246**(1): 157-160.
Marquez-Rios, E., Ocaño-Higuera, V.M., Maeda-Martinez, M.E. Lugo-Sanchez., M.E. Carvallo-Ruiz, M.G. and Pacheco-Aquilar, R (2009). Citric acid as pretreatment in drying of Pacific Lion's Paw Scallop (Nodipecten subnodosus) meats." Food Chemistry **112**(3): 599-603.
Naidoo, R. J., Slattery, S.L. and Bremner H.A. (1996) Evaluation of the Market for Dried Seafood 1993 to 1996. SSA R&D Report. Ascot, Seafood Services Australia Ltd.
Owusu-Apenten, R. K. (2002). Kjeldahl Method, Quantitative Amino Acid Analysis and Combustion Analysis. In *Food Protein Analysis - Quantitative Effects on Processing*. USA, CRC Press.
Potter, N. N. and Joseph, H.H. (1995). Food Science. Gaithersburg, Aspen Publishers, Inc.
Steinberg, J. (2005). The illicit abalone trade in South Africa. Pretoria, Institute for Security Studies.
Tanikawa, E., Motohiro, T and Akiba, M (1985). Marine Products in Japan. Tokyo, Koseisha Koseikaku Co., Ltd.
VanDemark, P.J. and Batzing, B.L. 1986. The Microbes. An Introduction to Their Nature and Importance. Benjamin / Cummings Publishing Company: California.
Wang, Y., Zhang, M. and Mujumdar, A.S. (2011). “Trends in Processing Technologies for Dried Aquatic Products.” Drying Technology **29:** 382-394.
Webb, N. B., Thomas, F.B. Busta, F.F. and Monroe R.J. (1969). "Variations in Proximate Composition of North Carolina Scallop Meats." Journal of Food Science **34**(6): 471-474.
Yoneda, C., Okubo, K., Kasai M., and Hatae K (2005). "Extractive components of boiled–dried scallop adductor muscle and effect on the taste of soup after mixing with chicken leg meat." Journal of the Science of Food and Agriculture **85**(5): 809-816.

Appendix 1: Article for Peer reviewed Journal

Using Vacuum and Freeze Drying to Create Dried Seafood Products for the Asian Market

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Sensory and Food Quality

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ABSTRACT:

Western Australian scallop (*Amusium balotti*) and pearl oyster (*Pinctada maxima*) were sourced locally and dried using vacuum drying and freeze drying technologies. The drying procedures were optimised, and the physical and chemical characteristics of the final products analysed and compared with equivalent, traditionally processed samples sold in Asian markets. Two focus groups using target consumers selected from traditional Asian backgrounds were asked, via a blind tasting of coded samples, to assess the overall sensory acceptability of the vacuum dried and freeze dried products alongside the traditionally processed equivalents. Physical and chemical analyses showed that the vacuum dried samples were not significantly different to the Asian samples. The sensory analysis revealed that all West Australian products created was acceptable to the panelists, and equal to the traditionally processed products. The rehydrated and cooked freeze dried products scored high mean acceptability ratings, with participants believing the samples were freshly cooked. The work has demonstrated that safe, consumer accepted dried products can be created from local Western Australian seafood species that compare favourably with traditionally dried equivalents in physical, chemical and sensory analysis.

Keywords: seafood, vacuum dried, freeze dried, sensory, quality

Practical Application: Sensory evaluation showed acceptable products were created from scallop and pearl adductor muscle using vacuum drying and freeze drying technologies. Chemical composition, physical properties and food safety analyses showed that products produced using vacuum drying technology were safe and within the range of results obtained from traditionally processed equivalents purchased from local and Asian markets. The research has piloted the production of safe, ready-to-eat dried products, with potential to be implemented on an industrial scale.

Introduction

Dried seafood products, held under the correct packaging/storage conditions can remain shelf-stable for up to a year or more at ambient temperatures, thus helping ease logistical and storage pressures whilst maximising the potential for product utilisation and/or export potential before spoilage takes place (Potter and Joseph 1995).

Many dried seafood products are considered delicacies and can attract high premiums. However, traditional drying methods for seafood products are highly labour intensive, taking weeks or months to complete (Steinberg 2005).

Advances in drying technologies make producing dried seafood products a potentially viable processing option in a developed economy such as Australia where using traditional drying methods may be considered inefficient. Further, mechanical dryers can be considered as an alternative to sun-drying as they dry products quickly and under controlled conditions and are less susceptible to undesirable environmental influences such as pests and harsh weather conditions (Greensmith 1998).

In this study two alternative forms of mechanical drying of seafood were investigated. Vacuum drying provides an attractive alternative to sun drying and other traditional methods because conditions can be controlled whilst operating costs remain low. Freeze drying technology provides an unique commercial opportunity, as products created using freeze drying techniques are virtually unaltered after the removal of all almost all internal moisture from within the food matrix (Clark 2009).

Australia already exports significant quantities of seafood products directly to Asian markets, and remains highly regarded by overseas markets as a safe and premium-quality supplier of seafood (Naidoo and others 1996). Very little of Australia's seafood is dried in Australia, potentially giving domestic producers an opportunity to sell locally produced dried seafood to target markets in Asia where local competition for new products is low and consumer demand for seafood products outstrips supply. This may be particularly applicable to dried scallop, known traditionally as 'conpoy' which is revered and widely consumed in traditional Asian cuisine (Naidoo and others 1996). Similarly dried pearl meat adductor muscle, a by-product of the pearling industry, is highly sought after in Asia, fetching premiums higher than dried scallop.

This study aims to evaluate whether acceptable products can be produced from West Australian seafood species (scallop and pearl meat adductor muscle) using vacuum and freeze drying. The study outlines results obtained from existing Asian products, and highlights similarities and differences between traditional products and those created from local scallop and pearl meat.

Materials and Methods

Experimental Samples

Adductor muscle of saucer scallop (*Amusium balloti*) was purchased block-frozen in 1kg packs from a local retailer sourced from a commercial operation in Shark Bay, Western Australia and harvested from the season beginning April 2010. Block frozen packs of 0.5kg of pearl meat adductor muscle of the silver-lip pearl oyster (*Pinctada maxima*) were obtained directly from a commercial pearling operation located in Broome, Western Australia and were harvested during the season beginning July 2010. All frozen samples were stored at -28 °C prior to further use.

Dried scallop and pearl meat sold in Asian markets were purchased for comparative analyses (Table 1).

Pre-treatment method development

The pre-determined drying objective was that samples be dried to a water content corresponding with a A_w < 0.6 (and moisture content < 10%) to promote long term shelf-stability by inhibiting the growth of spoilage bacteria and mould at ambient temperatures (Hall 1997).

In determining the most suitable pre-treatment to use for the vacuum dried products, samples from each trial were tested according to the methods of Tanikawa and others (1985), Yoneda and others (2005) and Marquez-Rios and others (2009). During pre-treatment optimisation products were assessed for sensory parameters according to Tanikawa (1985) with assistance from an experienced culinary chef. The final pre-treatment and drying parameters selected for both scallop and pearl meat processing and analysis are highlighted in Table 2. Following pre-treatment samples were placed immediately into the vacuum dryer (National Applicance).

Freeze drying pre-treatment optimisation results are shown in Table 3. Following pre-treatment samples were removed and left to drain for 5 min before being dried (patted with paper) and re-weighed. Samples were then individually vacuum packed and blast-frozen at -40 °C for 3 hr and stored (-28 °C) prior to freeze drying. Frozen samples were placed into plastic containers and transferred into the freeze dryer (Martin Christ Freeze Dryer, model alpha 1-2 LD plus).

Experimental plan

The 1 x 2 factorial experimental outline is shown in Figure 1. The inclusion of the effects of acid immersion was based on a method trialled by Marquez-Rios and others (2009). Each final experiment was replicated three times for all scallop and pearl meat sample groups.

The block-frozen scallop and pearl meats were thawed overnight at 1 °C before being separated into vacuum sealable bags and then vacuum packed, blast frozen, and stored at -28 °C. Following samples were thawed at 1 °C over 18 hrs, patted dry with a paper towel, and the fresh weight recorded. Acid treated samples were placed into a 0.1 M citric acid solution (pH 3) at 4 °C for 3 hr, with a sample/solution weight ratio of 1:2. Samples were then processed and dried according to the optimized parameters (Table 3 for vacuum dried samples and Table 4 for freeze dried samples). When the required dried weight was reached for each sample (A_w of < 0.6 and moisture content < 10%), it was removed and individually vacuum packed for storage at 0 °C prior to further analysis.

Analyses of dried samples

Colour was measured using a Minolta spectrophotometer CM-508i and results were quantified using the *CIE L* a* b** 3-dimensional scale. Readings were taken three times at the surface of each dried sample and the average recorded as a representation of surface colour.

Texture was analysed using the TA-XT2i texture analyser (Stable Micro Systems Ltd, Surrey, England) fitted with a 6 mm diameter spherical probe, at 5% strain using a 25 kg load cell at 2 mm/sec. Only whole samples were used to measure texture. Triplicate readings were taken and the mean recorded for each sample.

Water activity was measured using an AquaLab Water Activity Meter (Decagon Devices, Inc).

Moisture content was measured for all samples using the standard method of air drying (Graviometric moisture after drying at 105°C).

Ash content was determined according to the standard method for ash determination of seafood 938.08 (AOAC International 1938).

Protein content was determined by using the standard Kjeldahl method 955.04 for total nitrogen content as described by the AOAC International (1955), using a BÜCHI distillation unit K-314 and BÜCHI digestion system K-437 (BÜCHI Labortechnick AG, Switzerland). A protein conversion (f) factor of 5.82 for seafood (Owusu-Apenten 2002) was used to calculate protein content.

Crude fat content of samples was determined by the standard method of acid hydrolysis 948.15 as described by the AOAC International (1948) using a BÜCHI Soxhlet Extraction Unit E-812/816 SOX (BÜCHI Labortechnick AG, Switzerland).

Total carbohydrate content (crude fibre + nitrogen-free extract) was determined by subtractive difference upon completion of all other proximate analyses.

Cadmium, Lead and Arsenic were analysed for each sample group. Approx 1 g of sample was digested using concentrated HNO_3 and diluted to 20 mL in volumetric flasks for further analysis. Cadmium and lead were analysed by the flame spectrophotometry method 973.34 as described by AOAC International (1974). Arsenic was analysed using hydride generation atomic absorption spectrophotometry as described by Fabiyi, Sileo, and Aremu (2008).

Processing yields

Freeze dried products require a final moisture content of < 10% to retain original textural quality upon rehydration (Crapo and others 2010) and at these moisture percentages the water activity can be much lower than 0.6. A drying model was formulated and used for determining the target dried weight of each individual whole sample. The initial moisture content of samples was used to determine the target dried weight based on the optimised final moisture content for each product type. The drying model is represented by the following equation:

$$W_d = [\, W_f - (W_f * \{ \%MC_f / 100 \}) \,] * [\, 1 + (\%MC_d / 100) \,]$$

Where:

W_f = Weight of fresh sample (grams)

$\%MC_f$ = Percentage moisture content of fresh sample

$\%MC_d$ = Percentage moisture content of dried sample

W_d = Weight of dried sample (grams)

The final yield of each dried sample was determined by calculating the percent difference for each sample prior to and after drying.

Sensory analyses

Untrained participants from Asian (specifically Chinese, Japanese or south-east Asian) backgrounds were recruited in a Curtin email. The selected participants were chosen as representative target consumers with experience eating and/or preparing dried seafood products in traditional cuisine. Two separate 6-person focus groups (Ethics approval by Curtin University ethics council, code: SPH – 26 – 2010) were set up to test the acceptability of the samples according to guidelines outlined by Krueger and Casey (2000). To assess the acceptability of each sample a 20 cm long labelled hedonic scale (LHS) was given to each participant who were instructed to draw a horizontal line through the section of the scale that best represented their personal level of acceptability. Descriptors ranged from 'most liked sensation imaginable' to ' most disliked sensation immaginable'. A separate LHS scale was given for each sample. After each sample group was tasted, and results recorded, an in-depth discussion was held; focussing on the group's opinions and feedback regarding the sensory characteristics of samples and how their acceptability ratings reflected these opinions.

Each sample assessed by participants was represented by a random 3 digit number. Matching samples were presented to the group at the same time and a random plan for presentation of samples was developed (Table 5). In addition to the test samples created using freeze drying and vacuum drying, two traditionally dried Asian scallop variants (Table 1, Sample #11 and #13) and one traditionally dried pearl meat variant (Table 1, sample #2) were used for comparison. Equal amounts of each scallop and pearl meat sample were weighed out for sensory tests. Each sample was rehydrated for 24 hours in tap-water with a sample/water weight ratio of 1:2. A single cube of stock powder (Massel's salt reduced chicken-style stock cubes) was added to 0.5 L of boiling water and stirred for 2 minutes. The stock acted as a standardised carrier for each sample and was selected due to its light flavour and salt content so that the sensory properties of samples were not overwhelmed. Samples were broken up into smaller meat fragments, replicating traditional cooking methods, and then added to the liquid to create individual master stocks which would be further divided between focus group participants. Whole freeze dried samples followed the same preparation process, however as no further cooking was required for the freeze dried samples they were simply added to the boiled master-stock in a single thermos flask for each sample.

Each sample was served in individual white 150 ml ceramic bowls for tasting; with traditional white ceramic Chinese spoons and a napkin for each participant. For traditional and vacuum dried samples each participant received 1 ladle of stock (125 mL) containing equal amounts of broken up scallop fragments for scallop samples, and sliced pearl meat pieces for pearl meat samples. Prior to service each sample was microwaved for 40 sec on high to ensure even heating throughout the stock and a service temperature > 60 °C. For freeze dried samples the process was identical, with each service bowl served containing a whole rehydrated sample to taste.

SPSS (version 18.0) and Microsoft Excel (2007) software were used for all statistical analysis conducted for this study.

Results and Discussion

Although both freeze dried and vacuum dried products were produced, it should be noted that the objective was not to compare freeze drying and vacuum drying, but to evaluate the acceptability of both product types separately.

Processing yields

Final sample yields are essential in calculating the economic feasibility of commercialising products on an industrial scale. Factoring yields into processing and raw material costs can be used to determine at what cost the final products should be sold by processors to ensure viability and profitability during long-term production (Naidoo and others 1996). Table 4 compares the results predicted by the drying model for final mean yield, moisture content, and water activity to the actual results for vacuum and freeze drying experiments.

Dried sample analyses

Moisture content and water activity

Water activity is a measure of available water and predicts the stability and safety of the final product (Baker 1997). The food standards code defines dried meat products as having water activity readings below 0.85, a value that will inhibit the growth of *Staphylococcus aureus* bacteria (Food Standards Australia New Zealand 2010). All dried products produced in this study conformed with $A_w <$

0.85 (see Table 4). The A_w target of < 0.6 for this study aims to inhibit the growth of all pathogenic and spoilage microbes.

The mean water activity and moisture content results for vacuum dried scallop samples were within the mean ranges of the traditional samples analysed (min A_w 0.424 from Trad Aus Large, max A_w 0.679 from Trad China Small) and they were successfully dried to below the target water activity readings of > 0.600. Of the traditionally dried scallop samples the Trad Aus Med and Trad China Small groups showed water activity readings above A_w 0.600 (mean A_w 0.610 ± 0.00 ; and mean A_w 0.680 ± 0.00) which could make them susceptible to mould growth during long term storage at ambient temperatures (Hall 1997).

Vacuum dried pearl meat samples without acid pre-treatment were successfully dried below the A_w 0.600 target (A_w 0.523 ± 0.05, moisture content = 12.94% ± 1.98) however samples subjected to the acid immersion treatment yielded a mean water activity reading of 0.706 ± 0.02) and moisture content of 17.88% ± 1.23) which was above the A_w 0.600 target. The standard deviation for water activity in the acid treated pearl meat group is low, thus the optimisation process demonstrated a high precision but lack of accuracy for the target water activity in this sample group. This result suggests the initial moisture content of the samples used were higher than predicted, and therefore the samples in this group required further drying to achieve the target water activity readings.

The results indicate that variability in initial moisture contents of fresh samples resulted in the final water activity being significantly above or below the target range for some samples. During the traditional process of sun drying scallops, the batches are often brought inside at night for 'tempering', which aims to achieve an even moisture content across the entire batch (Yoneda and others, 2005). Further work may be necessary to achieve a similar standardisation for mechanically dried product.

Proximate Analyses

Chemicalproximate analysis comparisons (protein, fat, carbohydrate and ash content)showed similarities in composition …. Webb and others (1969) found that significant differences existed in the proximate composition within and between three different scallop species; and attributed the variations to seasonal, regional and environmental factors. In contrast Huda and Sari Dewi (2007) found no significant differences when comparing the proximate composition of vacuum dried Shark dendeng with traditionally dried dendeng.

In this study vacuum dried scallop samples showed composition of products waswithin the general range found in the Asian products (Table 5). High mean carbohydrate, fat and ash values may indicate that the animals was not wasted and therefore did not show signs of stress at the time of death and that the animal was well fed, with non depleted stores of glycogen and fat inside the muscle tissue (Gracey and others 1999).

Colour

Colour results are shown in Table 5. It was expected that variations in drying techniques in addition to variations in species and proximate composition would result in significant variation in colour between traditionally dried and vacuum dried scallop samples. The Kruskal-Wallis test for significance (set at 5%

significance level) between the traditionally dried scallops showed no significant differences between the samples for the L* (p-value = 0.248), a* (p-value = 0.248) and b* (p-value = 0.082) colour scale values.

However the vacuum dried scallop samples were noticeably paler and more uniform in colour than the traditional equivalents. Significance differences for CIE *L** (lightness) and *b** (yellowness) values was confirmed (*L** p-value 0.017, *b** p-value 0.026) by conducting a Kruskal-Wallis test at 5% significance. Conova and Dong (1998) reported that in the Hong Kong dried seafood markets there is a preference for dried seafood that is lighter in colour which suggests that the light pale colours observed in the test vacuum dried samples may be favorable in target markets.

The final pearl meat samples varied significantly in size (3.24 min, and 8.37 max final dried weights), and it was observed that the largest had a much darker surface colouring than the pale smaller sample. The small sample took 9 hrs to dry, while the larger sample needed 10 additional hours to reach the target weight so this may have contributed to darkening. This significant change in colour suggests that further optimisation methods need to be explored for larger samples which are susceptible to non-enzymatic browning when dried at the > 60 °C temperatures used for long periods of time, affecting the quality perception for potential buyers.

Comment [SOLAHV1]: why

Freeze dried samples from both scallop and pearl meat groups had a very chalky, pale white colour when dried. As chemical reactions are minimised during freeze drying the surface colour preserves the natural pigment of the animal.

Texture/Hardness

Both vacuum dried scallop and pearl meat samples had relatively low mean texture readings (hardness g force) when compared with the traditionally processed samples (see Table 5). This indicates that the nature of vacuum drying does not produce products as hard as traditional drying in the sun or air. Further research should be conducted to discover how species type and drying conditions may affect the textural properties of vacuum dried products.

Heavy metals

Although heavy metals were detected in all samples by atomic absorption spectrophotometry, the values for cadmium, lead, and arsenic (all<0.10ppm) were much lower than maximum residue limits found in the Food Standards code: Standard 1.4.1 for contaminants and natural toxicants (Food Standards Australia New Zealand 2010).

Sensory Analyses

Vacuum dried samples

Results for overall acceptability of scallop samples (Figure 2) show that all samples were deemed acceptable by the majority of participants. Acceptability ratings were tested for overall significance across the traditional and vacuum dried scallop samples using a Friedman's non-parametric test. The Friedman's test showed that significant differences in acceptability of samples existed (p-value 0.005 at 5% significance) so each sample's acceptability scores were then compared using the Wilcoxon signed ranks test. A significant difference existed only between acceptability ratings of the vacuum dried acid and no-acid scallop groups (p-value 0.012 at 5% significance) (or Wilcoxon signed ranks Z score -2.499).

It was found that during focus group discussions held after the first group of sample tasting (traditional and vacuum dried scallop) texture was a recurring discussion point and influenced the scores given. One participant proclaimed that the vacuum dried no acid sample had "*the most natural texture*" which prompted a higher score due to quality perception. It was agreed by all participants that saltiness was the greatest difference noticed between samples, and some participants found the saltiness overwhelming. The carrier stock used was a salt-reduced chicken-style sock which was pre-assessed to avoid noticeable saltiness, so the saltiness experienced by participants was imparted by the cooked scallop samples. Scallop and pearl meat samples cooked in plain tap water during pre-treatment trials did not impart a strong flavour or saltiness into the cook-water, so the intense flavour produced when samples were cooked in the salt reduced stock may be an indication that extractive components in the dried scallops and pearl meat are interacting with components in the stock. Yoneda and others (2005) found that the flavour of dried scallop broth was improved when adenosine monophosphate (AMP), an extractive component of dried scallop was converted to inosine monophosphate (IMP) when mixed with chicken meat extract containing AMP deaminase. The carrier stock used in this study was chicken-derived, however it is unknown if AMP exists in the stock cubes used to account for the flavour changes noticed. This observation opens the possibility to more research in determining flavour interactions between extractive compounds found in dried scallop/pearl meat, and selected stock ingredients to improve the flavour profile of soups and broths.

Acceptability results (Figure 2) show an even spread of scores for the vacuum dried pearl meat samples. This is contrasted to the wider range of results for traditional pearl meat samples. One participant remarked that younger consumers would be more open to trying new/uncommon kinds of dried seafood like the dried pearl meat, which had a unique flavour and “meaty” texture. The total sample size for this group is small, so accurate data based on panellist age cannot be conducted, however there was some agreement among the participants in regards to this comment. Mean acceptability ratings for both traditional and test dried pearl meat products showed that all three samples scored highly acceptable mean ratings. A Friedman’s test for overall significance of acceptability ratings was conducted and showed that no that overall significance existed between the acceptability of the different pearl meat samples (p-value 0.368 at 5% significance).

The focus group discussion following the tastings of traditional and vacuum dried pearl samples revealed that the majority of participants had not previously consumed dried pearl meat, and were inclined to compare the sensory qualities directly with dried scallop. Despite no significant difference in the mean acceptability between pearl meat samples it can be seen from Figure 1 that panellists did not give identical ratings for each sample, and there appears to be critical differentiation between the samples tasted. One panellist stated “*I think* *that maybe there could be a market for it (dried pearl meat), if it was cheap... cheaper than scallop!*" A few other participants nodded in agreement after this comment was made. This comment does not reflect the current market price for dried pearl meat relative to dried scallop prices (Table 1, sample #2), which further highlights the scarcity of dried pearl meat even within the Asian community.

It can be concluded from the acceptability ratings and statistical results acceptable products have been created from the scallop and pearl meat groups using vacuum drying technology.

Freeze dried samples

All freeze dried samples were deemed acceptable (Figure 2). A Wilcoxon signed ranks test for freeze dried scallop revealed that there was no significant difference (p-value 0.878 at 5% significance) between the acceptability ratings of the acid and non-acid samples, suggesting that both samples were equally acceptable amongst the majority of participants.

A Wilcoxon signed ranks test for freeze dried pearl meat revealed that there was a significant difference (p-value 0.022 at 5% significance) between the acceptability ratings given for the acid and non-acid samples. The Z score (-2.293) shows that the non-acid treated vacuum dried pearl meat was significantly favoured by the majority of participants.

Limitation

The final focus group discussion held after all product groups had been tasted revealed that some panellists disliked the carrier stock used, and the majority believed the freeze dried samples should have been prepared using an alternative carrier/no carrier at all.

It can be concluded from the acceptability ratings and statistical results that acceptable products have been created from the scallop and pearl meat groups using both vacuum and freeze drying technology.

Conclusions

Sensory evaluations showed acceptable products were created from scallop and pearl adductor muscle using vacuum drying and freeze drying technologies. Composition, physical properties and food safety analyses showed that products produced using vacuum drying technology were food safe and within the range of results obtained from traditionally processed equivalents purchased on local and Asian markets.

Optimised pre-treatment conditions were developed; producing safe, ready-to-eat dried products, with potential to be implemented on an industrial scale.

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References

AOAC International (1938). Method 938.08 Ash of Seafood. Gaithersburg.

AOAC International (1948). Method 948.15 Fat (Crude) in Seafood Acid Hydrolysis Method. Gaithersburg.

AOAC International (1955). Method 955.04 Nitrogen (total) in Fertilisers Kjeldahl method. Gaithersburg.

AOAC International (1974). Method 973.34 Cadmium in Food Atomic Absorption Sectrophotometric Method. Gaithersburg.

Baker, C. (1997). Industrial Drying of Foods. London, Blackie Academic and Professional. ISBN0751403849

Clark, J. P. (2009). Freeze Drying. Case Studies in Food Engineering, Springer New York**:** 67-73.

Conova, A. S. and -f Dong Y. (1998). Hong Kong Dried Fish Market. Dried Fish Market Investigation and Industry Demonstration Project. Alaska, University of Alaska Anchorage.

Crapo, C., Oliveira, A.C., Nguyen, P and Fong Q (2010). "Development of a Method to Produce Freeze-Dried Cubes from 3 Pacific Salmon Species." Journal of Food Science **75**(5): 269-275.

Fabiyi, F. A. S., Sileo M.A. and Aremu O. A. (2008). "Hydride Generation Atomic Absorption Spectrophotometry Method for the Determination of Arsenic at Ultramicro Levels." Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry **38**(9): 727 - 730.

Food and Agriculture Organization of the United Nations (2009). The state of the world's fisheries and aquaculture 2008. Rome, FAO.

Food Standards Australia New Zealand (2010). Food Standards Code: Standard 1.4.1 Contaminants and Natural Toxicants. Canberra.

Food Standards Australia New Zealand (2010). Food Standards Code: Standard 1.6.2 Processing Requirements. Canberra.

Gracey, J., Collins, D. and Huey R. (1999) Meat Hygiene 10th Edition London WB Saunders.

Greensmith, M. (1998). Practical rehydration. Cambridge Woodhead Publishing.

Hall, G. M. (1997). Fish Processing Technology. London, Blackie Academic and Professional.

Huda, R. A. and Sari Dewi, R. (2007). Effects of various drying methods on the quality of shark dendeng. Minden.

Krueger, R. A. and Casey M.A. (2000). Focus groups: A practical guide for applied research. California, Sage Publications

Marquez-Rios, E., Ocaño-Higuera, V.M., Maeda-Martinez, M.E. Lugo-Sanchez., M.E. Carvallo-Ruiz, M.G. and Pacheco-Aquilar, R (2009). Citric acid as pretreatment in drying of Pacific Lion's Paw Scallop (Nodipecten subnodosus) meats." Food Chemistry **112**(3): 599-603.

Naidoo, R. J., Slattery, S.L. and Bremner H.A. (1996) Evaluation of the Market for Dried Seafood 1993 to 1996. SSA R&D Report. Ascot, Seafood Services Australia Ltd.

Owusu-Apenten, R. K. (2002). Kjeldahl Method, Quantitative Amino Acid Analysis and Combustion Analysis. In *Food Protein Analysis - Quantitative Effects on Processing*. USA, CRC Press.

Potter, N. N. and Joseph, H.H. (1995). Food Science. Gaithersburg, Aspen Publishers, Inc.

Steinberg, J. (2005). The illicit abalone trade in South Africa. Pretoria, Institute for Security Studies.

Tanikawa, E., Motohiro, T and Akiba, M (1985). Marine Products in Japan. Tokyo, Koseisha Koseikaku Co., Ltd.

Webb, N. B., Thomas, F.B. Busta, F.F. and Monroe R.J. (1969). "Variations in Proximate Composition of North Carolina Scallop Meats." Journal of Food Science **34**(6): 471-474.

Yoneda, C., Okubo, K., Kasai M., and Hatae K (2005). "Extractive components of boiled–dried scallop adductor muscle and effect on the taste of soup after mixing with chicken leg meat." Journal of the Science of Food and Agriculture **85**(5): 809-816.

Table 1 Traditionally dried samples purchased in local and Asian markets

Sample group	Country of purchase / country of origin	Size category	Species	Mean dried weight of individual samples (g)	Mean dried dimensions		Retail value – As purchased (AUD)
					Diameter (mm)	Height (mm)	
(#11) Scallop	Aus / Unknown	M	Unknown	6.3146	25	15	$80/kg
(#12) Scallop	Aus / China	M	Unknown	5.8448	22	16	$17.50/100g
(#13) Scallop	China / China	S	Unknown	0.7204	9	10	$12/500g
(#14) Scallop	Aus / Unknown	L	Unknown	18.6280	37	23	$120/kg
(#15) Scallop	Japan / Japan	M	Unknown	7.3708	25	16	$19.50/100g
(#2) Pearl meat	Aus / Aus	L	*Pinctada maxima*	9.3406	66	25	$580/kg

Table 2 Pre-treatments trialled for vacuum dried samples with optimised treatment selections highlighted

Sample	**Pre-heat [°C/Time (mins)]**	**Cook time (mins)**	**Salt/Sugar concentration (%)**	**Temperature (°C)**	**Pressure (mmHg)**
Scallop	N/A	5	5/3	50	10
Scallop	N/A	10	5/3	50	10
Scallop	N/A	25	5/3	50	10
Scallop	N/A	25	N/A	60	10
Scallop	N/A	25	10.04/0	50	10
Scallop	N/A	25	10.04/0	60	15
Scallop	**N/A**	**25**	**10.04/0**	**65**	**15**
Scallop	N/A	25	10.04/0	70	15
Scallop	N/A	25	10.04/0	65	5
Pearl	N/A	25	10.04/0	65	15
Pearl	N/A	5	10.04/0	65	15
Pearl	N/A	2	2/0	65	15
Pearl	**105°C/50**	**0**	**N/A**	**65**	**15**

Table 3 Pre-treatments trialled for freeze dried samples with optimised treatments highlighted

Sample	Cook time (mins)	Salt/Sugar concentration (%)	Temperature (°C)	Pressure (Atm)
Scallop	5	2	-52	0.2
Scallop	5	2	-52	0.2
Scallop	2	2	-52	0.2
Scallop	4	2	-52	0.2
Scallop	3	2	-52	0.2
Scallop	**3.5**	**2**	**-52**	**0.2**
Pearl	3.5	2	-52	0.2
Pearl	**3**	**2**	**-52**	**0.2**
Pearl	2.5	2	-52	0.2

Table 4 comparisons of the target and actual mean yield, moisture content, and water activity of sample groups

Sample group[a]	**Mean yield (g/100g)**			**Mean Moisture content (g/100g)**			**Mean water activity (A_w)**		
	Target[b]	**Actual**	**Difference**	**Target[b]**	**Actual**	**Difference**	**Target[b]**	**Actual**	**Difference**
[c]VD scallop	20.25	20.04	-0.21	< 12.50	13.56	1.06	< 0.600	0.586	-0.014
[d]VDA scallop	20.25	19.17	-1.08	< 12.50	12.60	0.1	< 0.600	0.564	-0.036
VD Pearl	32.40	31.91	-0.49	< 20	12.94	-7.06	< 0.600	0.523	-0.077
VDA Pearl	32.40	31.82	-0.58	< 20	17.88	-2.12	< 0.600	0.706	0.106
[e]FD scallop	19.80	18.12	-1.68	< 10	11.07	1.07	< 0.600	0.284	-0.116
[f]FDA scallop	19.80	19.70	-0.10	< 10	9.86	-0.14	< 0.600	0.460	0.060
FD pearl	27.54	26.14	-1.40	< 10	9.83	7.83	< 0.600	0.350	-0.050
FD pearl + acid	27.54	30.87	-3.33	< 10	17.53	15.53	< 0.600	0.644	0.244

[a]Number: 3
[b]Based on initial moisture content of 83% for scallop samples and 73% for pearl meat samples
[c]VD vacuum dried
[d]VDA Vacuum dried with acid immersion
[e]FD Freeze fried
[f]FD freeze dried with acid immersion

Table 5: Proximate, Colour and Hardness/Texture results from traditional and experimental samples

Proximate Parameter	Traditional scallop groups min mean[a]	Traditional scallop groups max mean[a]	Vacuum dried scallop + acid mean value[a]	Vacuum dried scallop no acid mean value[a]
Moisture (%)	9.39 (Trad Aus Large)	27.81 (Trad China Small)	12.60	13.56
Ash (%)	8.26 (Trad Aus Large)	14.96 (Trad China Small)	18.10	14.38
Protein (%)	47.12 (Trad China Small)	61.97 (Trad Japan Med)	48.38	45.84
Fat (%)	1.36 (Trad China Med)	3.04 (Trad China Small)	3.21	2.11
Carbohydrate (%)	7.07 (Trad China Small)	19.41 (Trad Aus Large)	17.61	24.11
Lab colour scale variable				
L*	40.67 (Trad Aus Med)	47.55 (Trad China Med)	54.47	57.10
a*	5.56 (Trad Aus Large)	8.41 (Trad Jap Med)	6.40	1.32
b*	15.50 (Trad Aus Large)	26.11 (Trad Jap Med)	26.95	21.65
Hardness[b]	1355 (Trad China Small)	10895 (Trad Jap Med)	4513	1840

[a]Values from triplicate mean result

[b]Hardness is force required (grams) for probe to depress sample by 10% using a 25kg load cell at 2mm/sec

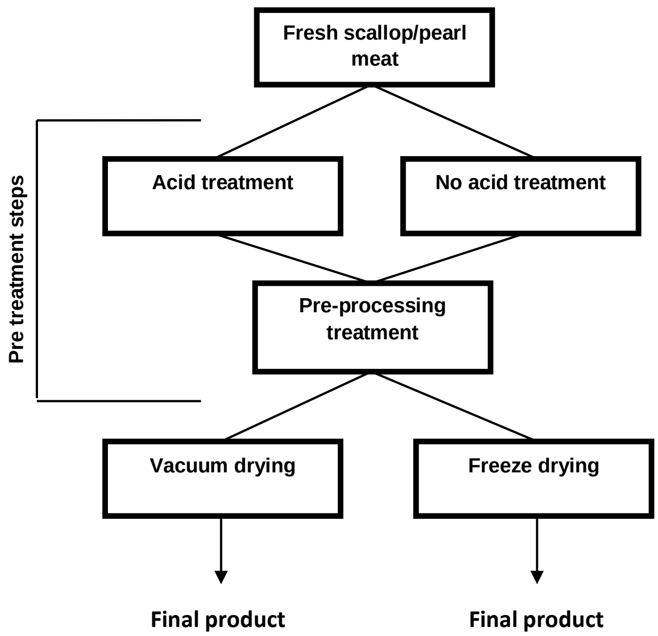

Figure 1 Flow diagram showing the product creation process

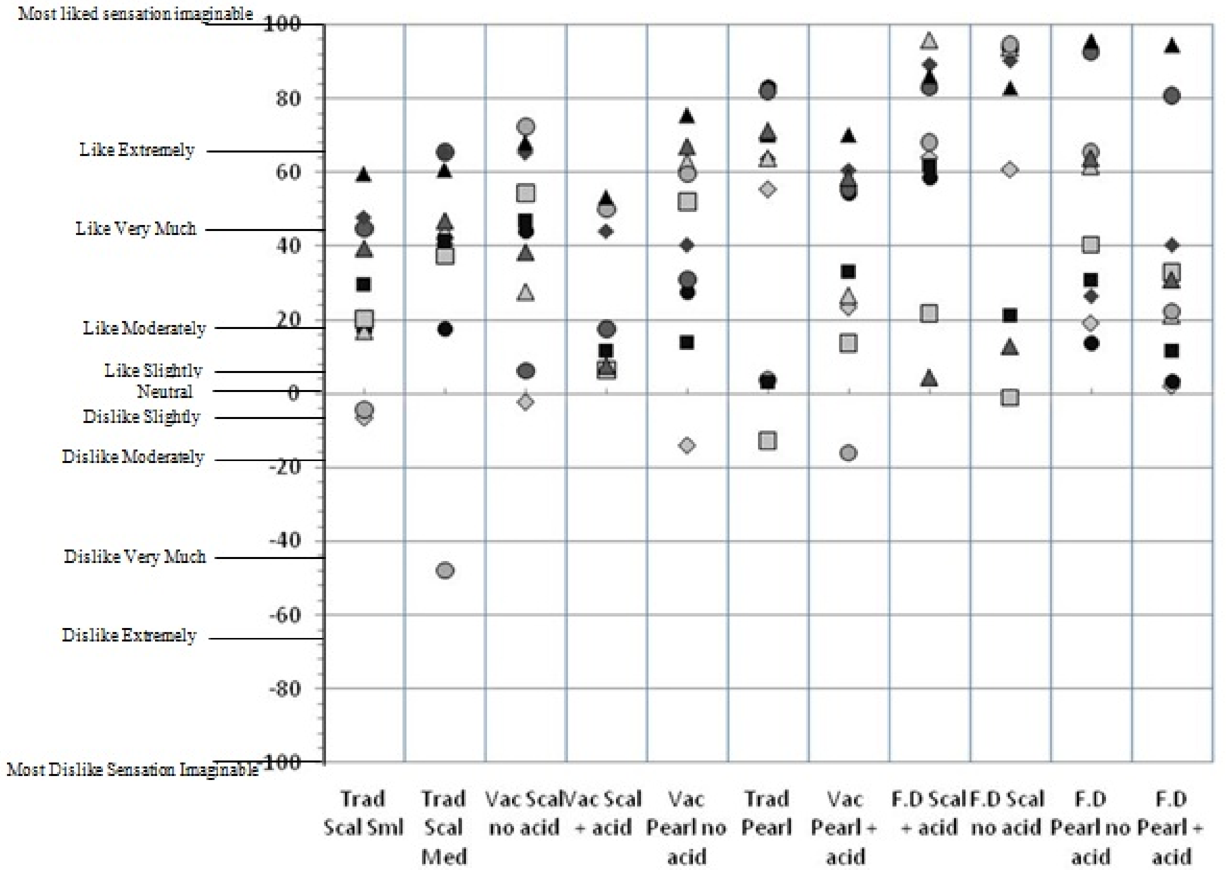

Figure 2 Graph showing sample group acceptability results with the labelled hedonic scale on the Y-axis and sample groups on the X-axis. Individual participants are represented by the different shape styles in the plot area.

Appendix 2: Biolite Dryer Operations Manual

Version 1.0

BIOLITE

OPERATIONAL INSTRUCTIONS FOR THE 50kg BIOLITE DRYER

Instruction manual for the operation and maintenance of the BioLite dryer.

Author: Stephen Iaschi
Date Last Printed: 20 February 2012
Filename: 20120220 Biolite Dryer instructions

50kg BIOLITE Dryer Instructions

Contents

Table of figures

1. COMPONENTS

a) Dryer box
b) Condenser
c) Water Tank
d) Bottom pump
e) Water extractor
f) Vacuum
g) Chiller
h) Holding tank
i) Boiler

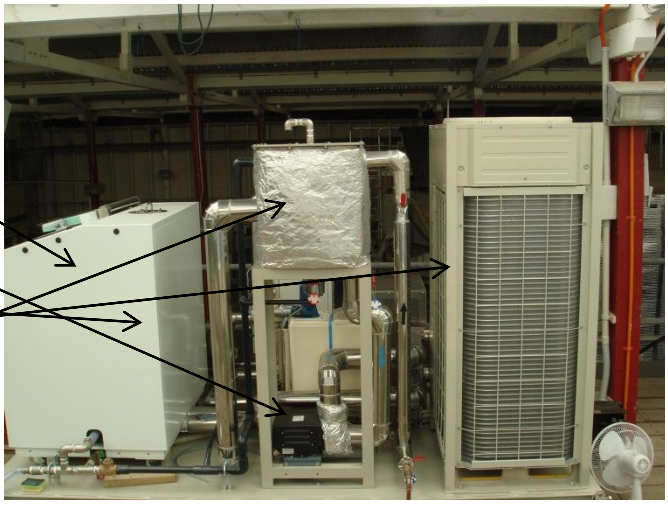

Figure 1. Dryer

2. PRINCIPLE

a) Water is pumped into the tank in the main dryer.
b) Water flows into the pump and then into the water extractor.
c) The water pressure drives the vacuum in the dryer.
d) The vacuum draws air from the drying drum.
e) Boiler sends stream into a jacket that surrounds the drying drum.
f) Steam that is generated within the drying drum is extracted into the condenser.
g) The water extracted from the sample is then collected into a vacuumed chamber for collection.

3. WATER SOFTENER

Prior to start-up, ensure that the water softener is charged with salt. The water softener works by conditioning water from your mains. Here, calcium and magnesium (the substances which make water hard and cause scale and scum) are removed by a process known as Ion Exchange. Soft water emerges and is routed to the boiler. The salt is required to provide a brine solution which the valve draws on to regenerate the resin at programmed intervals. Regeneration takes approximately 120 minutes, and is set to occur at convenient time intervals.

Figure 2. Water Softener

The water softener takes approximately 5kg of salt to charge to maximum. This level should be checked prior to operating the drier. Ensure that when adding the salt, that you introduce water into the salt chamber to the maximum level indicated inside the chamber. Should the machine be left a long time between operations, ensure that the remaining salt in the chamber is broken up and not clumped into a cake. Once you have inspected the water softener you can commence machine operation.

4. BIOSAFETY

Operations within Challenger TAFE must adhere to a biosafety protocol to reduce cross contamination to other projects being run in the same facility. In brief, the protocol aims to reduce the chance of contamination by; (a) cleaning and decontaminating raw samples prior to entry to the facility, (b) clean and decontaminate equipment used prior to processing and (c) ensure that proper protocols are adhered to when traveling throughout the facility (i.e. use of footbaths and hand washes where available).

4.1. Upon introducing raw samples into the facility, it is required that the foam boxes used to carry the raw samples from point of collection, should be sprayed with a 70% ethanol solution or chlorhexidine disinfectant.

4.2. Following weighing and initial measurements of the raw starting material, balances are to be decontaminated with 70% ethanol by spraying and wiping.

4.3. Raw material introduced into the facility needs to be isolated within an enclosed box (lidded boxes).

4.4. When traveling to other areas within the facility it is a requirement to use foot-baths and hand wash stations, where available, to minimise any spread of contamination.

4.5. All waste products to be collected and disposed of in the correct manner under biosafety guidelines (minimal movement between areas).

5. START-UP

This explains the basic starting mode for drying samples.

5.1. Turn on main power (3 phase switch).

Figure 3. 3 phase power switch

5.2. Turn on water flow via red lever at the bottom of machine between the water holding tank and chiller.

Figure 4. Water intake valve

5.3. Switch on the boiler (ensure that the red lever on the top of the boiler is shut off).

Figure 5. Boiler controls

5.4. Ensure that water is flowing into the boiler by checking the gauges on the intake line.

5.5. The boiler will take approximately 10 mins to heat up. The operating pressure of the boiler is 0.3 kpa. Purge the boiler by opening the red valve on top of the boiler for 4 seconds and then shut the valve. Steam will discharge from the steam trap or line.

5.6. This operation should be carried out at least twice per 8 hour shift or unit running.

5.7. We must fill in the running log sheet hourly for the first 3 hours, then 2 hourly thereafter. New log sheet each day, record salt tank level and when filled.(5kg)

5.8. Ensure that the dryer has power by checking the touch button display.

5.9. The dryer is ready to operate.

6. LOADING THE DRYER

6.1. Open the lid of the dryer and introduce the sample.

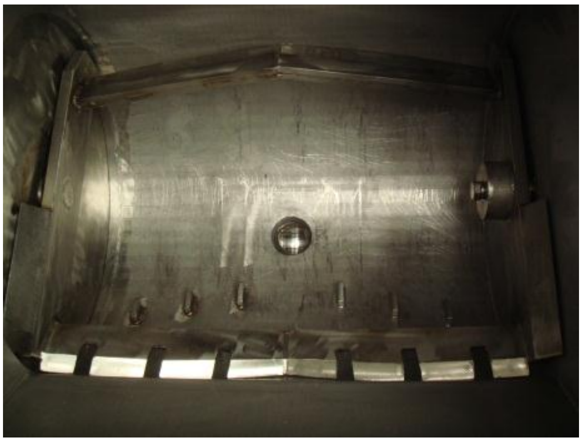

Figure 6. Drying drum (inside)

6.2. Ensure that the lid seals are clean and clear of debris.

6.3. Once the lid seals have been cleaned close the lid and ensure that the locks are fully rotated to the lock position.

7. PRE-COOK

This step is not necessary for all types of drying. The cooking step involves the heating of the drying drum with the rotation of the agitator. The cooking step does affect the drying time. The lid remains open slightly to allow the agitator to rotate. The following steps are to be used for pre-cooking.

7.1. Enter the main menu on the touch display on top of the dryer.

7.2. Select "MANUAL OPERATION"

7.3. In the "MANUAL OPERATION" sub-menu select "VALVE".

Figure 7. Valve manual operation display

7.4. In the "VALVE" sub-menu select "STEAM VALVE OPEN". This will allow steam to enter the jacket surrounding the drying drum, heating the sample.

7.5. In the “VALVE” sub-menu, located at the bottom of the display is the “MOTOR” sub-menu. Select the “MOTOR” sub-menu.

7.6. In the “MOTOR” sub-menu (it can also be selected from the “MANUAL DRIVING” menu), Press “START” under the agitator drive. The agitator will start to rotate the sample in the drying drum while it cooks.

Figure 8. Motor manual operation display

7.7. Check the consistency of the cooking of the sample to determine the end of the pre-cook step.

7.8. When cook is completed, “STOP” the agitator in the “MOTOR DRIVE” menu.

7.9. Select the “VALVE” sub-menu and “CLOSE” the steam valve.

7.10. The pre-cook step is complete.

8. DRYING

The drying step is used for the drying of samples following a pre-cook or on a raw product (without cooking).

The second protocol involves the drying of the product. The steps for drying are below.

8.1. In the main menu, three modes can be programmed using the “DRYING (COOLING) DRIVE” menu in the main menu.

a) Mode can be changed for specific products.
b) The time can be adjusted.
c) The agitator speed can be adjusted.
d) The heater control (infa-red) for sterilisation can be adjusted. However, not recommended for fish.

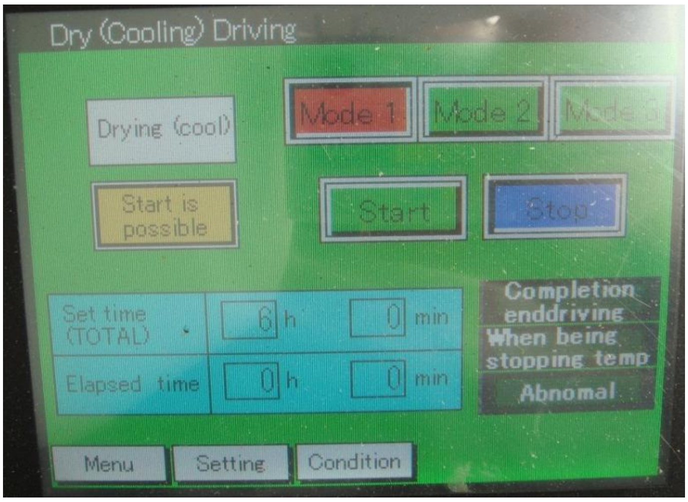

Figure 9. Drying (cooling) drive operational display

8.2. The sensor for the lid will be displayed in the sub-menus for drying/cooling and manual drive. If the lid is not closed the agitator will not engage, this will be indicated by a yellow flashing start button (won’t start door open) or blue flashing button (ready).

8.3. Once the mode has been programmed you can lock the lid and press start in the “DRYING (COOLING) DRIVE” sub-menu. The dryer will not engage if the lid is not secure.

9. THINGS TO LOOK FOR WHILE DRYING

There are indicators for proper running for the dryer. These are listed below;

9.1. Pressure indicator on boiler should read approximately 0.3 kpa.

9.2. The steam from the boiler is directed into a reducer valve, the reading on this valve should be approximately 0.1 kpa.

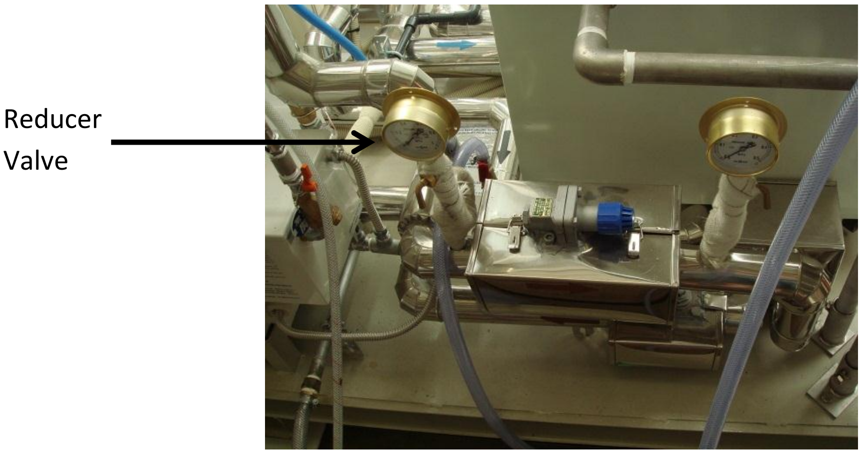

Figure 10. Reducer valve and gauges

9.3. Once the pressure in the drying drum has reached -80 kpa, the steam valve will vent into the steam jacket surrounding the drying drum.

9.4. If the temperature indicated on the display on the dryer does not go up, there might be some condensate within the steam jacket. This can be vented using the manual valve located after the steam reducer. Using a spanner slowly open the valve and wait until no water comes out the hose leading into the drain. Once water flow has stopped retighten the valve.

9.5. Located on the left hand side of the dryer is a green lever. Ensure that this lever is open (it collects the condensate from the sample). Ensure that the two red valves located on the liquid collection pot are closed. The condensate will collect in the pot while drying. If the collector becomes too full, close the green lever at the side of the dryer then open the red lever on the top of the collection pot slowly to equalise the pressure. Once the pot has been equalised you can collect the liquid from the bottom red lever located on the pot. Once you have collected the liquid, close both red levers and open the green lever on the side of the dryer. Collection of the condensate will commence again.

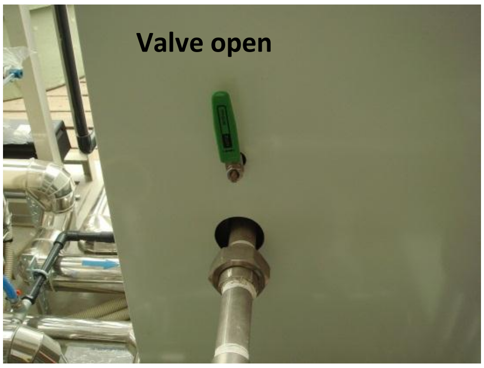

Figure 11. Dryer water reclaim valve in the open position

Figure 12. Dryer water reclaim valve i the closed position

Figure 13. Reclaim pot vacuum valve in the closed position

Figure 14. Reclaim pot vacuum valve in the open position

Figure 15. Water reclaim valve on the bottom of the pot. Used for collecting the reclaimed water from the drying process

10. STOPPING THE DRYING CYCLE

To stop the current run or to finish a completed run use the following instructions.

10.1. Enter the main menu in the touch display and select the sub-menu “DRYING (COOLING) DRIVE”.

10.2. Press “STOP” in the “DRYING (COOLING) DRIVE”. You will need to wait until the machine powers down and the “STOP” icon has stopped flashing.

10.3. Once the “STOP” icon has stopped flashing press the “when being stopping temp” button in the same menu. This will bring up a sub-menu.

10.4. Press the reset button in this menu and then press the execute button to confirm this selection.

10.5. The vacuum will be released and the lid will be free to be opened.

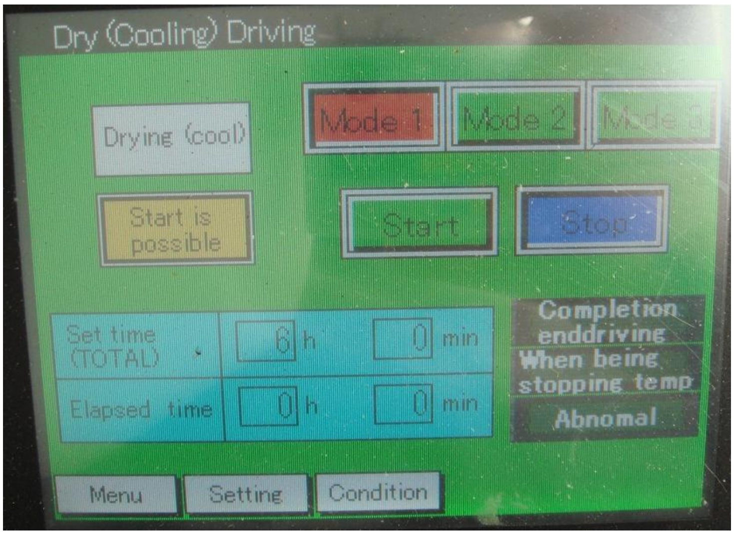

Figure 16. Dry (cooling) driving menu. Pressing stop will shut of drying operations

11. EMPTYING THE DRYER

The following steps are to be used to empty the drying drum of the dried sample.

11.1. Enter the main menu of the display on the top of the dryer.

11.2. Select “EXHAUST DRIVING”.

11.3. Within this menu press “START”. The lid must be closed in order for this protocol to commence. The agitator will start rotating and the exhaust valve will open. This will not completely empty the drying drum and as a consequence will require further manual clearing.

11.4. When the drying drum is emptied of its contents press “STOP” in the same menu.

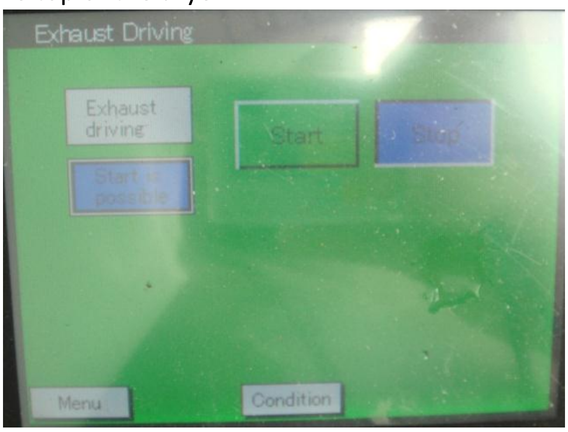

Figure 17. Exhaust drive operation display for automatic emptying of the drying drum

11.5. The protocol is completed.

To further empty the drying drum follow the below steps.

11.6. Enter the main menu of the display on the top of the dryer.
11.7. Select "MANUAL OPERATION"
11.8. Select the "VALVE" sub- menu.
11.9. In the valve menu locate the exhaust valve and press open. The valve at the bottom of the drying drum will now open allowing you to push the dried sample into the collection drawer located below the front of the dryer.
11.10. Ensure that there is a collection bucket or container in the collection drawer.
11.11. Scrape the contents of the drying drum into the exhaust valve.
11.12. Once you have empty the machine of dried material press "CLOSE" in the valve menu. Once pressed, the valve will close.

Figure 18. Manual valve control display. Use for emptying manually the drying drum

12. SHUT-DOWN SEQUENCE

When you have completed using the machine you will need to shut down. This will involve switching off power and venting the steam in the boiler. Follow the below instructions.

12.1. Following the stopping of the drying cycle sequence, you are now prepared to shut down the dryer.
12.2. Turn the boiler off using the switch located on the front of the boiler.
12.3. Located on the top of the boiler is a red lever. Open this red lever to vent the steam out of the boiler.
12.4. Locate the water intake valve to the machine (located between the water reservoir and chiller), and switch off.
12.5. Switch the machine off at the 3 phase power switch.
12.6. Shut off is completed.

13. CLEANING

You will need to clean the drying drum after use, unless you immediately commence another run using the same product. However, it should be noted that residual product left in the drying drum might over-dry and harden in the drying drum. You will have to determine whether you will require a complete clean after a run.

13.1. Following the stopping of the drying cycle sequence and the emptying of the drying drum of dried product, you will need to commence cleaning the various components of the dryer. This will include the drying drum, the dust trap (located in the pot on top of the dryer) and the liquid collection pot (located to the side of the dryer).

13.2. With the scraper provided, scrape off any material caked on the inner surface of the drying drum. This is best conducted with the exhaust valve closed (see 9.6 to 9.11 for instructions).

13.3. Once you have scraped off as much residue as possible open the exhaust valve (see 9.6 to 9.11) and empty the contents of the drum into a collection bucket. Once completed close the exhaust valve.

13.4. Using the hose, located on the left hand side of the machine, wash the interior of the drying drum and scrub any remaining reside off. Open the exhaust valve to collect the wash.

13.5. Repeat 11.4 if necessary until the drying drum is clean.

13.6. Following the cleaning of the drying drum, proceed to remove the lid of the dust collector located on top of the dryer.

13.7. Remove the direction plate and wash with soapy water, rinse and dry.

13.8. Wash the inside of the dust collector pot with water. It is important to remove all traces of water from the dust collector when you have finished washing. You can siphon out the water in the dust collector then dry with a cloth. Replace the direction plate in the correct orientation and then replace the lid and secure with the butterfly bolts.

13.9. Remove the lid to the liquid collection located on the left hand side of the dryer.

13.10. Remove and collect any remaining liquid then wash out the pot.

13.11. Replace the lid to the liquid collector when finished washing.

13.12. Wipe away any moisture around and on the machine that has spilled throughout the cleaning process. Washing of the machine is completed.

14. TROUBLESHOOTING

Breakdowns are annotated on the touch display located on top of the dryer. In the main menu select “BREAKDOWN”. This will show a list of what errors have occurred. Some possible scenarios are listed below.

14.1. If there is a vacuum error the possible causes could be;

a) Lid is not sealed properly. This may be due to dirt interfering with the seal around the lid. Correct by cleaning seal and lid.

b) The valve is not closing properly. This may be a result of the Teflon seals around the exhaust valve having fractured. To correct this, the seals must be replaced. Full instructions on exhaust valve seal replacement to follow.

14.2. If there is a high temperature error, possible causes could be;

a) The infra-red lamp located in the top part of the drying drum may be broken. To correct this, the lamp must be replaced.

14.3. Once the problems have been addressed, press the reset button in the breakdown menu to reset the machine.

15. DAILY CHECKPOINTS

To ensure that the machine runs smoothly, there are daily checkpoints to observe.

15.1. Check daily the water-softener. Ensure that the salt level in the softener is replenished before each use.

15.2. Ensure that the steam from the boiler is released after each use.

15.3. Ensure that the dust collector is cleaned after each use.

15.4. If the machine is used frequently, empty the circulation water from the dryer periodically using the green butterfly lever located on the bottom right hand side of the dryer. Once the water has been removed, close this lever. The machine will replenish the water upon the commencement of another run.

16. SAFETY

The facility is run under the same conditions of a laboratory. Appropriate Personal Protective Equipment (PPE) is needed to ensure a safe working environment. These include;

16.1. Enclosed footwear is a requirement for working within the facility (Figure 19).

16.2. Eye protection where appropriate.

16.3. Gloves where appropriate.

16.4. Know where fire extinguishers are located in the facility.

16.5. Work sensibly, be aware of your surroundings and take appropriate precautions when conduction tasks to minimise dangers.

Failure to adhere to safety protocols will result in expulsion from the facility and subsequent reporting.

Figure 19. Minimum footwear requirements for laboratories and workshops.

Appendix 3: Report: Development and Application of a Framework Model to Assess the Opportunities for Dried Seafood Products to Asia from Australia

Dried WA Seafood Products for the Asian market

A pilot study

CESSH
CENTRE OF EXCELLENCE
SCIENCE SEAFOOD HEALTH

Curtin University
CURTIN HEALTH INNOVATION
RESEARCH INSTITUTE

Seafood Services
AUSTRALIA

Prepared by
Centre of Excellence Science Seafood
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Curtin University

March 2010

Dried WA Seafood Products for the Asian market

A pilot study

Authors

Acknowledgements

Report number

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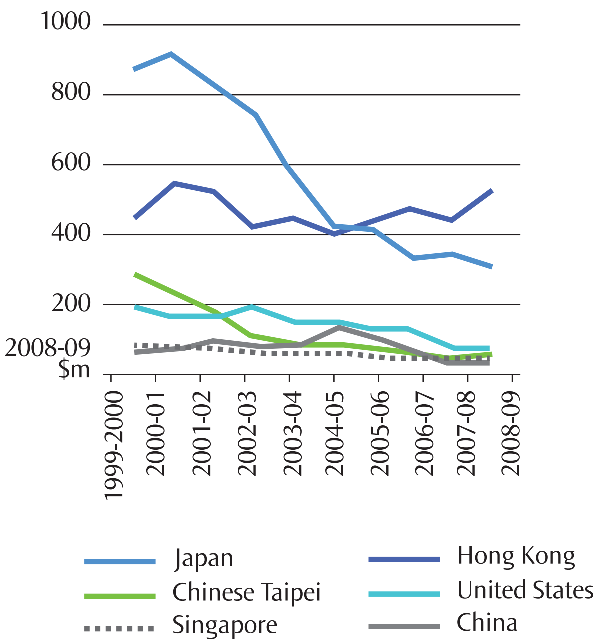
1.0 Introduction

In 2008-09, Australia's major seafood export destinations were Hong Kong worth AUD$525.3 million and Japan worth AUD$302 million as (refer Figure 1). Hong Kong remained Australia's major export destination for edible fisheries products, accounting for 48 per cent of the total export value for edible fisheries products. Japan accounted for 28 per cent of the total export value of edible fisheries products in 2008-09.

Figure 1. Australian exports of edible fisheries products (excluding live), by destination



Source: ABARE 2010

Contributing to previous studies, (i) 'Evaluation of the markets for dried seafood (Revised addition for the Australian seafood industry) prepared by the Department of Primary Industries and Fisheries 2005 and (ii) 'Evaluation of the Market for Dried Seafood 1993-96' prepared by Department of Primary Industries and Fisheries, Project 94/123, this report establishes price points for exporting Australian dried seafood species to Hong Kong and Japan.

This report will provide an overview of the Hong Kong and Japanese seafood sector and dried seafood market in general, tariff and tax overviews and will highlight the "Top down" and "Bottom up" calculations to assess the economic viability for agreed seafood products to the Asian markets.

Note, costs of production were not provided, consequently in order to demonstrate costing structures, assumptions for several values were made. Outcomes of the report were: (i) to develop a consolidated and agreed seafood species price list, as can be seen in appendix 1; (ii) calculate a cost plus pricing for agreed seafood species; and, (iii) to calculate demand based pricing for the agreed seafood species.

2.0 Hong Kong as a potential market for dried seafood products

Over the past decade, Hong Kong represents the sixth largest importer of seafood behind the EU, Japan, US, China and the Republic of Korea, due to a rising value of edible seafood imports. Hong Kong is also an important export partner for Australia as it replaced Japan as the largest seafood export market by value (ABARE 2010).

- Hong Kong offers a sophisticated seafood market characterised by:
- No tariffs for imported seafood products
- No taxes on seafood imports, including value-added taxes (VAT)
- Consistent strong demand for seafood driven by domestic seafood consumption
- A stable seafood trading system
- Limited red tape
- A well organised wholesale seafood market system
- A well developed and reliable banking system
- Hong Kong dollar is pegged to the US dollar
- The English language as operating language.

As no tariffs on any seafood imports exist, Hong Kong remains a free port for exporting seafood, however, entering the closely controlled, competitive market may prove challenging.

The seafood market is an important part of the Hong Kong lifestyle and trade; however the dried fish sector is not very popular within the seafood industry. The Hong Kong consumers do prefer live or fresh seafood and fish, which is due to the huge offering of seafood available at relatively low prices.

The Hong Kong dried seafood sector is very competitive and other than shark fin, Abalone, Sea Cucumbers, fish bladders and seasoned snacks, the traditional dried fish products are almost nonexistent. High value products are dominating the market, relatively small compared to other Asian dried fish markets however efficient and stable. The range of dried products with good market potential in the Hong Kong dried seafood market includes seaweed, Mussels, Scallops and Squid (Chan Chun Man 2009).

3.0 Japan as a potential market for dried seafood products

Japan is one of the world's largest consumers and importers of fish and seafood products. Imports accounted for about 45% or nearly AUD$17.3 billion of the total fish and seafood market in 2006. About half of Japan's total fishery product imports consist of Prawn, Tuna and Marlin, Salmon and Trout, Crab, processed Eels, Cod and Pollock roes, and processed Prawn (Agriculture and Agri-Food Canada 2007).

In Japan, seafood consumption has fallen due to the increased adoption of a more westernised diet and increased intake of meat. Where traditionally the Japanese diet relied almost entirely on seafood for animal protein, in 2003 seafood consumption decreased and accounted for only 39% of the total animal protein intake. Markets for traditional products (e.g. Herring roe, Smelt, or Spawn on Kelp) are stagnant or decreasing. Consumers are purchasing fewer fresh fish and seafood products directly from retailers, and are consuming more fresh fish products in the food-service sector and are consuming more ready made meals (e.g. boxed meals, rice balls).

Individuals still enjoy the unique taste of dried fish products. However, the popularity of fully preserved fish is on the decline. Japanese tastes have advanced and developed and they now prefer half-dried products, categorised as "half-preservatives".

In regards to tariff regulations, Japan has experienced some major changes within the last decade. Some agricultural and food products have been deregulated and tariffs are being reduced (DAFF 2005). However certain seafood products are still subject to import quotas and tariffs. Tariff rates for some dried fish can be seen in Table 1:

Table 1. Tariff rates for dried seafood products

HS	Product	Tariff Rate (%)
0305.20-090	Dried, salted or brined (other fish)	3.0 or free
0305.30-010	Fish fillet, dried, slated, or brined (salmonidae)	9.1
0305.90-090	Fish fillet, dried, salted, or brined (other fish)	11.4
0305.59-010	Dried fish (salmonidae)	9.1
0305.59.010	Dried fish (herring, cod, yellowtail...saury pike)	15.0
0305.59-090	Dried fish (others)	11.4

(Source: Seafood Services Australia 2011)

The tariff rates are applied on the CIF (Cost insurance freight) value. A consumption tax of 5% is applied at the retail level. If the imported product is shipped directly to the end user, the tax is applied at the time of entry on the CIF plus duty value (Agriculture and Agri-Food Canada 2007).

4.0 A Framework for assessing the economic feasibility

4.1 Calculation of the raw material cost before drying

The first step for evaluating economic feasibility for export is a realistic assessment of the Australian production costs. Production costs have been developed by incorporating collected retail prices at selected seafood markets in Hong Kong and Japan. The prices were provided by Curtin University (refer to Appendix 1). The calculations are based on:

AUD$/kg for raw material costs before drying, which is essential for developing the cost of production.

Those costs are based on assumptions for:

i. ex vessel price which represents the price received by fishermen for fish, shellfish and other aquatic plants and animals landed at the dock.

ii. % per edible portions, which represents the percentage of the fish that is edible.

iii. edible portion cost, which can be defined as the cost per unit of the fabricated food.

iv. Labour cost which will depend on for example, local rates of pay, the degree of automation and the type and size of plant which represents 15%.

** The ex vessel price and the % per edible portion are assumed after the contribution of several seafood processors.*

Calculation of raw material cost before drying for each species:

i. dividing the ex vessel price $/kg by the % per edible portions

ii. resulting in the edible portion cost excluding labour

iii. adding labour cost of 15% to this value

Conducting the different steps of the calculations results in the final raw material cost before drying for each of the selected seafood species.

Table 2. Tariff rates for dried seafood products

Product	Ex vessel price $/kg	% per edible portion	Edible portion cost (excl. labour)	Labour cost 15%	Raw material cost before drying
Threadfin Salmon	$1.20	60%	$2.00	**$0.30**	$2.30
Sea Cucumber					
Teatfish	$20.00	70%	$28.58	**$4.29**	$32.87
Sandfish	$6.50		$9.29	**$1.40**	$10.69
Abalone	$33.50	60%	$55.84	**$8.38**	$64.22
Scallops	$3.30	50%	$6.60	**$0.99**	$7.59
Squid	$4.30	60%	$7.17	**$1.08**	$8.25
Cuttlefish	$5.30	60%	$8.84	**$1.33**	$10.17
Prawn	$11.60	35%	$33.15	**$4.98**	$38.13
Shark fin	$32.00	100%	$32.00	**$6.40**	$38.40

Source of Prices: ABARE-BRS 2010, Australian Fisheries Statistics 2009
Source of Edible Portion: Pers. Com. with seafood processors.
Note: Assumptions are shown in bold font; calculations are shown in regular font

4.2 FOB Australia cost of production

Once the raw material cost before drying is calculated, the Free on Board (FOB) Australian cost can be calculated. Table 3 provides a hypothetical example of how FOB Australia costs may be calculated for the specified dried seafood products.

The dry recovery rate, or the ratio of dried product weight to wet product weight, (column 3) is a significant factor in evaluating production cost and is based on assumptions through personal communication. When processing the products, the raw material costs before drying are likely to increase by a factor of three or more when measured due to the typically low recovery rate for dried seafood.

To calculate the FOB Australia cost of production (raw material, labour, packaging, energy, plant, etc.) for each seafood species, the following steps are to be followed:

i. the raw material costs before drying is divided by the dry recovery rate
ii. this results in a value for the raw material cost after drying.
iii. add assumed labour and material cost for producing the product to the cost after drying ,
iv. add plant and administration overhead cost for operating the drying process to the cost after drying
v. add an assumed profit margin of 25% to actually yield profit through producing the dried seafood product
vi. all the values summed up, result in the FOB Australia cost of production

Table 3. Calculation of FOB Australia cost

Product	Raw material cost before drying	Dry recovery rate	Raw material cost after drying	Labour and materials	Plant and admin. overhead	Desired profit	FOB Aust. cost
Threadfin Salmon	$2.30	**20%**	$11.50	**$1.05**	**$0.65**	**25%**	$16.50
Sea Cucumber							
Teatfish	$32.87	**10%**	$328.70				$413.00
Sandfish	$10.69		$106.90	**$1.05**	**$0.65**	**25%**	$135.75
Abalone	$64.22	**20%**	$321.10	**$1.05**	**$0.65**	**25%**	$403.50
Scallops	$7.59	**20%**	$37.95	**$1.05**	**$0.65**	**25%**	$49.57
Squid	$8.25	**20%**	$41.25	**$1.05**	**$0.65**	**25%**	$53.69
Cuttlefish	$10.17	**20%**	$50.85	**$1.05**	**$0.65**	**25%**	$65.69
Prawn	$38.13	**20%**	$190.65	**$1.05**	**$0.65**	**25%**	$240.44
Shark fin	$38.40	**50%**	$76.80	**$1.05**	**$0.65**	**25%**	$98.13

Source: Hypothetical costs and recovery rated provided by Colin Bishop, Seafood Services Australia.
For the raw material cost before drying please refer to the calculation in Appendix 2.
Note: Assumptions are shown in bold font; calculations are shown in regular font

The FOB Australia cost of production will then be the essential value for calculating the "Bottom up' approach for assessing the economic feasibility of the products.

4.3 "Bottom up" calculation

The bottom up calculation is based on all cost incurred in producing the product prior to shipment from Australia (FOB cost as provided in Table 3). To assess the final retail price, the following calculations, starting with the FOB value are essential:

i. add freight and insurance, including all additional costs involved in getting the product to the customer, for example sea freight/air freight charges to wharf/airport, sea/air documents fees e.g. airway Bill, B/L, Transport contingency.
ii. add importing costs including a 10% margin on the previous value and potential marine insurance premium costs
iii. add potential import duties/taxes for the Japan market (calculated as percentage of CIF price, plus customs clearance fees, delivery charges
iv. add wholesaling costs, including an assumed 30% margin
v. plus retailing costs (expressed as 20% margin)

The total of this calculation will result in the estimated price the Australian product must demand in the market. Table 4 and Table 5 provide the calculations based on final FOB calculations for the eight product species to Hong Kong and Japan respectively.

Table 4. Hypothetical example of "Bottom up" calculation to Hong Kong

Costs	Threadfin Salmon	Sea Cucumber Teatfish	Sea Cucumber Sandfish	Abalone	Scallops	Squid	Cuttlefish	Prawns	Shark fin
Estimated FOB Australia cost	$16.50	$413.00	$135.75	$403.50	$49.57	$53.69	$65.69	$240.44	$98.13
Freight and Insurance cost ($/kg)	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50
CIF cost	$21.00	$417.50	$140.25	$408.00	$54.07	$58.19	$70.19	$244.94	$102.63
Importer 10% margin	$2.10	$41.75	$14.03	$40.80	$5.41	$5.82	$7.02	$24.50	$10.27
Importer cost	$23.10	$459.25	$154.28	$448.80	$59.48	$64.01	$77.21	$269.44	$73.27
Wholesale 30% margin	$6.93	$137.78	$46.29	$134.64	$17.85	$19.21	$23.17	$80.84	$21.99
Wholesale cost	$30.03	$597.03	$200.57	$583.44	$77.33	$83.22	$100.38	$350.28	$95.26
Retail 20% margin	$6.01	$119.41	$40.12	$116.69	$15.47	$16.65	$20.08	$70.06	$19.06
Estimated retail cost ($/kg)	**$36.04**	**$716.44**	**$240.69**	**$700.13**	**$92.80**	**$99.87**	**$120.46**	**$420.34**	**$114.32**

Note: The costs and calculations are based on assumptions.

Table 5. Hypothetical example of "Bottom up" calculation to Japan

Costs	Threadfin Salmon	Sea Cucumber Teatfish	Sea Cucumber Sandfish	Abalone	Scallops	Squid	Cuttlefish	Prawns	Shark fin
Estimated FOB Australia cost	$16.50	$413.00	$135.75	$403.50	$49.57	$53.69	$65.69	$240.44	$98.13
Freight and Insurance cost ($/kg)	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50
CIF cost	$21.00	$417.50	$140.25	$408.00	$54.07	58.19	$70.19	$244.94	$102.63
Tariffs 11.4 %	$2.40	$47.60	$15.99	$46.52	$6.17	$6.64	$8.01	$27.93	$11.70
Importer 10% margin	$2.34	$46.54	$15.63	$45.46	$6.03	$6.49	$7.82	$27.29	$11.44
Importer cost	$25.74	$511.61	$171.87	$499.98	$66.27	$71.32	$86.02	$300.16	$125.77
Wholesale 30% margin	$7.73	$153.49	$51.57	$150.00	$19.89	$21.40	$25.81	$90.05	$37.74
Wholesale cost	$33.46	$665.10	$223.44	$649.98	$86.16	$92.72	$111.83	$390.21	$163.51
Retail 20% margin	$6.70	$133.02	$44.69	$130.00	$17.21	$18.55	$22.37	$78.05	$32.71
Consumption tax 5%	$2.01	$39.91	$13.41	$39.00	$5.17	$5.57	$6.71	$23.42	$9.82
Estimated retail cost ($/kg)	**$42.17**	**$838.03**	**$281.54**	**$818.98**	**$108.57**	**$116.84**	**$140.91**	**$491.68**	**$206.04**

Note: The costs and calculations are based on assumptions.

According to calculations for bottom up costing for Hong Kong and Japan, the sum of the costs for each seafood product is the "estimated retail cost". If the estimated retail price is less than the retail price identified in the market, then it could be assumed, that the product is economically viable or feasible.

4.4 "Top down" calculation

The "top-down" calculation approach is based on the retail price for which the product species were sold in the Hong Kong and Japanese market. This price represents the consumer price at the retail store excluding VAT/GST/Sales tax. To work backwards in order to determine the FOB Australia price and to determine whether the product is profitable or not, the following steps need to be followed:

i. subtract assumed retailing costs (expressed as 20% margin)
ii. deduct potential consumption tax (Japan)
iii. subtract a wholesale margin of 30%
iv. subtract an importer/distributor margin of 10%, potential customs clearance fees, or import duty (based on a per cent of the CIF price)
v. and deduct freight and insurance, e.g. Freight to Airport/Wharf, export documentation fees, or customs clearance

This calculation results in the final FOB Australia price (see Tables 6 and 7 for calculations for Hong and Japan respectively). If the estimated FOB Australia price is less than the estimated FOB Australia cost, then it might be assumed that the product is economically viable or feasible.

Table 6. Hypothetical example of top-down calculation to Hong Kong

Similar product at a retail Store	Threadfin Salmon	Sea Cucumber	Abalone	Scallops	Squid	Cuttlefish	Prawns	Shark fin
Consumer price excluding VAT/GST/sales tax ($/kg)	$124.00	$1055.00	$936.00	$653.00	$107.00	$119.00	$174.00	$397.00
Retail 20% margin	$24.80	$211.00	$187.20	$130.60	$21.40	$23.80	434.80	$79.40
Wholesale price	$99.20	$844.00	$748.80	$522.40	$85.60	$95.20	$139.20	$317.60
Wholesale 30% margin	$29.76	$253.20	$224.64	$156.72	$25.68	$28.56	$41.76	$95.28
Importer price	$69.44	$590.80	$524.16	$365.68	$59.92	$66.64	$97.44	$222.32
Importer 10% margin	$6.94	$59.08	$52.41	$36.57	$6.00	$6.66	$9.74	$22.23
CIF price	$62.50	$531.72	$471.75	$329.11	$53.92	$59.98	$87.70	$200.09
Freight and Insurance cost ($/kg)	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50
Estimated FOB Australia price	**$58.00**	**$527.22**	**$467.25**	**$324.61**	**$49.42**	**$55.48**	**$83.20**	**$195.59**

Note: The retail prices were provided by Curtin University. The other costs and calculations are based on assumptions.

Table 7. Hypothetical example of top-down calculation to Japan

Similar product at a retail Store	Threadfin Salmon	Sea Cucumber	Abalone	Scallops	Squid	Cuttlefish	Prawns	Shark fin
Consumer price excluding VAT/GST/sales tax ($/kg)	$124.00	$1055.00	$936.00	$653.00	$107.00	$119.00	$174.00	$397.00
Retail 20% margin	$24.80	$211.00	$187.20	$130.60	$21.40	$23.80	$34.80	$79.40
Consumption tax 5%	$4.96	$42.20	$37.69	$26.12	$4.28	$4.76	$6.96	$15.88
Wholesale price	$94.24	$801.80	$711.11	$496.28	$81.32	$90.44	$132.24	$301.72
Wholesale 30% margin	$28.28	$240.54	$213.34	$148.89	$24.40	$27.14	$39.68	$90.52
Importer price	$65.96	$561.26	$497.77	$347.39	$56.92	$63.30	$92.56	$211.20
Importer 10% margin	$6.60	$56.13	$49.78	$34.74	$5.70	$6.33	$9.26	$21.12
Tariffs 11.4%)	$6.77	$57.59	$51.07	$35.65	$5.84	$6.50	$9.50	$21.67
CIF price	$52.59	$447.54	$396.92	$277.00	$45.38	$50.47	$73.80	$168.41
Freight and Insurance cost ($/kg)	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50	$4.50
Estimated FOB Australia price	**$48.09**	**$443.04**	**$392.42**	**$272.50**	**$40.88**	**$45.97**	**$69.30**	**$163.91**

Note: The retail prices were provided by Curtin University. The other costs and calculations are based on assumptions.

5.0 Overall summary

This section compares the estimated FOB Australia costs from Tables 4 and 5 with the estimated FOB Australia price calculations from Tables 6 and 7 and suggests that not all Australian dried seafood products may be economically viable for exporting.

Table 8. Economic feasibility for Hong Kong market

Product	Estimated FOB Australia cost	Estimated FOB Australia price	Economic feasibility
Threadfin Salmon	$16.50	$58.00	Yes
Sea Cucumber - Sandfish	$135.75	$527.22	Yes
Abalone	$403.50	$467.25	Yes
Scallops	$49.57	$324.61	Yes
Squid	$53.69	$49.42	No
Cuttlefish	$65.69	$55.48	No
Prawn (e.g. brown or coral)	$240.44	$83.20	No
Shark fin	$98.13	$195.59	Yes

Threadfin Salmon, Sea Cucumber Sandfish, Abalone, Scallops and Shark fin might be competitive for the Hong Kong market based on both, the “Bottom up” and “Top down” calculations. As the estimated FOB Australia price is higher than the estimated FOB Australia cost, these products might be economically feasible.

Table 9. Economic feasibility for Japan market

Product	Estimated FOB Australia cost	Estimated FOB Australia price	Economic feasibility
Threadfin Salmon	$16.50	$58.00	Yes
Sea Cucumber - Sandfish	$135.75	$467.25	Yes
Abalone	$403.50	$324.61	No
Scallops	$49.57	$324.61	Yes
Squid	$53.69	$49.42	No
Cuttlefish	$65.69	$55.48	No
Prawn (e.g. brown or coral)	$240.44	$83.20	No
Shark fin	$98.13	$195.59	Yes

According to the above calculation, Threadfin Salmon, Sea Cucumber, Scallops and Shark fin may be competitive in the Japanese market based as the estimated FOB Australia price is higher then the FOB Australia cost.

References

1. Agriculture and Agri-Food Canada 2007, The Fish and Seafood Market in Japan, viewed 15 January 2011, http://www.ats.agr.gc.ca/asi/4345-eng.htm

2. Agriculture and Agri-Food Canada 2007, The Fish and Seafood Sector Profile - Hong Kong & Macao, viewed 15 December 2010, http://www.ats.agr.gc.ca/asi/4579-eng.htm

3. Australian Bureau of Agricultural and Resource Economics (ABARE), Canberra 2011, Australian Fisheries Statistics 2010, viewed 05 February 2011, http://www.abareconomics.com/publications_html/ins/insights_10/a3.pdf

4. Austrade 2007, Getting Your Export Pricing Right, Australian Government, http://www.austrade.gov.au

5. Australian Government Department of Agriculture, Fisheries and Forestry 2005 (DAFF), HK$15 billion reason to access the Hong Kong seafood market, A guide to exporting Australia's fisheries products to the Hong Kong SAR.

6. Chan Chun Man 2009, Hong Kong Seafood Export Guide, Maine International Trade Centre, Portland, Maine.

7. Galik G 1998, Dried Fish Exports to Japan, Korea, China, Singapore, and Taiwan, AADLAND Marketing, Anchorage, Alaska.

8. Knapp G 1998, Economic Feasibility of Exporting Dried Seafood Products form Alaska to Selected Asian Markets. Institute of Social and Economic Research, University of Alaska Anchorage.

9. Shawneen A and Yuan-fang Dong 1998, Hong Kong Dried Fish Market, The Unoth Pacific Fisheries Program, University of Alaska Anchorage.

Appendices

Appendix 1. Dried seafood feasibility study agreed seafood price list

Product	$AUD/kg sold dried in Hong Kong 2010	$AUD/kg sold dried in Japan 2010	$AUD/kg from 1996 report (HK and Taiwan)
Threadfin Salmon	$124.00	$56.00	45.00 HK$ per 600 grams
Sea Cucumber	$1055.00	100 g for $2230.00 247 g for $537.00	$10.00 - $50.00
Abalone	$936.00	28 g for $2787.00	$180.00 - $1000.00
Scallops			$28.00 - $258.00
small	$653.00	$93.00 - $119.00	
medium	$521.00	$106.00 - $305.00	
large	$861.00	$209.00	
Squid	$107.00	Large $33.00 Small $83.00	$20.00
Cuttlefish	$119.00	Whole dried for $38.00 Whole sliced for $70.00	$24.00 - $50.00
Prawn (e.g. brown or coral)			
Jumbo	$278.00	Large $200.00	
Large	$174.00	Small $48.00-$65.00 Very small $42.00	
Shark fin	$397.00	Extra large for $921.00 Very large for $862.00 Large for $804.00 Medium for $760.00 Small for $716.00 Very small for $672.00	$150.00 (varies with which fin)

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Appendix 4: Karl Hansal Honours Powerpoint Presentation

Using vacuum drying and freeze drying to produce dried seafood products for Asian markets

AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE

Honours Project proposal 2010

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Introduction

- Huge demand for seafood in Asia (not enough to meet future supply trends)
- High quality Australian seafood = highly competitive
- Australian seafood processors interested in adding value to waste products and extending current production lines
- Cutting edge technology available in Australia
  - Efficient, less labour intensive, safe, less destructive
- Products created for this study have never been trialled/studied before – **Pilot study**
  - Gap in literature for modern seafood drying processes

Project Aims

- Create acceptable, safe, ready to eat products from scallop and pearl meat adductor muscle using vacuum and freeze drying
- Determine and optimise pre-treatments and drying parameters
- Compare results with equivalent products currently in Asian markets through analysis of samples
  - Analytical testing
    - Proximate composition, physical properties, food safety
  - Sensory evaluation
    - Consumer acceptability

West Australian Products

- Scallop adductor muscle
  - Shark bay saucer scallop (Amusium balloti)

Fresh weight of individual samples (g)	Dimensions		Retail value (AUD$/kg dried)
	Length (mm)	Width (mm)	
24.87	35	15	80

- Pearl meat adductor muscle
  - Broome silver lip pearl oyster (Pinctada maxima)

Fresh weight of individual samples (g)	Dimensions		Retail value (AUD$/kg dried)
	Length (mm)	Width (mm)	
17.23	82	8	150

Traditionally processed Samples

Sample	Country of purchase / country of origin	Size category	Species	Dried weight of individual samples (g)	Dried dimensions		Retail value (AUD)
					Diameter (mm)	Height (mm)	
(#11) Scallop	Aus / Unknown	M	Unknown	6.3146	25	15	$80/kg
(#12) Scallop	Aus / China	M	Unknown	5.8448	22	16	$17.50/100g
(#13) Scallop	China / China	S	Unknown	0.7204	9	10	$12/500g
(#14) Scallop	Aus / Unknown	L	Unknown	18.6280	37	23	$120/kg
(#15) Scallop	Japan / Japan	M	Unknown	7.3708	25	16	$19.50/100g
(#2) Pearl meat	Aus / Aus	L	Pinctada maxima	9.3406	66	25	$580/kg

Drying Technology

- Vacuum drying
  - Vacuum and heat applied to product
  - Low partial pressure forces moisture migration from within food matrix to surrounding air
  - High potential for chemical reaction and alteration of food structure during drying
  - Significant changes in sensory characteristics

- Freeze Drying
  - Vacuum and heat applied to frozen product
  - Moisture migration by sublimation of ice
  - Low chance of chemical reaction or alteration of food matrix during drying
  - Limited change in sensory characteristics

Pre-treatment and drying method development

- Initial reduction in moisture content and Aw
  - Reduce drying time and promote sensory quality
  - Significantly reduce bacterial load

- Pre-treatments for vacuum dried product based on traditional methods described by Tanikawa, E., T. Motohiro, and M. Akiba (1985)
  - **No literature describing dried pearl meat processing**

- Acid immersion of samples based on a method trialled by Marquez-Rios et al. (2009)
  - May Improve drying speed and enhance sensory quality

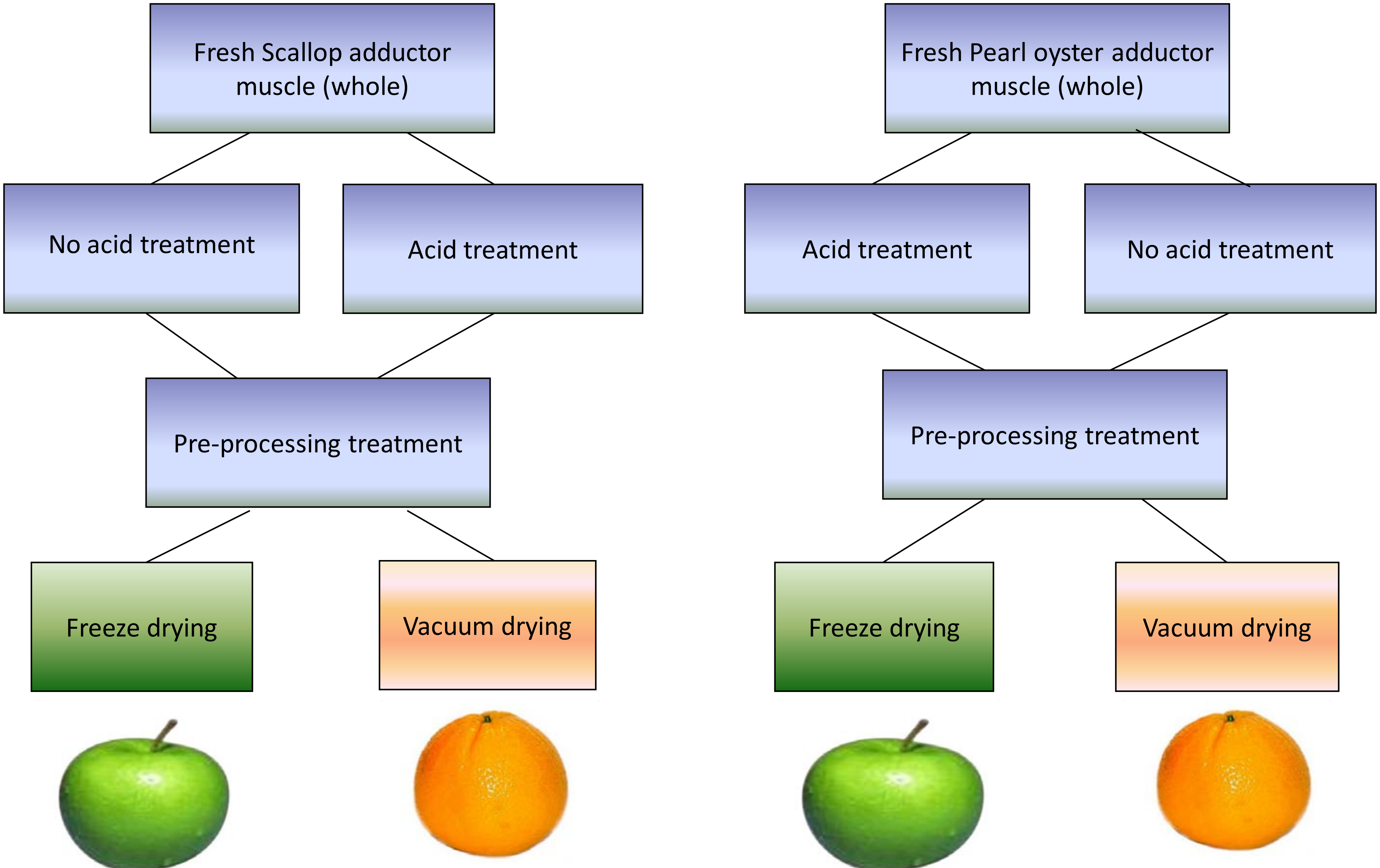
Vacuum dried pre-treatments and drying parameter trials

Sample	Pre-heat [°C/Time (min)]	Cook time (mins)	Salt/Sugar concentration (%)	Drying Temperature (°C)	Pressure (mmHg)
Scallop	N/A	5	5/3	50	10
Scallop	N/A	10	5/3	50	10
Scallop	N/A	25	5/3	50	10
Scallop	N/A	25	N/A	60	10
Scallop	N/A	25	10.04/0	50	10
Scallop	N/A	25	10.04/0	60	15
Scallop	N/A	25	10.04/0	65	15
Scallop	N/A	25	10.04/0	70	15
Scallop	N/A	25	10.04/0	65	5
Pearl	N/A	25	10.04/0	65	15
Pearl	N/A	5	10.04/0	65	15
Pearl	N/A	2	2/0	65	15
Pearl	105°C/50	0	N/A	65	15

Freeze dried pre-treatment and drying parameter trials

Sample	Cook time (min)	Salt (%)	Drying Temperature (°C)	Pressure (mbar)
Scallop	5	2	-52	0.2
Scallop	5	2	-52	0.2
Scallop	2	2	-52	0.2
Scallop	4	2	-52	0.2
Scallop	3	2	-52	0.2
Scallop	3.5	2	-52	0.2
Pearl	3.5	2	-52	0.2
Pearl	3	2	-52	0.2
Pearl	2.5	2	-52	0.2

Product Creation




OSMER
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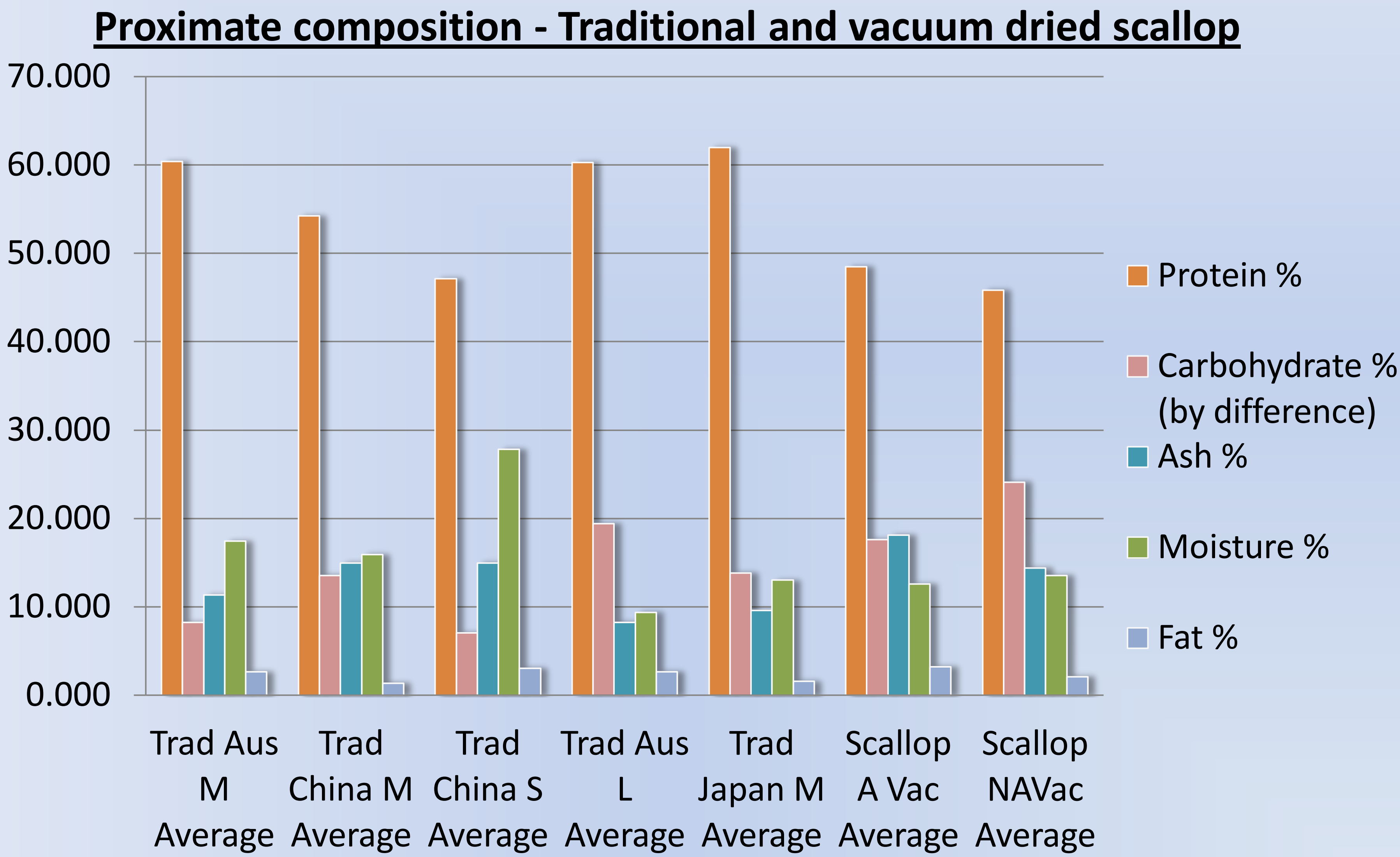
Analysis of samples

- Proximate composition
- Water activity
- Texture
- Colour
- Sensory

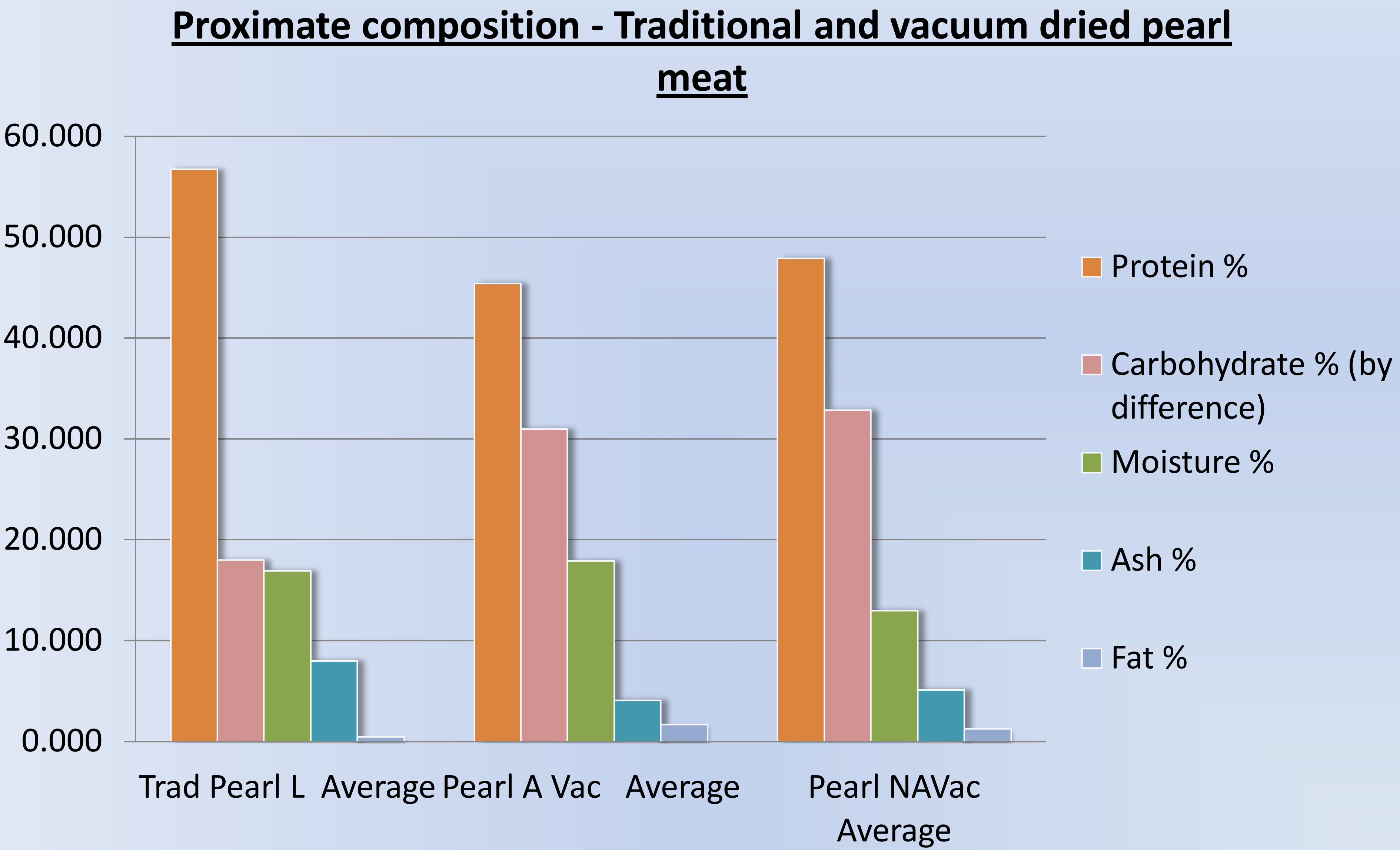
Proximate composition

- Breakdown of nutrient categories
  - Moisture, protein, fat, carbohydrate, ash
    - AOAC standard methods
- Expect differences between species and within species
  - Region, season, age, species type
- Can indicate poor health/quality of animal or anomaly in processing method

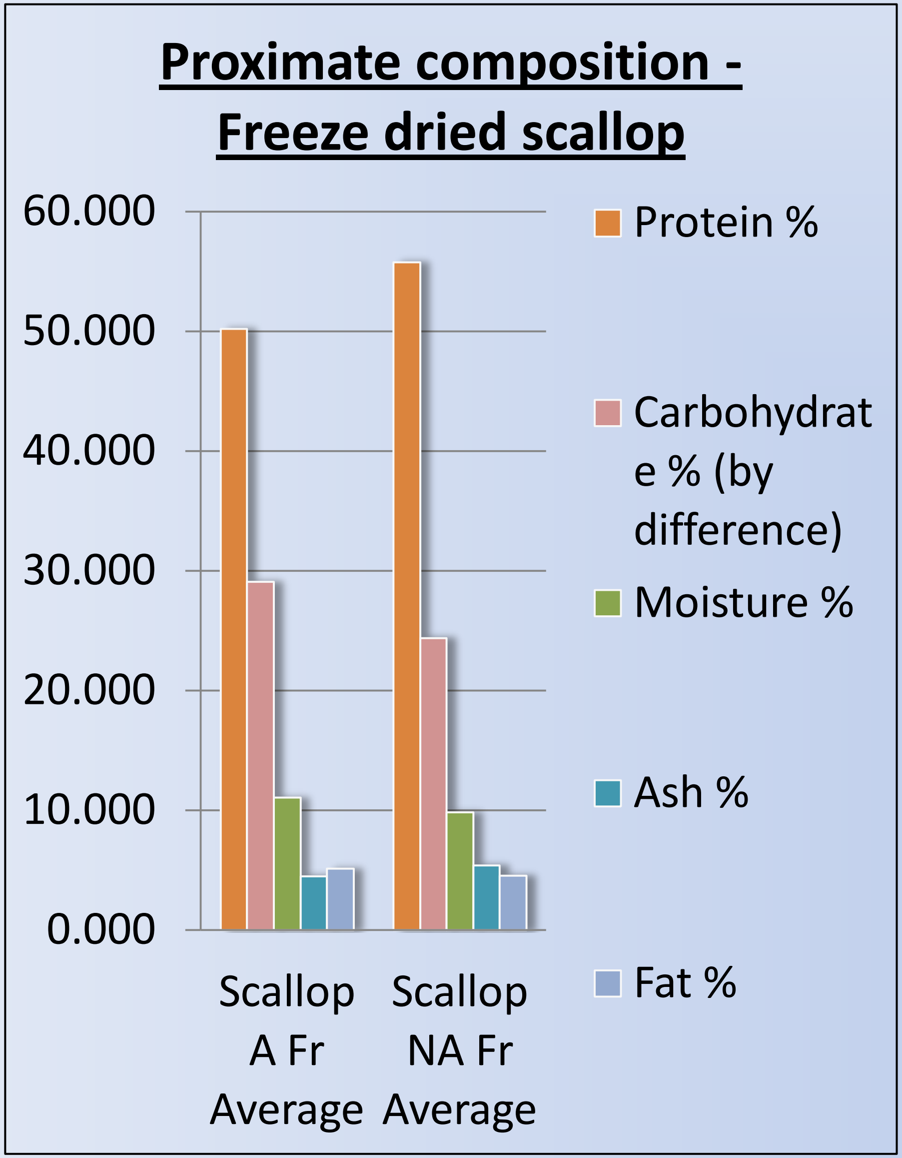
Proximate composition

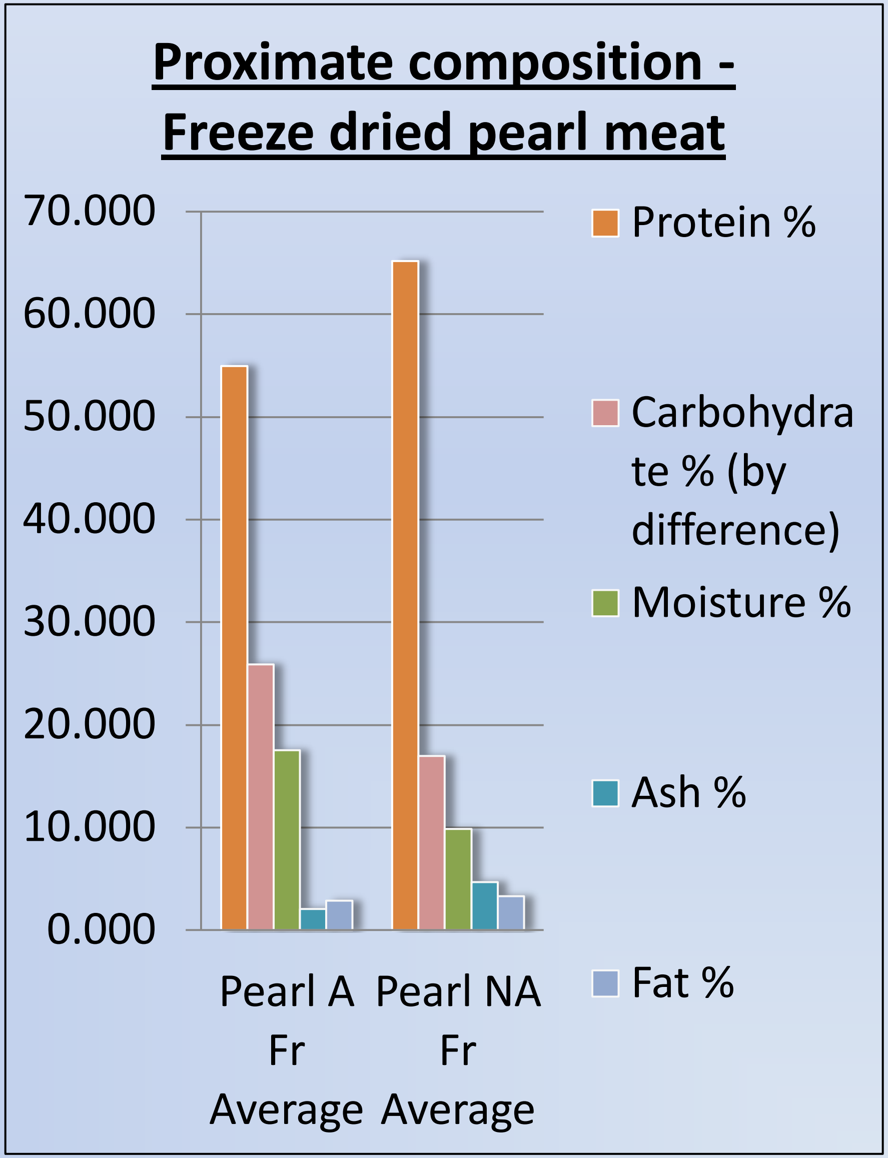


Proximate composition



Proximate composition

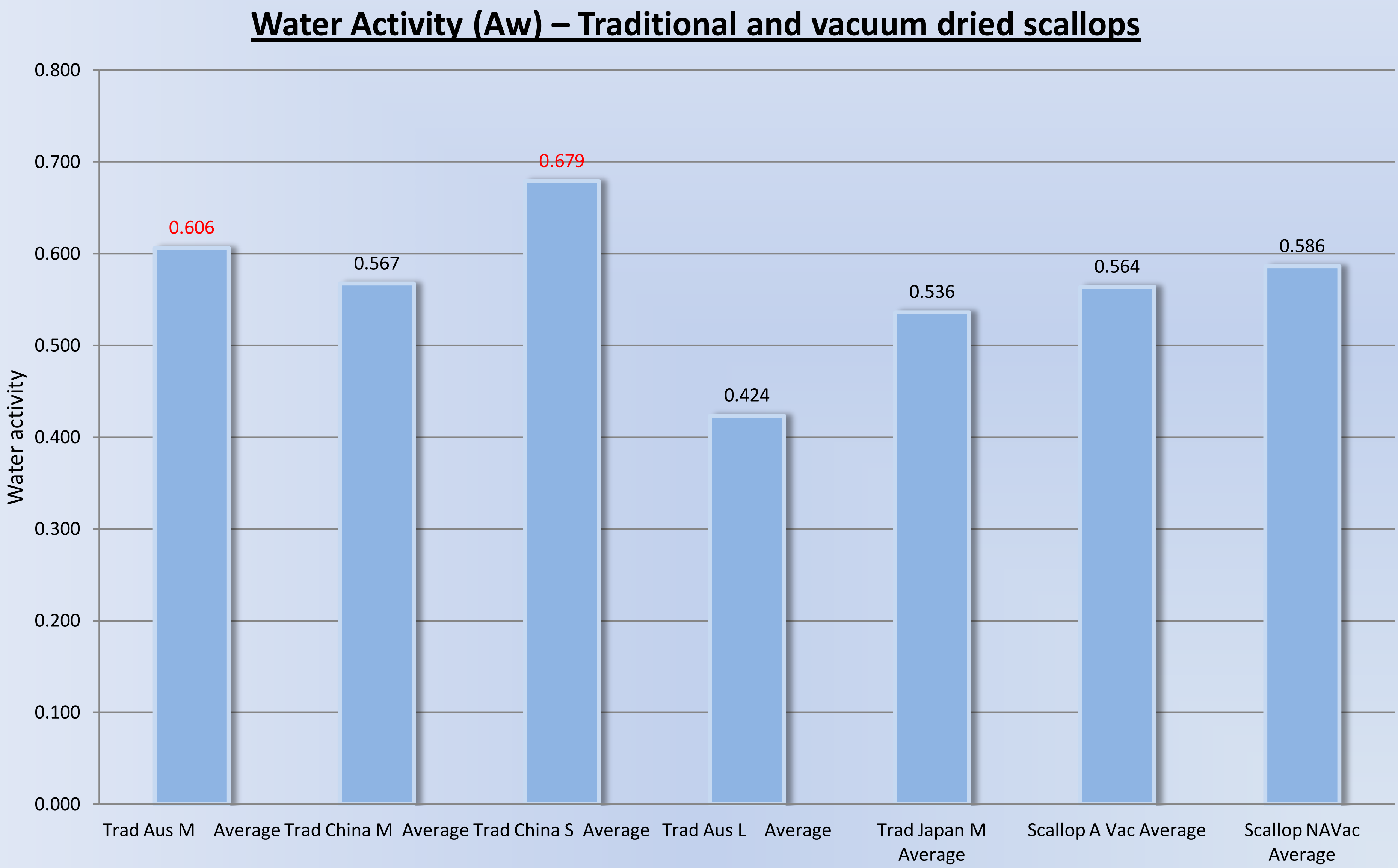




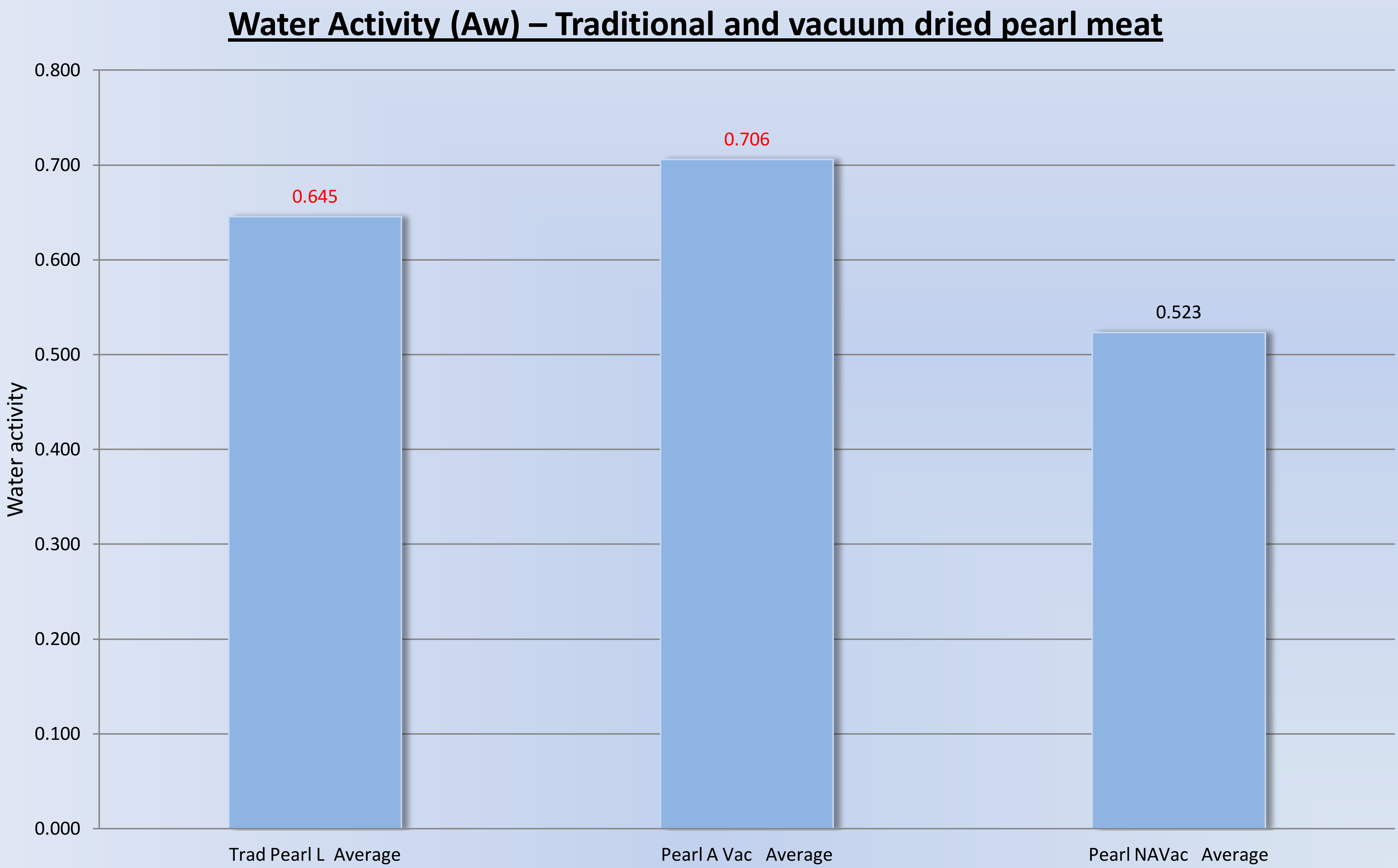
Water activity

- Measures unbound water (water available for chemical reaction and metabolism by microorganisms)
- Target dried levels:
  - Aw < 0.6 for vacuum dried samples
  - Aw < 0.6 combined with < 10% moisture is ideal for retaining original texture properties upon rehydration
- Used AquaLab Water Activity Meter

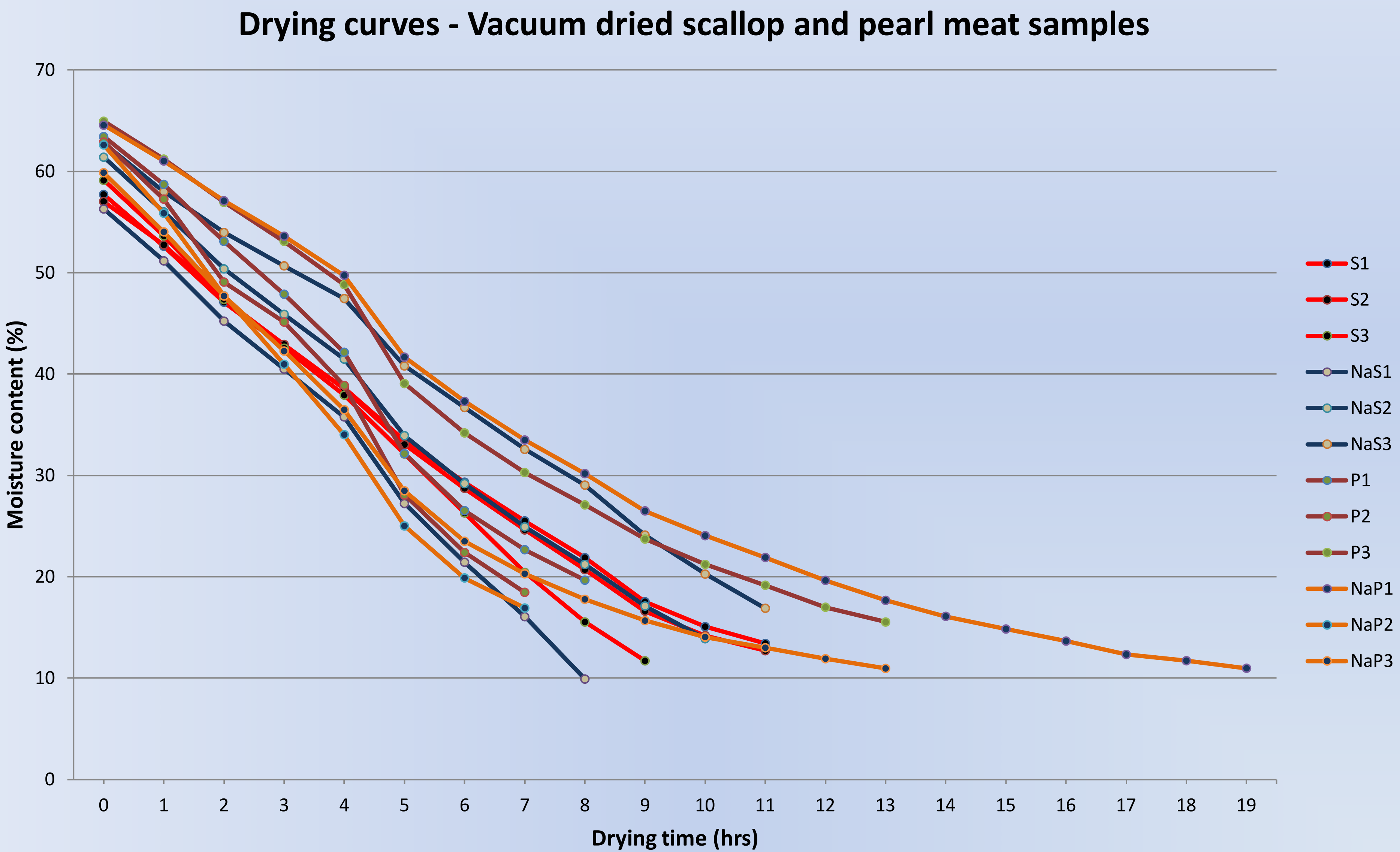
Water activity



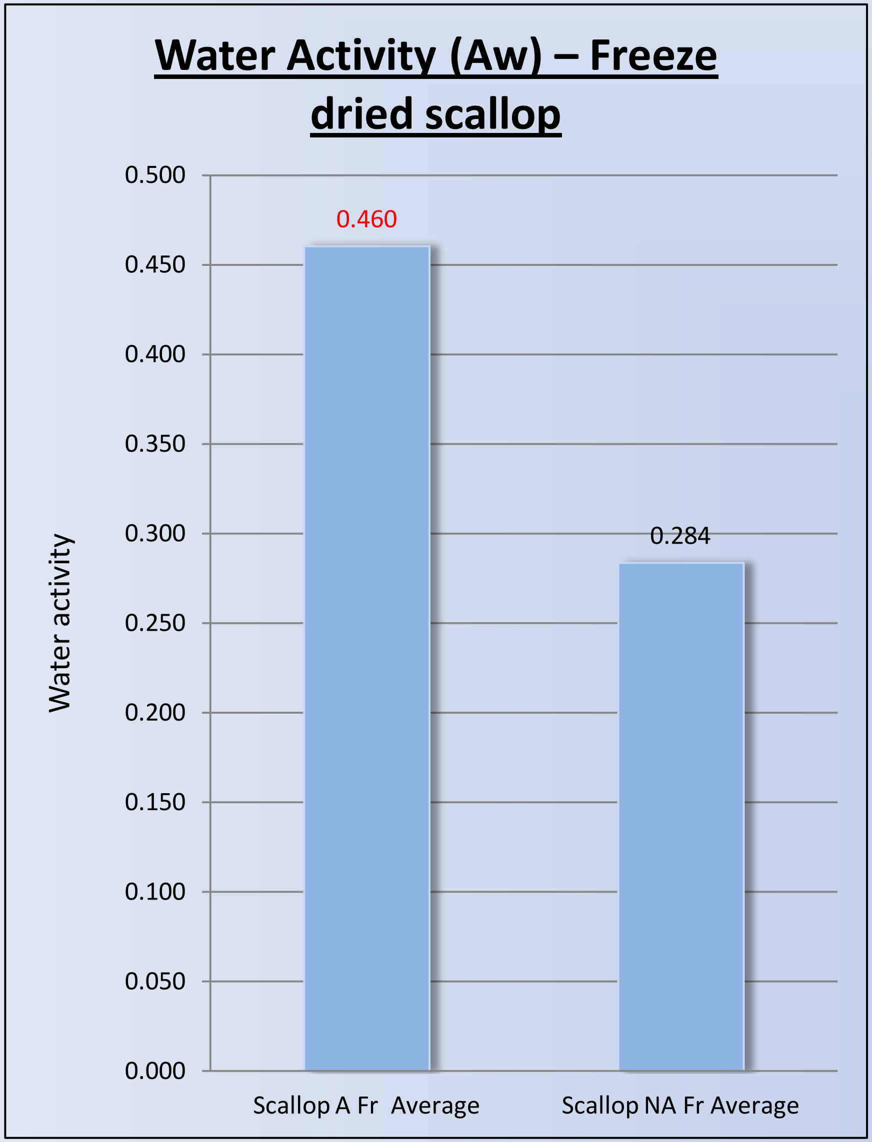
Water activity

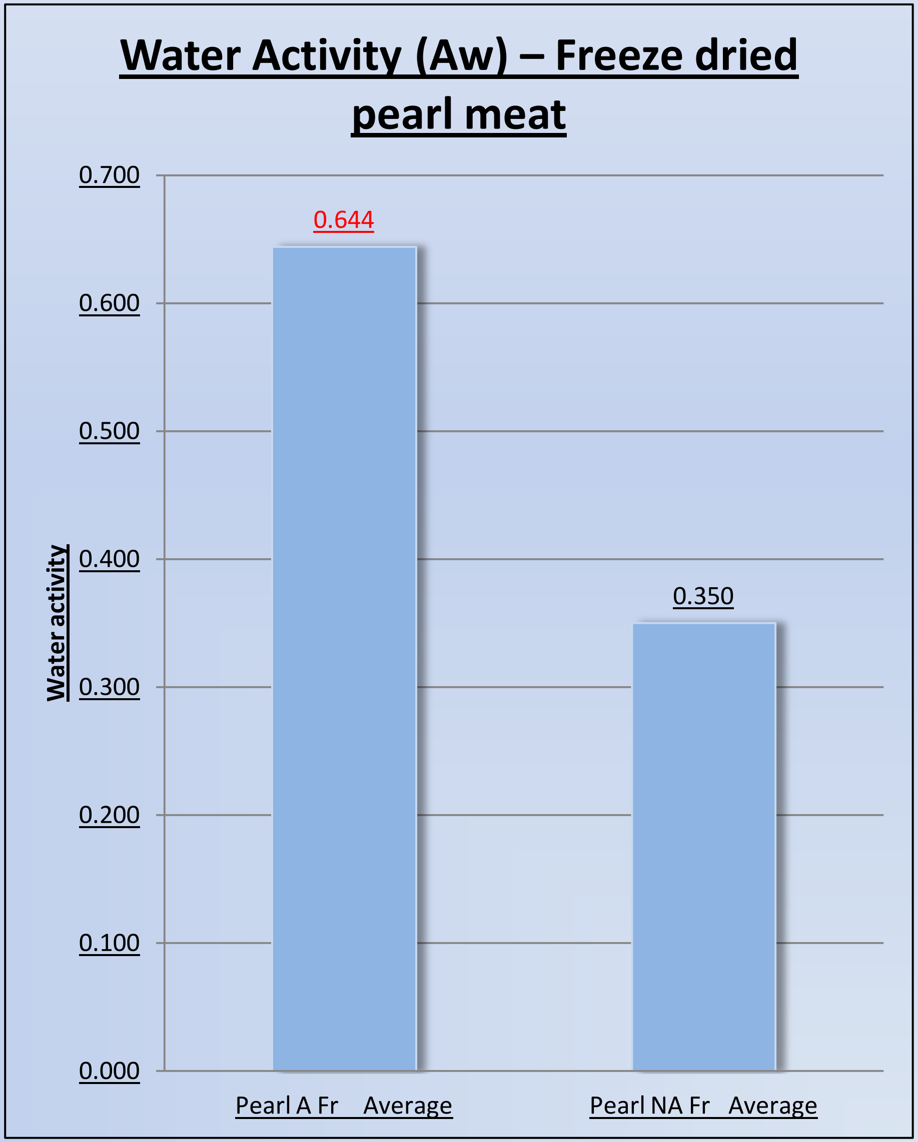


Drying Curves



Water activity

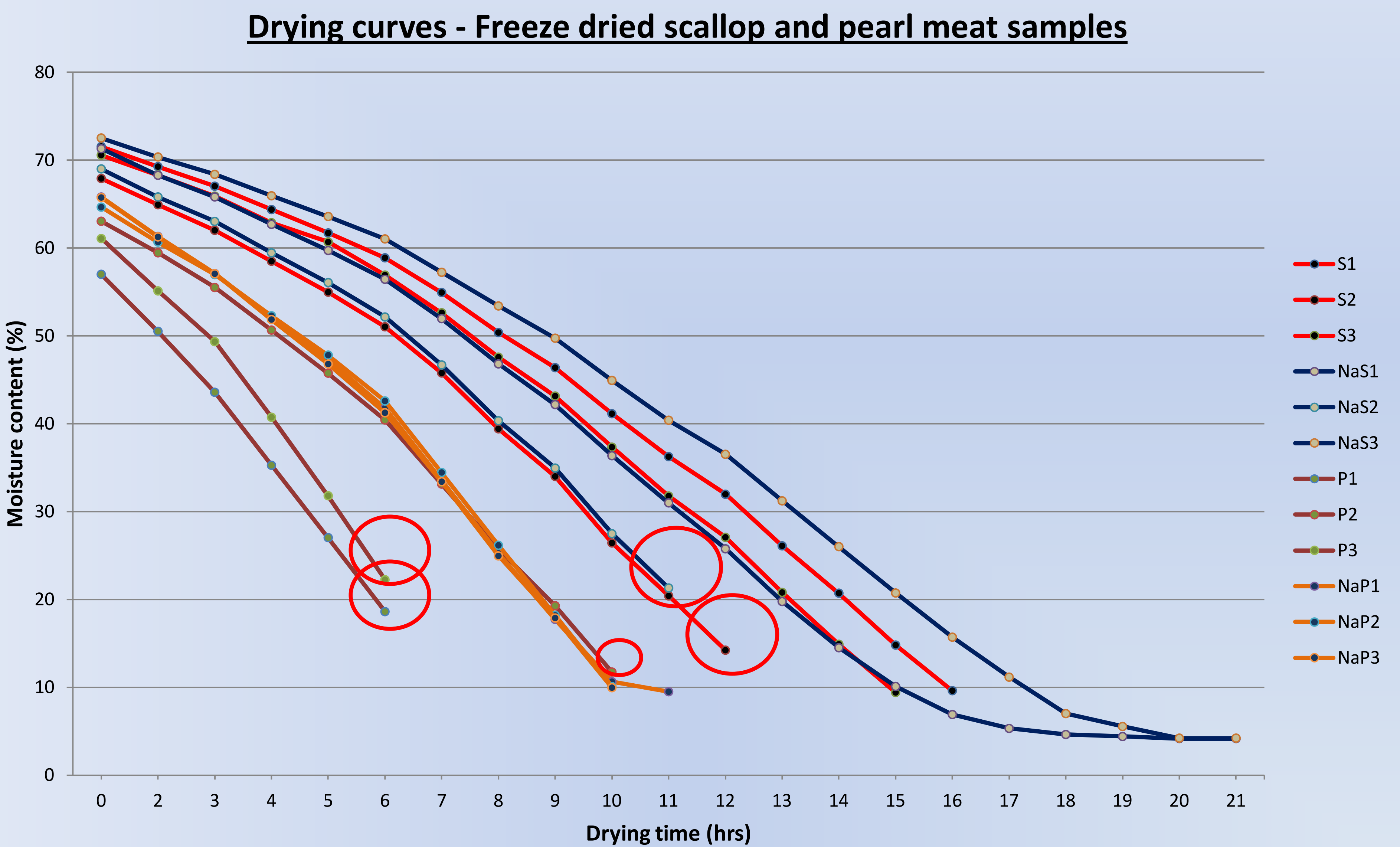




Limitation in the drying model

- When fresh moisture content is higher than predicted by original analysis
  - Optimal drying weight predicted from original moisture content weight
  - When original moisture % is higher than expected, the expected dry weight will also have a higher moisture %

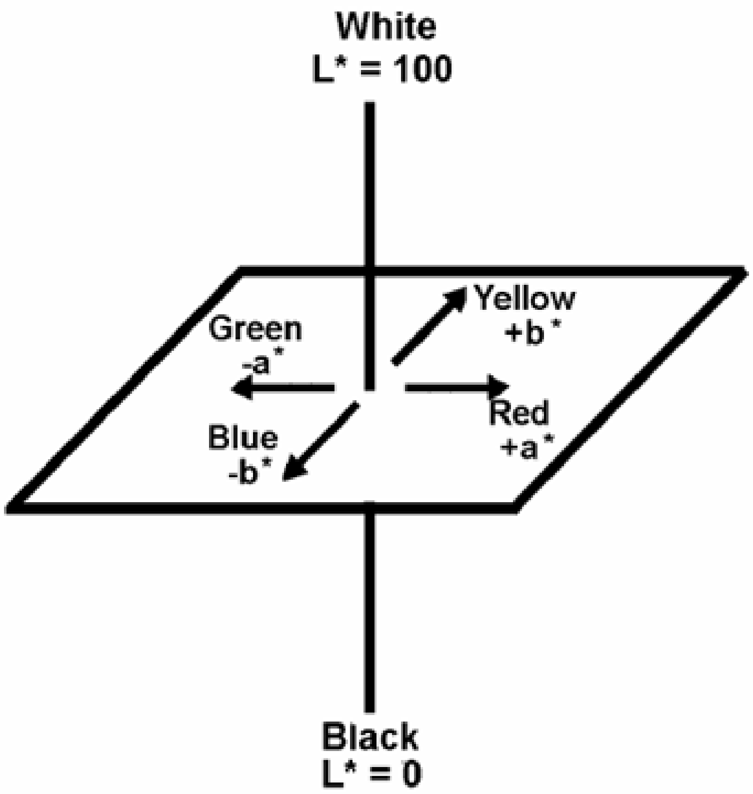
Drying Curves



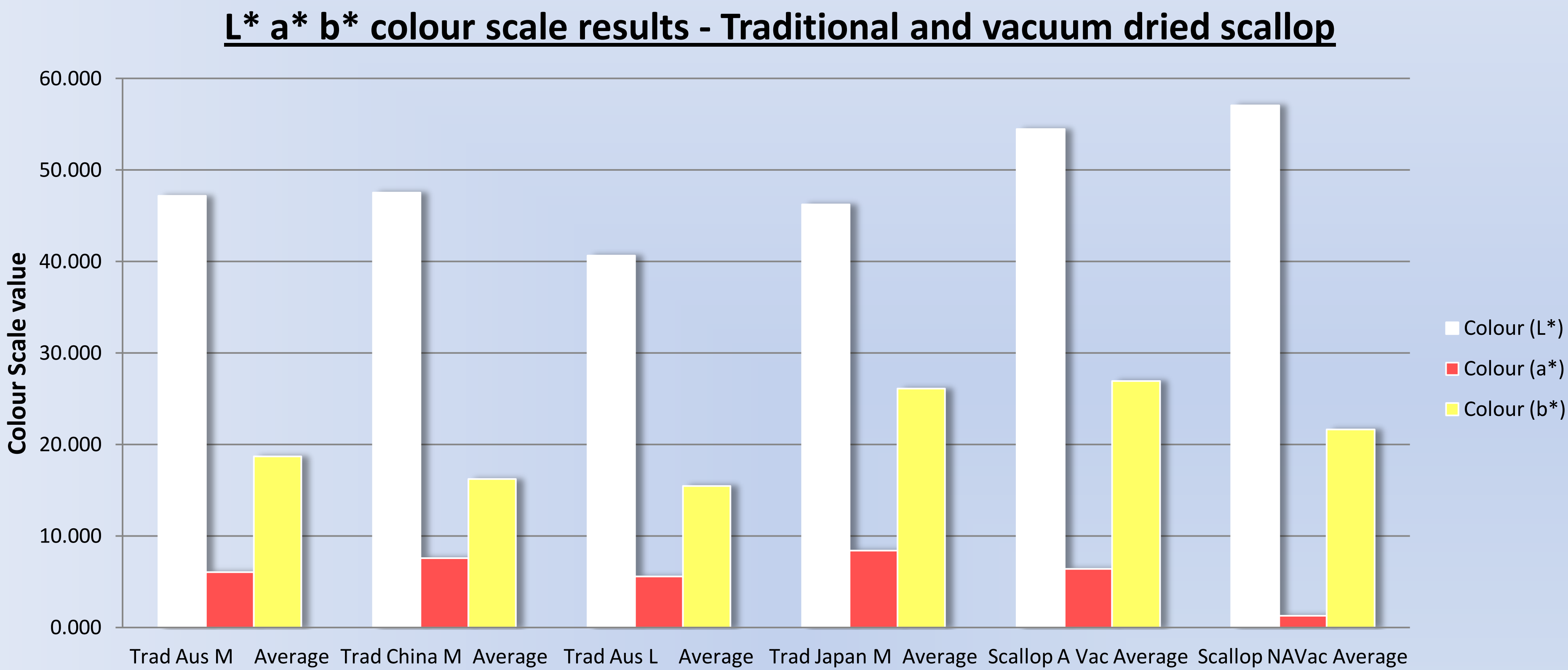
Colour

- Initial sensory stimulus!
- Familiarity or foreign
- Quality and safety

- L*a*b* colour scale
  - Simple representation of human colour perception
  - Quantify key differences in colour across samples
- Minolta spectrophotometer CM-508i

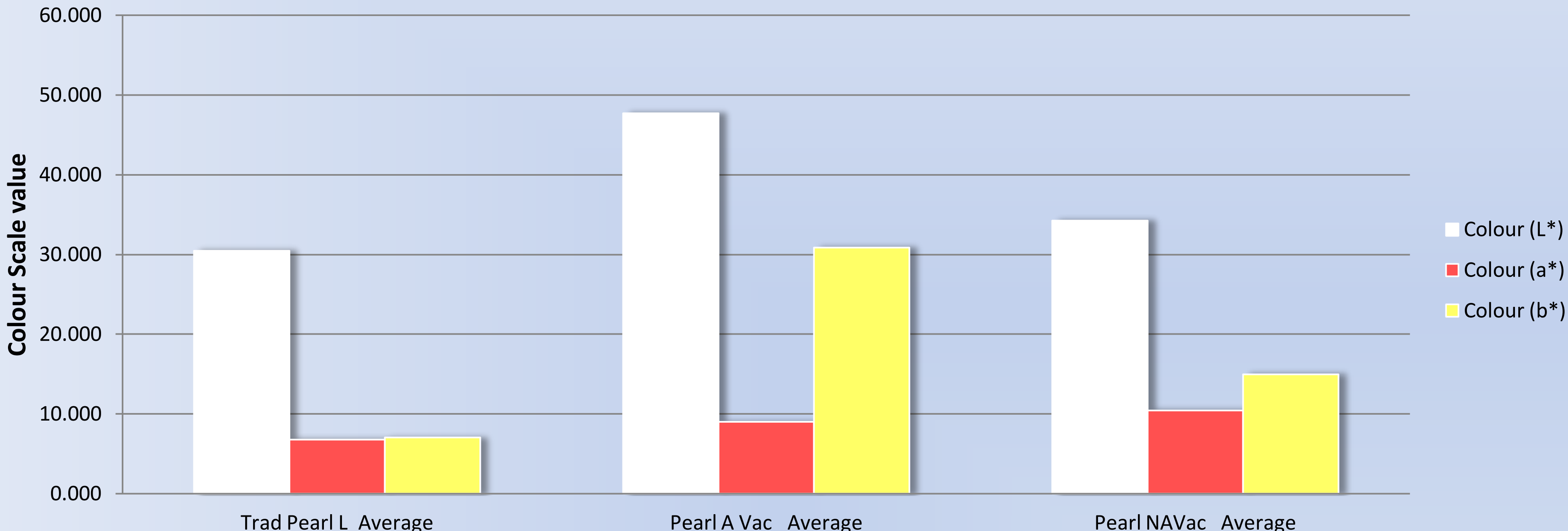


Colour

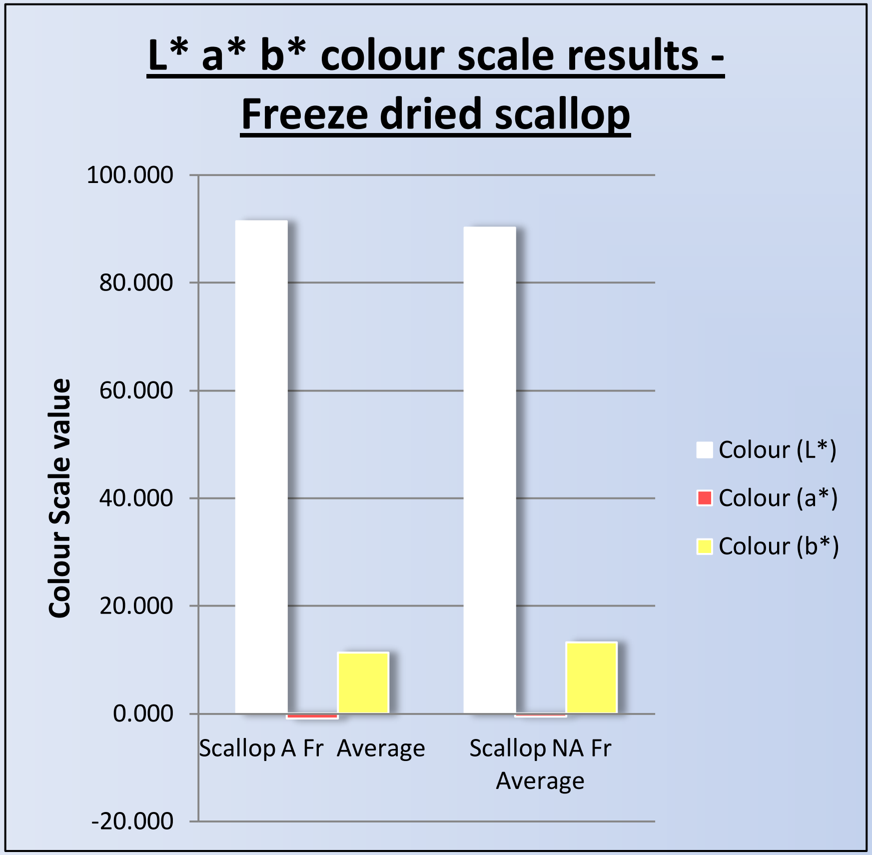

L* a* b* colour scale results - Traditional and vacuum dried scallop
Colour Scale value
60.000
50.000
40.000
30.000
20.000
10.000
0.000
Trad Aus M Average
Trad China M Average
Trad Aus L Average
Trad Japan M Average
Scallop A Vac Average
Scallop NAVac Average
Colour (L*)
Colour (a*)
Colour (b*)

Colour

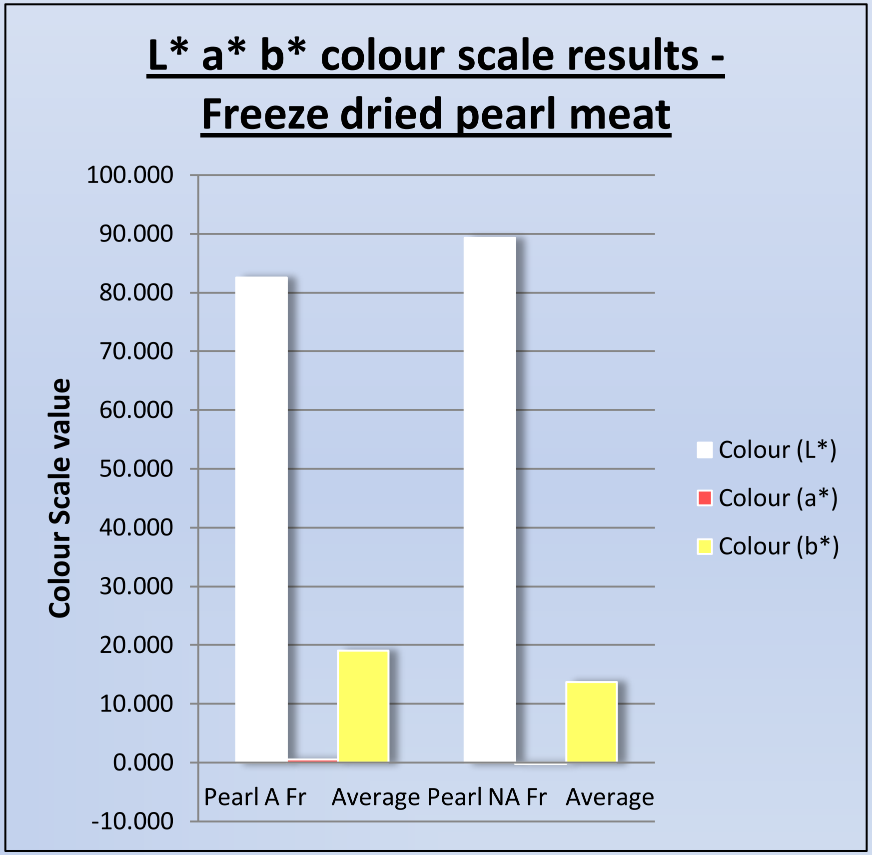
L* a* b* colour scale results - Traditional and vacuum dried pearl meat



Colour



L* a* b* colour scale results - Freeze dried scallop
100.000
80.000
60.000
40.000
20.000
0.000
-20.000
Colour Scale value
Scallop A Fr Average
Scallop NA Fr Average
Colour (L*)
Colour (a*)
Colour (b*)



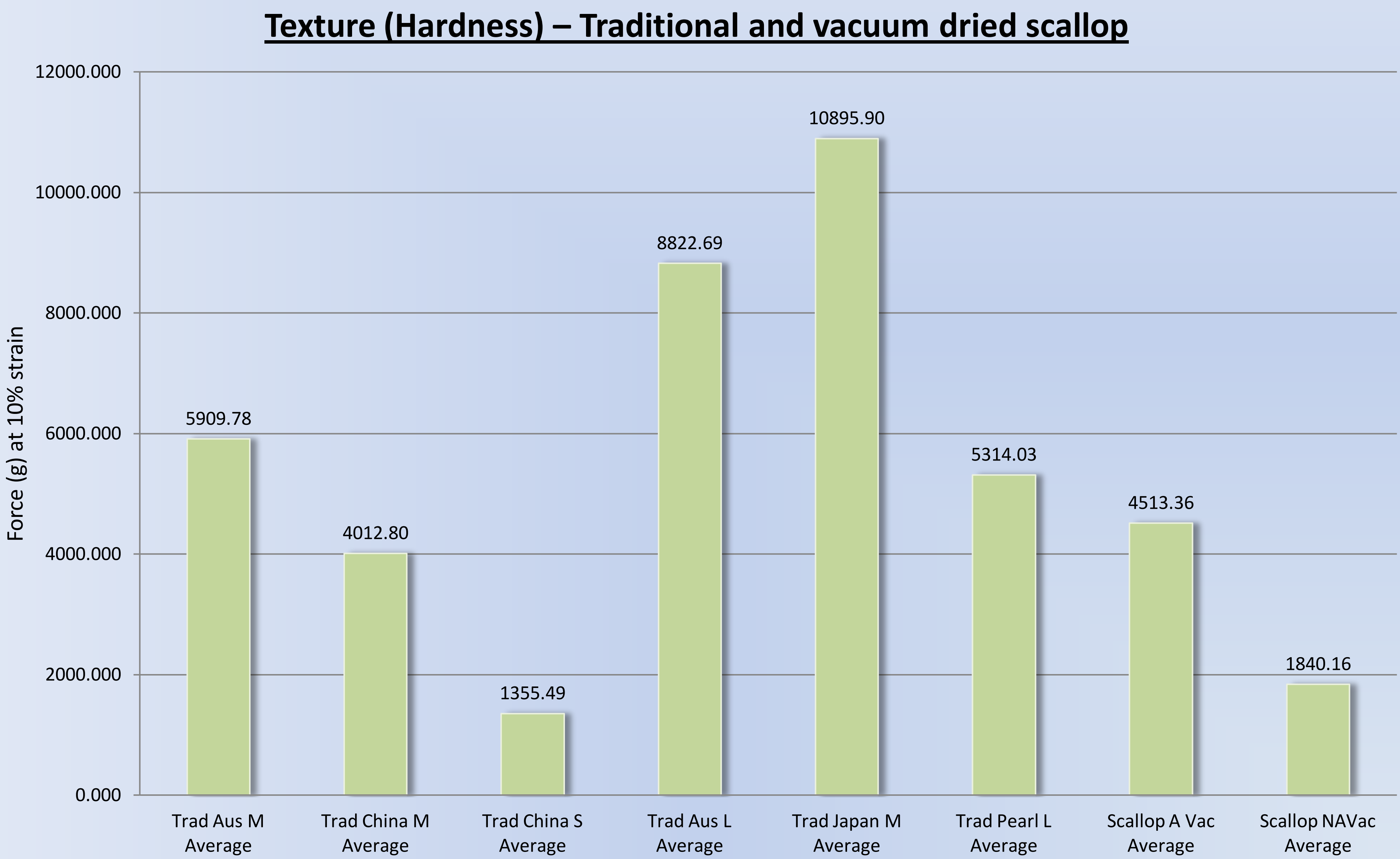
L* a* b* colour scale results - Freeze dried pearl meat
100.000
90.000
80.000
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0.000
-10.000
Colour Scale value
Pearl A Fr Average
Pearl NA Fr Average
Colour (L*)
Colour (a*)
Colour (b*)




Texture

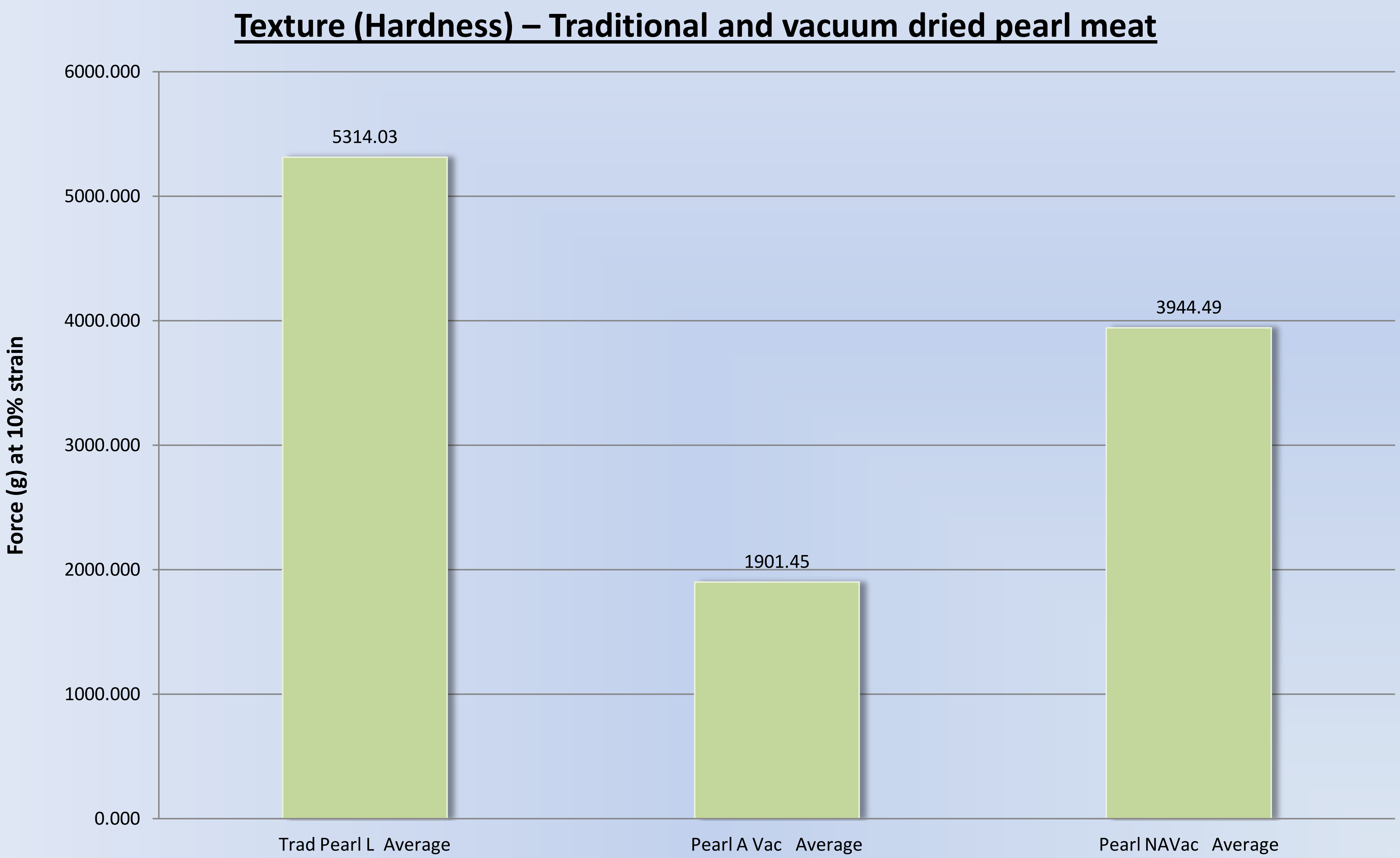
- Important that texture not extremely different to equivalent products
  - Not too soft or not too hard as to appear or feel odd
  - Important initial sensory stimulus (before taste)
- How?
  - TA-XT2i texture analyser
  - Grams of force required to depress sample by 5% using a 6mm spherical probe and 25kg load cell

Texture



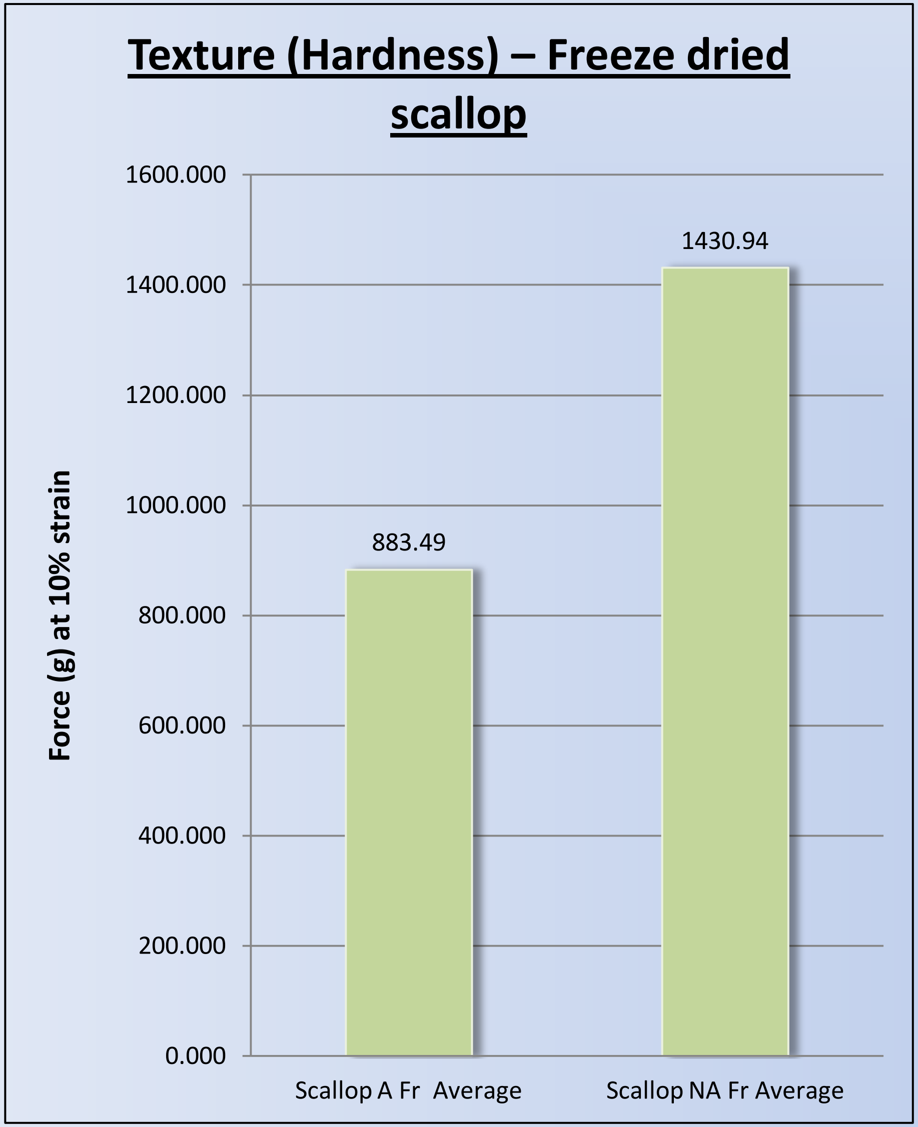
Texture (Hardness) – Traditional and vacuum dried scallop
Force (g) at 10% strain
12000.000
10000.000
8000.000
6000.000
4000.000
2000.000
0.000
5909.78
4012.80
1355.49
8822.69
10895.90
5314.03
4513.36
1840.16
Trad Aus M Average
Trad China M Average
Trad China S Average
Trad Aus L Average
Trad Japan M Average
Trad Pearl L Average
Scallop A Vac Average
Scallop NAVac Average

Texture

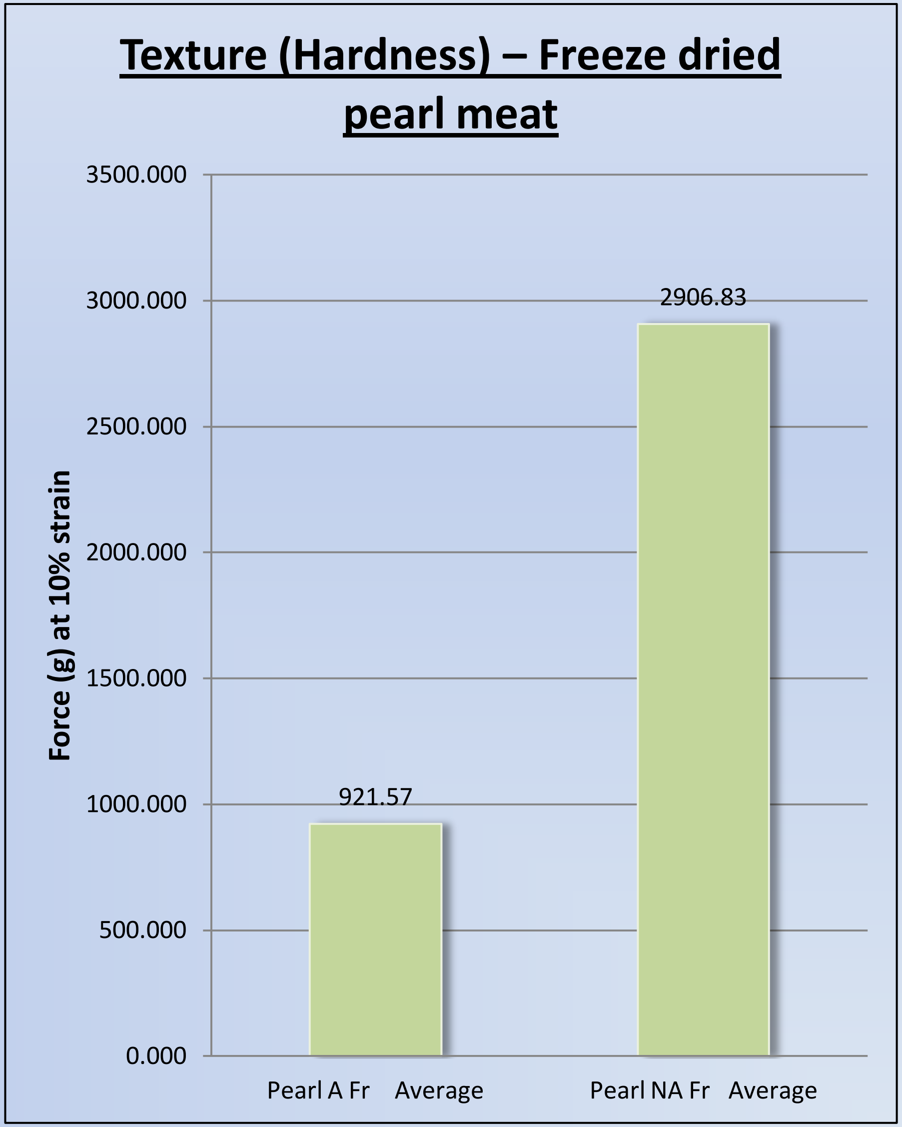


Texture (Hardness) – Traditional and vacuum dried pearl meat
Force (g) at 10% strain
6000.000
5000.000
4000.000
3000.000
2000.000
1000.000
0.000
5314.03
1901.45
3944.49
Trad Pearl L Average
Pearl A Vac Average
Pearl NAVac Average

Texture

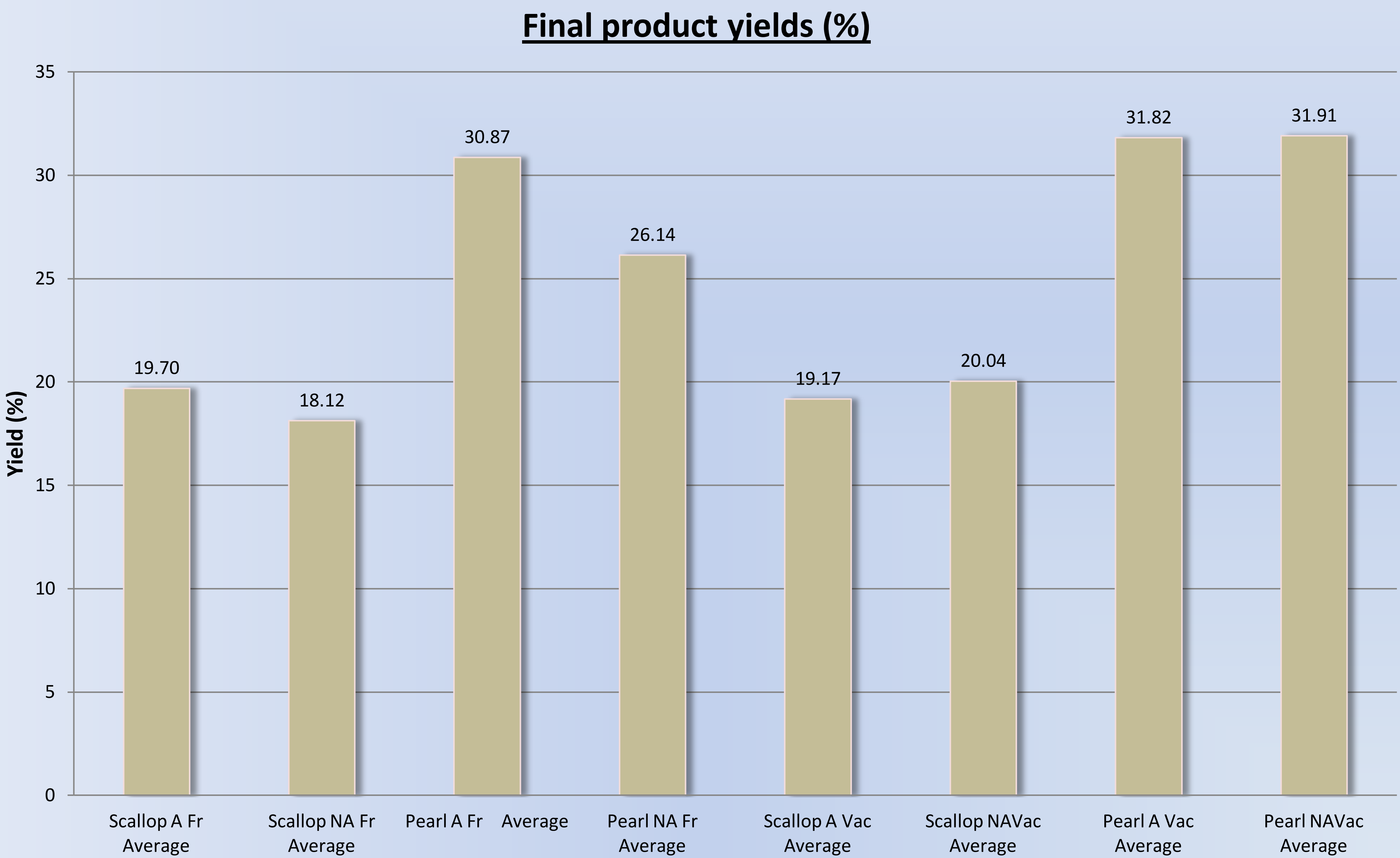


Texture (Hardness) – Freeze dried scallop
Force (g) at 10% strain
1600.000
1400.000
1200.000
1000.000
800.000
600.000
400.000
200.000
0.000
883.49
1430.94
Scallop A Fr Average
Scallop NA Fr Average



Texture (Hardness) – Freeze dried pearl meat
Force (g) at 10% strain
3500.000
3000.000
2500.000
2000.000
1500.000
1000.000
500.000
0.000
921.57
2906.83
Pearl A Fr Average
Pearl NA Fr Average

Final Product Yield



Focus Discussion Panels

Focus discussion panels

- Can extract large amounts of valuable information with a small sample size
  - Important contextual and personal information not usually revealed in large consumer panels
  - Comfort in smaller numbers
    - Ideal size 6-8 people for non-commercial topics
    - Equal opportunity for discussion

Focus Groups – Selection Criteria

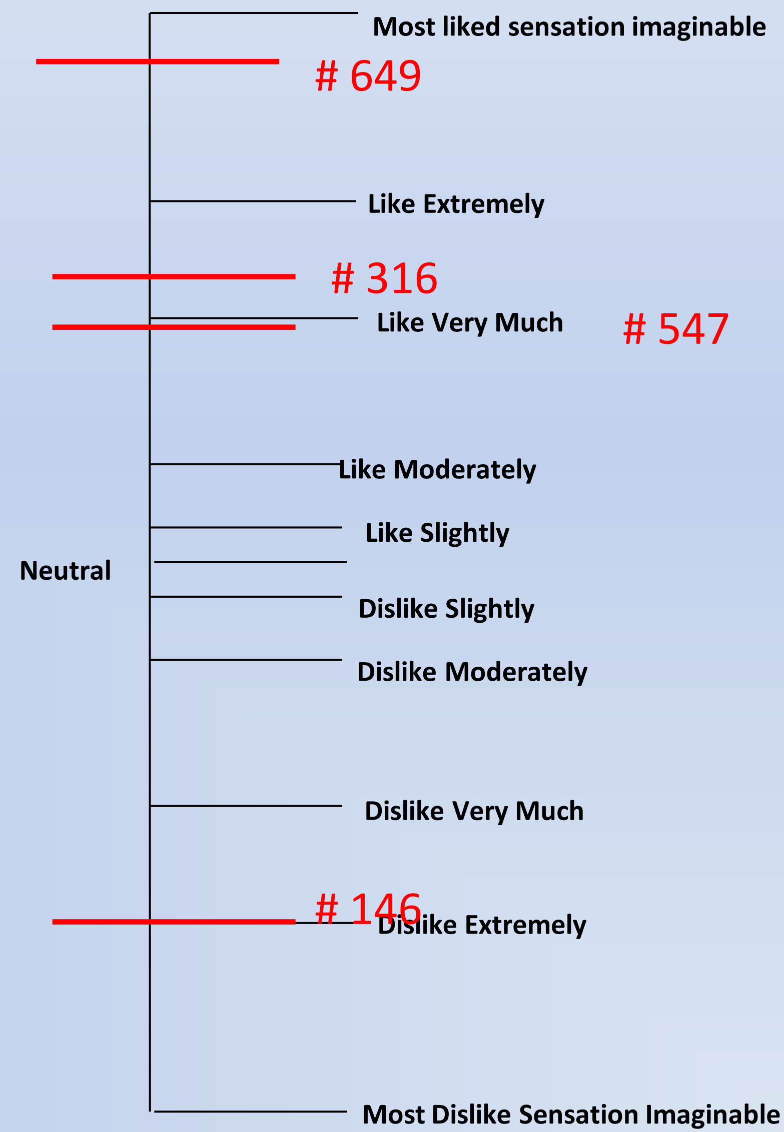
- Untrained participants who were raised in Asian countries (Chinese, Japanese, or South-East Asian)
- Best representation of target consumers
- Likely to have experience eating and/or preparing similar foods in traditional cuisine

Structure of Focus Session

- Two 6-person focus groups held over two separate sessions
  - Different participants in each group
- Taste test analysis
  - 11 products over 2 tasting phases and 4 product groups
    - Phase 1:
      - Group 1: 4 Scallop samples (2 Asian, 2 vacuum dried)
      - Group 2: 3 Pearl meat samples (1 Asian, 2 vacuum dried)
    - Phase 2:
      - Group 3: 2 freeze dried scallop samples
      - Group 4: 2 freeze dried pearl meat samples

Structure of Focus Session

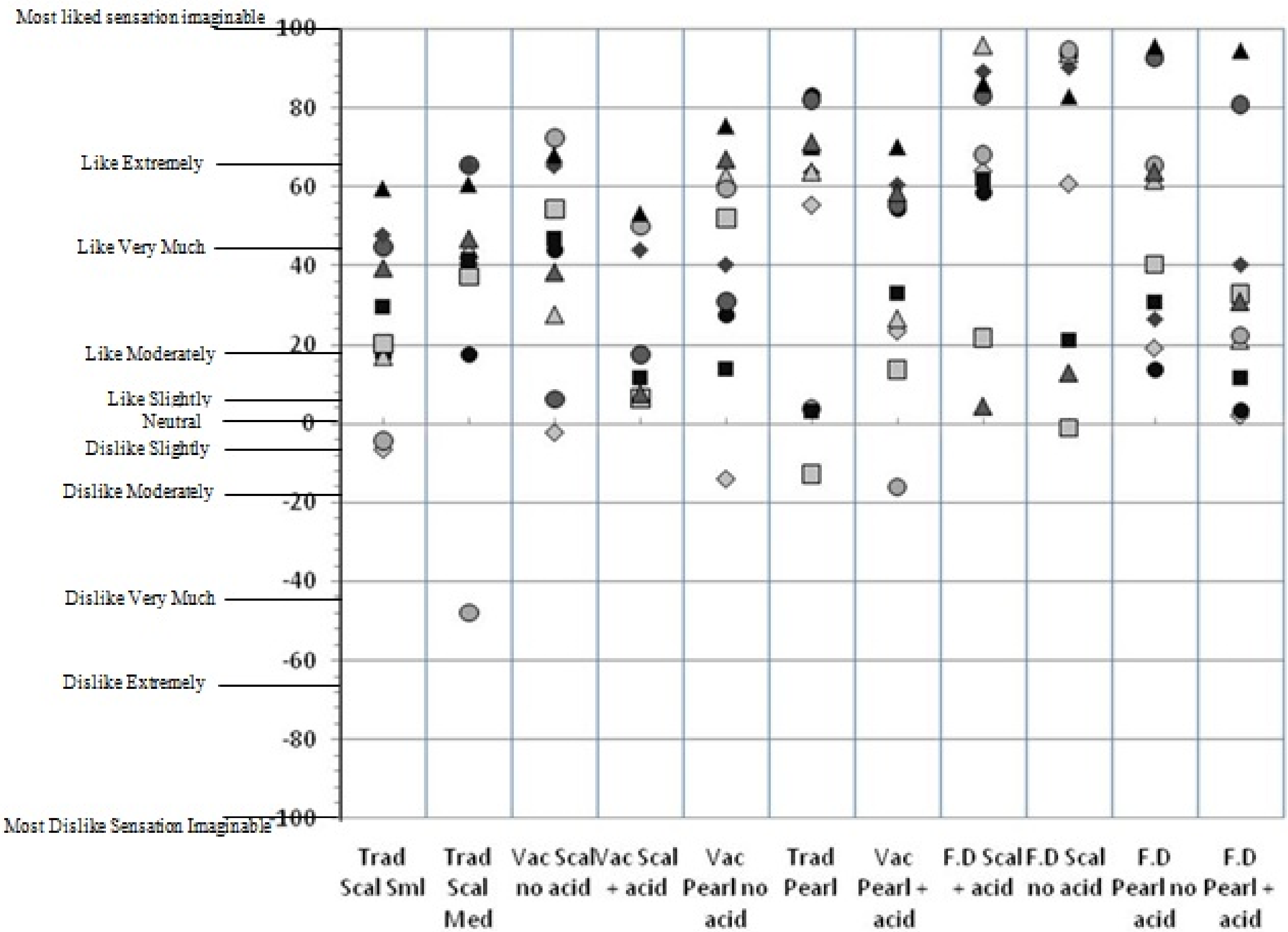
Welcome and opening discussion	
Phase 1 samples	**Code #**
Vac dried scallop - no acid (14g)	649
Vac dried scallop + acid (14g)	547
Traditional scallop 1 – Medium (14g)	263
Traditional scallop 2 – Small (14g)	146
Group 1 Discussion	
Vac dried pearl oyster - no acid (15g)	964
Vac dried pearl oyster + acid (15g)	316
Asian pearl oyster (15g)	498
Group 2 Discussion	
Phase 2 samples	**Code #**
Freeze dried scallop - no acid (1x whole)	528
Freeze dried scallop + acid (1x whole)	297
Group 3 Discussion	
Freeze dried Pearl meat - no acid (1x 1/2 whole)	817
Freeze dried Pearl meat + acid (1x ½ whole)	761
Group 4 discussion and close	



Dried Seafood Opening Discussion

- Perceived as high end products (special, not for daily consumption)
  - Regional differences in consumption habits
- Seen as promoting health and wellbeing
- Enjoyment of traditional shopping experience
- Packaging and branding very important in influencing buying decision
  - "But word-of-mouth is most important!"

Analysis of Sensory Results



Overall product acceptability results

Group 1			
Sample	**Mean**	**Std. Dev**	**Significant differences in group?**
Aznscallopsml#146	26.4886	21.86735	• Vacuum dried scallop samples significantly different. • Scallop without acid enjoyed significantly over acid immersion scallop sample. • Friedman's test → Wilcoxon signed ranks • P-value: 0.012
Aznscallopmed#263	37.1266	33.22453	
Scallopvacnoacid#649	42.1158	25.3201	
Scallopwithacid#547	20.957	19.85973	

Group 2			
Sample	**Mean**	**Std. Dev**	**Significant differences in group?**
Pearlnoacid#964	41.5946	27.55609	No significant difference between samples using Friedman's test P-value > 0.05
Pearlwithacid#316	37.9777	26.6637	
Aznpearl#498	48.3497	35.93592	

Group 3			
Sample	**Mean**	**Std. Dev**	**Significant differences in group?**
F.Dscallopwithacid297	63.2429	29.62391	No significant difference between samples using Wilcoxon signed ranks test P-value >0.05
F.Dscallopnoacid528	64.2535	38.47761	

Group 4			
Sample	**Mean**	**Std. Dev**	**Significant differences in group?**
F.Dpearlnoacid817	51.0092	29.2974	• Freeze dried pearl meat without acid significantly preferred. • P-value: 0.22
F.Dpearlwithacid761	34.0416	31.07154	

Discussion: Traditional and vacuum dried samples

Vac dried Scallop

- Differences between samples noticeable, especially in texture
    - 4th sample (vacuum dried no acid) described as "most natural texture" by two participants
- Group was split between preferring chewy elastic texture or soft delicate texture
- Saltiness was greatest difference noticed between samples
    - Broth concentration and volume standardised, so taste is from the meat
- "broth from final sample (vacuum dried with acid) was most balanced"
- "Meat from no acid sample was best": 1 person (regarding texture)
    - 2 people preferred the 'Asian small' sample

Discussion: Traditional and vacuum dried samples

Dried Pearl Meat

- 4 panellists recalled previously eating dried pearl meat (1 Hong Kong, 3 China)
  - However, lack of knowledge in value of the meat
- "broth tasted same for all three"
  - Refer to results (No significant difference)!
  - Some panellists did not notice a difference in flavour between the scallop and pearl meat samples
    - Some noticed a great difference
    - Many comments on the different appearance
- Group split between like and dislike – major discussion on whether younger participants preferred the pearl meat taste and texture to scallop.
- Most compared the flavour to scallop, with a unique texture for the meat
  - Some did not like the meat stuck between their teeth
    - Texture described as very meaty and chewy "like a piece of wood"
- "Possible market in China, maybe a good alternative to scallop if it is cheaper!"

Discussion: Freeze Dried samples

Freeze dried Scallop

- 95% of freeze dried scallop samples served were liked by participants
  - 100% of participants thought they were eating fresh samples cooked on the spot

  "Ah, here are the fresh ones!"
  - Only one participant disliked one of the F.D scallop samples
  - Majority of panellists agreed the soup stock was not a desirable carrier for the F.D. Samples "too basic"

Freeze dried pearl meat

  - Same feedback as scallop regarding the soup and preparation method
  - 90% preferred no acid sample however both liked by all participants

All samples acceptable

Some preferred scallop

  Less attractive visually than scallop

Texture more meaty than scallop

Final discussion

- 100% of participants agreed that marketable products could be created from the lab-produced samples
  - Willing to purchase at the right price (after tasting)
- Freeze dried samples scored very highly with some participants
  - 7 of the participants found the visual aspect of freeze dried samples more appealing that the vacuum dried “the delicacy of the texture gives the impression of quality and freshness”. This was a major theme in the F.D. Product discussion
  - 5 of the participants could not tell differences between acid immersion and non acid immersed product
- Panellists were generally okay with the freeze-dried concept however some could not understand the concept
  - No physical samples to show

“You will be rich very soon!”

Results and Project Limitations

- Small sample sizes
- Different species (vacuum dried scallop)
- Small number of focus group participants
  - Difficult to represent whole of Asia
- Limited visual assessment of products for focus groups
- Further investigation needed to extrapolate processing costs for industry scale

Conclusion

- Comparable proximate and analytical results
- Acceptable products created using both technologies
- Acid immersion may not be a desirable addition to pre-treatments of scallop and pearl meat for both vacuum and freeze dried scallop/pearl meat
  - No improvement on sensory
  - Questionable drying improvements

Appendix 5: Dried Products Compositional Analyses

APPENDIX 5 : DRIED SAMPLES COMPOSITIONAL RESULTS

Chem Centre
EXPERT SOLUTIONS

Report of Examination

None
11K0084; 3.1.1
Peter Taylor

Centre of Excellence of Science, Seafood
7 Parker Place
Technology Park
WA 6102

Attention : Janet Howieson

Report On:
3 samples received on 11/10/2011

CCWA ID	Material	Client Description
11K0084 / 001	seafood	Dried Sardine trial 1
11K0084 / 002	seafood	Dried Atlantic Salmon Frames
11K0084 / 003	seafood	Dried Prawns

CCWA ID **Client ID** **Sampled**		11K0084/001 Dried Sardine 26/09/2011	11K0084/001 Dried Sardine 26/09/2011	11K0084/002 Dried Atlantic 21/09/2011	11K0084/002 Dried Atlantic 21/09/2011
Analyte	**Unit**				
Ash	%ar	14.8		11.5	
Fat Folc	%ar	6.5		49.5	
Moisture	%ar	7.1		1.0	
Protein	%ar		71.4		36.5

CCWA ID **Client ID** **Sampled**		11K0084/003 Dried Prawns 23/09/2011	11K0084/003 Dried Prawns 23/09/2011
Analyte	**Unit**		
Ash	%ar	14.3	
Fat Folc	%ar	4.1	
Moisture	%ar	13.2	
Protein	%ar		64.6

Analyte	Method	Description
Ash	FS 91	Ash by gravimetric determination after combustion at 600C
Fat Folc	SP505	Fat determination using Folch procedure (chloroform/methanol)

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abn 40 991 885 705

Fatty Acid Results for Samples 11K0084001-3

Client ID		Dried Sardine	Dried Atlantic Salmon Frames	Dried Prawns
Lab ID		11K0084/001	11K0084/002	11K0084/003
Name	Notation	Conc %ar	Conc %ar	Conc %ar
Capric	c10	0.9		
Myristic	C14.0	3.3	3.2	1.1
Pentanoic	C15.0	1.0	0.3	1.0
unknown		0.4		1.6
Pentadecanoic acid	c15.1 C10			0.3
unknown				0.2
Palmitic	C16.0	26.7	16.5	13.3
Palmitelaidic	C16.1 t-9	0.9		
unknown			0.4	1.0
Palmitoleic	C16.1 c-9	2.1	6.6	3.8
unknown				0.9
unknown				0.4
	c16.2 n4	1.6	0.2	0.3
Margaric	C17.0	1.6	0.2	2.2
	c16.3 n4	0.6	0.5	2.1
unknown		0.4	0.2	1.1
unknown				0.6
unknown			0.4	
Stearic	C18.0	7.6	4.2	9.7
Elaidic	C18.1 t-9			0.3
Oleic	C18.1 c-9	6.9	29.5	10.5
Vaccenic	C18.1 c-11	2.7	3.7	3.4
unknown	C18.2 c-9,t-12		0.2	
Linoleic	C18.2 c-9,12	1.4	9.1	2.2
Nonadecanoic/Linolenelaidic	c19/ C18.3 t9,12,15	0.3	0.3	
unknown		0.2	0.3	0.2
Linolenic	C18.3c9c12t15		0.2	
gamma-Linolenic	C18.3 c-6,9,12 or C18:3 c9,c12,c15	0.5	1.2	0.3
Arachidic	C20.0	0.3		0.2
Stearidonic	C18.4 c-6,9,12,15	0.5	0.8	0.7
Gondoic	C20.1 c-11	0.5	2.2	1.0
Heneicosanoic	C21.0	0.3	0.6	1.3
Arachidonic	C20.4 c5,8,11,14	1.7	0.8	8.6
unknown			0.3	0.2
Eicosatrienoic	C20.3 c-11,14,17	0.3		0.3
Behenic	C22.0	0.4	0.4	0.3
Erucic	C22.1 c-13		0.2	
Eicosapentanoic	C20.5 c-5,8,11,14,17	6.0	6.2	10.8
unknown	18:3 t-9,11,13			0.4
unknown			0.4	0.2
Lignoceric	C24.0	0.6		1.2
unknown		1.2		1.3
Nervonic	C24.1 c-15	1.4	0.2	0.3
unknown				0.6
Docasapentenoic	C22.5 c-7,10,13,16,19	0.9	2.5	1.8
Docosahexenoic	C22.6 c-4,7,10,13,16,19	25.8	6.8	11.7
unknown				0.2
Heptacosanoic	C27		0.2	

ChemCentre

Residues Laboratory

Report of Examination

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www.chemcentre.wa.gov.au
ABN 40 991 885 705

Purchase Order: None
Your Reference:
ChemCentre Reference: 12K0008

Centre of Excellence of Science, Seafood Health
7 Parker Place
Technology Park
WA 6102

Attention: Janet Howieson

Final Report on 3 samples of fish received on 05/07/2012

LAB ID	Client ID and Description
12K0008 / 001	Barramundi Frames
12K0008 / 002	Sardine Frames
12K0008 / 003	Atlantic Salmon Frames

Analyte		As	Ash	Cd_total	Fat Folc	FFA	H2O
Method		Heavy Metals	Ash	Heavy Metals	Vet10	FFA	Vet09
Unit		mg/kg	%ar	mg/kg	%ar	% oleic eq	%ar
Lab ID	Client ID						
12K0008/001	Barramundi Frames	0.6	14.5	<0.001	38.2	0.4	1.34
12K0008/002	Sardine Frames	10	15.8	0.4	11.3	2	21.6
12K0008/003	Atlantic Salmon Frames	0.6		<0.001			

Analyte		Hg_total	Pb_total	Protein
Method		Heavy Metals	Heavy Metals	(combc)
Unit		mg/kg	mg/kg	%ar
Lab ID	Client ID			
12K0008/001	Barramundi Frames	<0.01	0.1	36.7
12K0008/002	Sardine Frames	0.1	0.4	53.1
12K0008/003	Atlantic Salmon Frames	0.04	0.012	

Analyte	Method	Description
Protein	(combc)	Crude Protein (N x 6.25) calculated from N by combustion (Leco) method P3.1
Ash	Ash	Graviometric determination of ash by combustion at 600*C
FFA	FFA	Free fatty Acid Value
Cd_total	Heavy Metals	Cadmium (Total)
As	Heavy Metals	Arsenic (Total)
Hg_total	Heavy Metals	Mercury (Total)
Pb_total	Heavy Metals	Lead (Total)
H2O	Vet09	Graviometric moisture after drying at 105*C
Fat Folc	Vet10	Graviometric Total Lipids by Folch extraction

These results apply only to the sample(s) as received.

Fatty acid profile results are attached.

Fatty Acid Results for Samples 11K0084001-3

Client ID		Dried Sardine	Dried Atlantic Salmon Frames	Dried Prawns
Lab ID		11K0084/001	11K0084/002	11K0084/003
Name	Notation	Conc %ar	Conc %ar	Conc %ar
Capric	c10	0.9		
Myristic	C14.0	3.3	3.2	1.1
Pentanoic	C15.0	1.0	0.3	1.0
unknown		0.4		1.6
Pentadecanoic acid	c15.1 C10			0.3
unknown				0.2
Palmitic	C16.0	26.7	16.5	13.3
Palmitelaidic	C16.1 t-9	0.9		
unknown			0.4	1.0
Palmitoleic	C16.1 c-9	2.1	6.6	3.8
unknown				0.9
unknown				0.4
	c16.2 n4	1.6	0.2	0.3
Margaric	C17.0	1.6	0.2	2.2
	c16.3 n4	0.6	0.5	2.1
unknown		0.4	0.2	1.1
unknown				0.6
unknown			0.4	
Stearic	C18.0	7.6	4.2	9.7
Elaidic	C18.1 t-9			0.3
Oleic	C18.1 c-9	6.9	29.5	10.5
Vaccenic	C18.1 c-11	2.7	3.7	3.4
unknown	C18.2 c-9,t-12		0.2	
Linoleic	C18.2 c-9,12	1.4	9.1	2.2
Nonadecanoic/Linolenelaidic	c19/ C18.3 t9,12,15	0.3	0.3	
unknown		0.2	0.3	0.2
Linolenic	C18.3c9c12t15		0.2	
gamma-Linolenic	C18.3 c-6,9,12 or C18:3 c9,c12,c15	0.5	1.2	0.3
Arachidic	C20.0	0.3		0.2
Stearidonic	C18.4 c-6,9,12,15	0.5	0.8	0.7
Gondoic	C20.1 c-11	0.5	2.2	1.0
Heneicosanoic	C21.0	0.3	0.6	1.3
Arachidonic	C20.4 c5,8,11,14	1.7	0.8	8.6
unknown			0.3	0.2
Eicosatrienoic	C20.3 c-11,14,17	0.3		0.3
Behenic	C22.0	0.4	0.4	0.3
Erucic	C22.1 c-13		0.2	
Eicosapentanoic	C20.5 c-5,8,11,14,17	6.0	6.2	10.8
unknown	18:3 t-9,11,13			0.4
unknown			0.4	0.2
Lignoceric	C24.0	0.6		1.2
unknown		1.2		1.3
Nervonic	C24.1 c-15	1.4	0.2	0.3
unknown				0.6
Docasapentenoic	C22.5 c-7,10,13,16,19	0.9	2.5	1.8
Docosahexenoic	C22.6 c-4,7,10,13,16,19	25.8	6.8	11.7
unknown				0.2
Heptacosanoic	C27		0.2	

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REPORT OF ANALYSIS

Report No. RN955625

Client	: CURTIN UNIVERSITY CENTRE OF EXCELLENCE FOR SCIENCE SEAFOOD & HEALTH (CESSH) 7 PARKER PLACE TECHNOLOGY PARK WA 6102	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: CURT06/130122 : QT-01792 : : : 22-JAN-2013
Attention	: Dr Janet Howieson	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V13/002211	1	Dried Atlantic Salmon Heads

Lab Reg No.		V13/002211				
Sample Reference	**Units**	1				**Method**
Trace Elements						
Cadmium	mg/kg	1.2				VL247
Lead	mg/kg	0.014				VL247

Paul Adorno, Section Manager
Inorganics - Vic

6-FEB-2013

Lab Reg No.		V13/002211				
Sample Reference	**Units**	1				**Method**
Proximates						
Moisture	g/100g	8.9				VL298
Fat (Soxhlet)	g/100g	40.5				VL300
Protein (N x 6.25)	g/100g	44.8				VL299
Ash	g/100g	4.7				VL286

V13/002211
- V13/002215

The total fat was determined by the Soxlet method using Diethyl ether as solvent.
The Folch method uses a different solvent for the fat extraction.
For fish samples the two methods should give similar results.

REPORT OF ANALYSIS

Report No. RN955625

Lab Reg No.		V13/002211				
Sample Reference	Units	1				Method

Neil Menz

Neil Menz, Analyst
Food Composition - Vic

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REPORT OF ANALYSIS

Report No. RN955626

Client	: CURTIN UNIVERSITY CENTRE OF EXCELLENCE FOR SCIENCE SEAFOOD & HEALTH (CESSH) 7 PARKER PLACE TECHNOLOGY PARK WA 6102	Job No. Quote No. Order No. Date Sampled Date Received	: CURT06/130122 : QT-01792 : : : 22-JAN-2013
Attention	: Dr Janet Howieson	Sampled By	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	Phone	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V13/002212	2	Dried Atlantic Salmon Skins

Lab Reg No.		V13/002212				
Sample Reference	Units	2				Method
Trace Elements						
Cadmium	mg/kg	<0.01				VL247
Lead	mg/kg	<0.01				VL247

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Lab Reg No.		V13/002212				
Sample Reference	Units	2				Method
Proximates						
Moisture	g/100g	10.1				VL298
Fat (Soxhlet)	g/100g	39.3				VL300
Protein (N x 6.25)	g/100g	54.9				VL299
Ash	g/100g	4.3				VL286

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Report No. RN955627

Client	: CURTIN UNIVERSITY CENTRE OF EXCELLENCE FOR SCIENCE SEAFOOD & HEALTH (CESSH) 7 PARKER PLACE TECHNOLOGY PARK WA 6102	**Job No.** **Quote No.** **Order No.** **Date Sampled** **Date Received**	: CURT06/130122 : QT-01792 : : : 22-JAN-2013
Attention	: Dr Janet Howieson	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V13/002213	3	Dried Escolar

Lab Reg No.		V13/002213				
Sample Reference	**Units**	3				**Method**
Trace Elements						
Cadmium	mg/kg	1.2				VL247
Lead	mg/kg	0.012				VL247

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Lab Reg No.		V13/002213				
Sample Reference	**Units**	3				**Method**
Proximates						
Moisture	g/100g	7.7				VL298
Fat (Soxhlet)	g/100g	43.9				VL300
Saturated Fat	g/100g	1.5				VL289
Protein (N x 6.25)	g/100g	41.1				VL299
Ash	g/100g	4.0				VL286
Mono trans fats	g/100g	<0.1				VL289
Mono-unsaturated fat	g/100g	36.0				VL289
Omega 3 fats	g/100g	2.2				VL289
Omega 6 fats	g/100g	1.9				VL289
Poly trans fats	g/100g	0.2				VL289
Poly-unsaturated fat	g/100g	4.2				VL289
Trans fats	g/100g	0.3				VL289
Saturated Fatty Acids						
C4:0 Butyric	%	<0.1				VL289
C6:0 Caproic	%	<0.1				VL289
C8:0 Caprylic	%	<0.1				VL289

REPORT OF ANALYSIS

Report No. RN955627

Lab Reg No.		V13/002213				
Sample Reference	Units	3				Method
Saturated Fatty Acids						
C10:0 Capric	%	<0.1				VL289
C12:0 Lauric	%	<0.1				VL289
C14:0 Myristic	%	0.3				VL289
C15:0 Pentadecanoic	%	<0.1				VL289
C16:0 Palmitic	%	2.1				VL289
C17:0 Margaric	%	<0.1				VL289
C18:0 Stearic	%	1.0				VL289
C20:0 Arachidic	%	<0.1				VL289
C22:0 Behenic	%	<0.1				VL289
C24:0 Lignoceric	%	<0.1				VL289
Total Saturated	%	3.6				VL289
Mono-unsaturated Fatty Acids						
C14:1 Myristoleic	%	<0.1				VL289
C16:1 Palmitoleic	%	2.8				VL289
C17:1 Heptadecenoic	%	0.1				VL289
C18:1 Oleic	%	68.8				VL289
C20:1 Eicosenic	%	12.8				VL289
C22:1 Docosenoic	%	0.6				VL289
C24:1 Nervonic	%	0.5				VL289
Total Mono-unsaturated	%	85.8				VL289
Poly-unsaturated Fatty Acids						
C18:2w6 Linoleic	%	2.2				VL289
C18:3w6 gamma-Linolenic	%	<0.1				VL289
C18:3w3 alpha-Linolenic	%	0.4				VL289
C20:2w6 Eicosadienoic	%	0.3				VL289
C20:3w6 Eicosatrienoic	%	0.2				VL289
C20:3w3 Eicosatrienoic	%	0.1				VL289
C20:4w6 Arachidonic	%	1.5				VL289
C20:5w3 Eicosapentaenoic	%	1.1				VL289
C22:2w6 Docosadienoic	%	<0.1				VL289
Omega 3 Fatty Acids	%	5.3				VL289
Omega 6 Fatty Acids	%	4.5				VL289
C22:4w6 Docosatetraenoic	%	0.3				VL289
C22:5w3 Docosapentaenoic	%	0.7				VL289
C22:6w3 Docosahexaenoic	%	3.1				VL289
Total Poly-unsaturated	%	9.9				VL289
Total Mono Trans Fatty Acids	%	0.2				VL289
Total Poly Trans Fatty Acids	%	0.5				VL289
P:M:S Ratio		2.7:23.7:1				VL289

REPORT OF ANALYSIS

Report No. RN955627

Lab Reg No.	Units	V13/002213				Method
Sample Reference		3				

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REPORT OF ANALYSIS

Report No. RN955628

Client	: CURTIN UNIVERSITY CENTRE OF EXCELLENCE FOR SCIENCE SEAFOOD & HEALTH (CESSH) 7 PARKER PLACE TECHNOLOGY PARK WA 6102
Attention	: Dr Janet Howieson
Project Name	:
Your Client Services Manager	: Tim Stobaus
Job No.	: CURT06/130122
Quote No.	: QT-01792
Order No.	:
Date Sampled	:
Date Received	: 22-JAN-2013
Sampled By	: CLIENT
Phone	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V13/002214	4	Dried Aust Salmon

Lab Reg No.		V13/002214				
Sample Reference	Units	4				Method
Trace Elements						
Cadmium	mg/kg	<0.01				VL247
Lead	mg/kg	<0.01				VL247

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Lab Reg No.		V13/002214				
Sample Reference	Units	4				Method
Proximates						
Moisture	g/100g	20.9				VL298
Fat (Soxhlet)	g/100g	9.6				VL300
Saturated Fat	g/100g	4.5				VL289
Protein (N x 6.25)	g/100g	64.1				VL299
Ash	g/100g	5.0				VL286
Mono trans fats	g/100g	<0.1				VL289
Mono-unsaturated fat	g/100g	2.0				VL289
Omega 3 fats	g/100g	2.0				VL289
Omega 6 fats	g/100g	0.5				VL289
Poly trans fats	g/100g	0.1				VL289
Poly-unsaturated fat	g/100g	2.6				VL289
Trans fats	g/100g	0.1				VL289
Saturated Fatty Acids						
C4:0 Butyric	%	<0.1				VL289
C6:0 Caproic	%	<0.1				VL289
C8:0 Caprylic	%	<0.1				VL289

REPORT OF ANALYSIS

Report No. RN955628

Lab Reg No.	Units	V13/002214				Method
Sample Reference		4				
Saturated Fatty Acids						
C10:0 Capric	%	<0.1				VL289
C12:0 Lauric	%	0.2				VL289
C14:0 Myristic	%	4.2				VL289
C15:0 Pentadecanoic	%	1.4				VL289
C16:0 Palmitic	%	28.2				VL289
C17:0 Margaric	%	1.9				VL289
C18:0 Stearic	%	11.5				VL289
C20:0 Arachidic	%	<0.1				VL289
C22:0 Behenic	%	0.7				VL289
C24:0 Lignoceric	%	0.4				VL289
Total Saturated	%	48.5				VL289
Mono-unsaturated Fatty Acids						
C14:1 Myristoleic	%	<0.1				VL289
C16:1 Palmitoleic	%	5.5				VL289
C17:1 Heptadecenoic	%	<0.1				VL289
C18:1 Oleic	%	15.1				VL289
C20:1 Eicosenic	%	0.7				VL289
C22:1 Docosenoic	%	0.1				VL289
C24:1 Nervonic	%	0.6				VL289
Total Mono-unsaturated	%	22.0				VL289
Poly-unsaturated Fatty Acids						
C18:2w6 Linoleic	%	1.8				VL289
C18:3w6 gamma-Linolenic	%	<0.1				VL289
C18:3w3 alpha-Linolenic	%	0.6				VL289
C20:2w6 Eicosadienoic	%	0.4				VL289
C20:3w6 Eicosatrienoic	%	0.2				VL289
C20:3w3 Eicosatrienoic	%	0.2				VL289
C20:4w6 Arachidonic	%	2.6				VL289
C20:5w3 Eicosapentaenoic	%	3.3				VL289
C22:2w6 Docosadienoic	%	<0.1				VL289
Omega 3 Fatty Acids	%	22.0				VL289
Omega 6 Fatty Acids	%	5.8				VL289
C22:4w6 Docosatetraenoic	%	0.8				VL289
C22:5w3 Docosapentaenoic	%	2.3				VL289
C22:6w3 Docosahexaenoic	%	15.7				VL289
Total Poly-unsaturated	%	27.9				VL289
Total Mono Trans Fatty Acids	%	0.3				VL289
Total Poly Trans Fatty Acids	%	1.2				VL289
P:M:S Ratio		0.6:0.5:1				VL289

REPORT OF ANALYSIS

Report No. RN955628

Lab Reg No.		V13/002214				
Sample Reference	Units	4				Method

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REPORT OF ANALYSIS

Report No. RN955629

Client	: CURTIN UNIVERSITY CENTRE OF EXCELLENCE FOR SCIENCE SEAFOOD & HEALTH (CESSH) 7 PARKER PLACE TECHNOLOGY PARK WA 6102	**Job No.**	: CURT06/130122
		Quote No.	: QT-01792
		Order No.	:
		Date Sampled	:
		Date Received	: 22-JAN-2013
Attention	: Dr Janet Howieson	**Sampled By**	: CLIENT
Project Name	:		
Your Client Services Manager	: Tim Stobaus	**Phone**	: (03) 9644 4849

Lab Reg No.	Sample Ref	Sample Description
V13/002215	5	Dried Rusy Threadfin Bream

Lab Reg No.		**V13/002215**				
Sample Reference	**Units**	**5**				**Method**
Trace Elements						
Cadmium	mg/kg	0.39				VL247
Lead	mg/kg	<0.01				VL247

Paul Adorno, Section Manager
Inorganics - Vic

6-FEB-2013

Lab Reg No.		**V13/002215**				
Sample Reference	**Units**	**5**				**Method**
Proximates						
Moisture	g/100g	35.8				VL298
Fat (Soxhlet)	g/100g	2.8				VL300
Protein (N x 6.25)	g/100g	50.4				VL299
Ash	g/100g	13.2				VL286

Neil Menz, Analyst
Food Composition - Vic

6-FEB-2013

REPORT OF ANALYSIS

1/153 Bertie Street, Port Melbourne Vic 3207 Tel: +61 3 9644 4888 Fax: +61 3 9644 4999 www.measurement.gov.au

Appendix 6: WAFIC EoI form for Dried Seafood Opportunity

Project number 2009/773 December 2011

An opportunity to dry your seafood

WAFIC is offering harvesters, processors and retailers the opportunity to participate in a unique product enhancement trial.

Curtin University has successfully trialed an ambient temperature vacuum drying process, allowing seafood to be dried at ambient temperatures and therefore not compromising the flavour profile. Studies have also shown that the colour, shape and active nutrient components are retained during the drying process. The result is a quality assured process that produces market ready dried seafood products.

In addition to having your product dried, you can opt to have the chemical composition, physical characteristics, sensory characteristics and microbiological safety of your product analysed in comparison to existing Asian products (to ensure food safety/quality standards are met).

If the trials indicate a commercially viable product can be produced, then there is the possibility to expand operations to develop hubs in regional areas and add value to traditionally undervalued fisheries.

For more information or to lodge your expression of interest please direct your queries to Neil Macguffie at WAFIC.

Specifications

Capacity	50kg of product
Cost	Drying Product only - $$$ tbc Compositional profile - $$$ tbc
Time to dry	Varies depending on the product ~ approximately 4 hours
Benefits	Open new market opportunities Increased shelf life Ease logistical & storage pressures Enhancing export potential New product development

Contact Neil Macguffie on 08 9432 7777 or via email neil@wafic.org.au to arrange an appointment

WAFIC Western Australian Fishing Industry Council Inc.

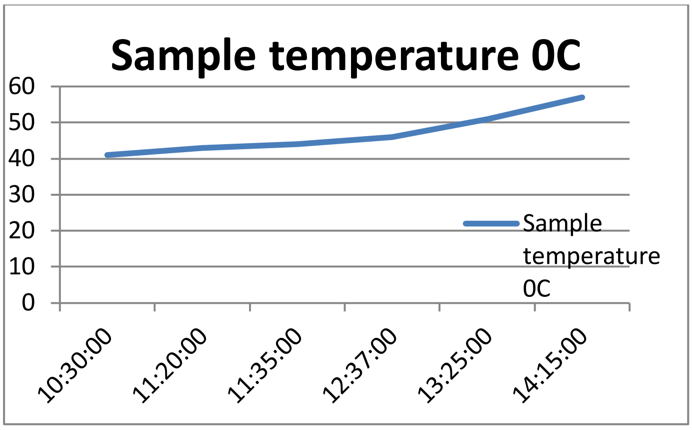
AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE

Curtin University

Appendix 7: Dried seafood detailed results

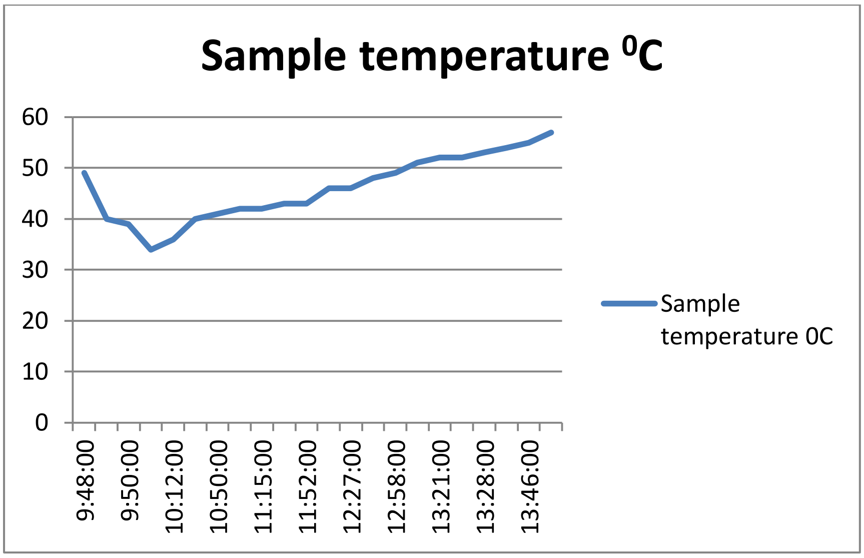
Appendix 7 Dried Seafood: Raw Data Experimental Summaries

Date	23/02/2012	
Type of sample	Salmon (Atlantic)	
Source of sample	Kalis received (21/02/2012)	
Weight of samples (Gross)	29.795	kg
Packaging	2.085	kg
Weight of raw sample (Nett)	**27.71**	**kg**
Precook time	10:00	min
Time start	9:52:00	time
Run finish	14:15:00	time
Time finish	16:16:00	time
Kilowatt hour reading (start)	911	kwh
Kilowatt hour reading (finish)	1231	kwh
Total Kilowatt hours used	**320**	**kwh**
Solids & Oil recovered	**11.6**	**kg**
Liquid recovered	**15.9**	**ltrs**
Loss	**0.210**	**kg**
Sample drying time	**4:23:00**	**hrs**
Cleaning time	2:01:00	hrs



Dried Seafood: Experimental Summaries

Date	28/02/2012	
Type of sample	Salmon (Atlantic)	
Source of sample	Kalis received (28/02/2012)	
Weight of samples (Gross)	24.775	kg
Packaging	1.615	kg
Weight of raw sample (Nett)	**23.16**	**kg**
Precook time	9.00	min
Time start	9:44:00	time
Run finish	13:57:00	time
Time finish	15:33:00	time
Kilowatt hour reading (start)	1231	kwh
Kilowatt hour reading (finish)	1520	kwh
Total Kilowatt hours used	**289**	**kwh**
Solids & Oil recovered	**9.61**	**kg**
Liquid recovered	**13.5**	**ltrs**
Loss	**0.050**	**kg**
Sample drying time	**4:13:00**	**hrs**
Cleaning time	1:36:00	hrs



Percentage Moisture	Temperature	Time
18.49%	41	62
10.84%	43	124
9.49%	46	154
6.12%	49	190
4.26%	52	216
4.46%	55	238
2.85%	57	248

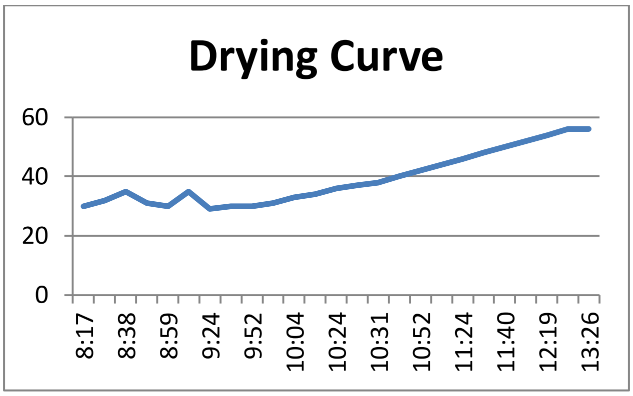
Date	28/02/2012		28/02/2012		
Type of sample	Oysters Pacific		Sydne Rocks Oysters		
Source of sample	Chantelle		Chantelle		
Weight of samples (Gross)	32	oysters	24	oysters	
Packaging					
Weight of raw sample (Nett)					
Precook time					
Time start	9:34:00	time		11:50:00	time
Run finish	11:45:00	time		13:25:00	time
Time finish	13:35:00	time		13:35:00	time
Kilowatt hour reading (start)	1520	kwh		1520	kwh
Kilowatt hour reading (finish)	1653	kwh		1653	kwh
Total Kilowatt hours used	**133**	**kwh**		**133**	**kwh**
Solids & Oil recovered					
Liquid recovered	**0.2**	**ltrs**		0.13	ltrs
Loss					
Sample drying time	**2:11:00**	**hrs**		**1:35:00**	**hrs**
Cleaning time		hrs		0:10:00	hrs

Run Log

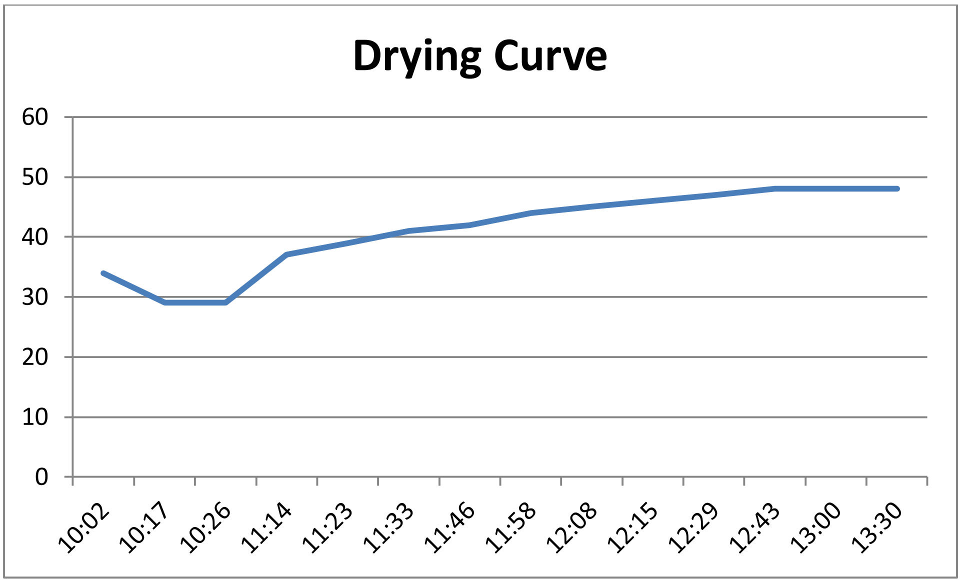
Time	temp ^{0}C	Time	temp ^{0}C
9:34:00	32	12:00	64
9:42:00	37	12:25	63
9:44:00	39	12:34	64
9:46:00	40	12:43	65
9:52:00	45	12:51	66
10:01:00	40	13:09	66
10:05:00	44	13:10	67
10:16:00	47	13:25	68
10:22:00	48		
10:28:00	50		
10:32:00	51		
10:35:00	52		
10:39:00	53		
10:44:00	54		
10:50:00	55		
10:52:00	56		
10:57:00	57		
11:15:00	60		
11:27:00	61		
11:31:00	62		
11:38:00	63		
11:45:00	64		

Dried Seafood: Experimental Summaries

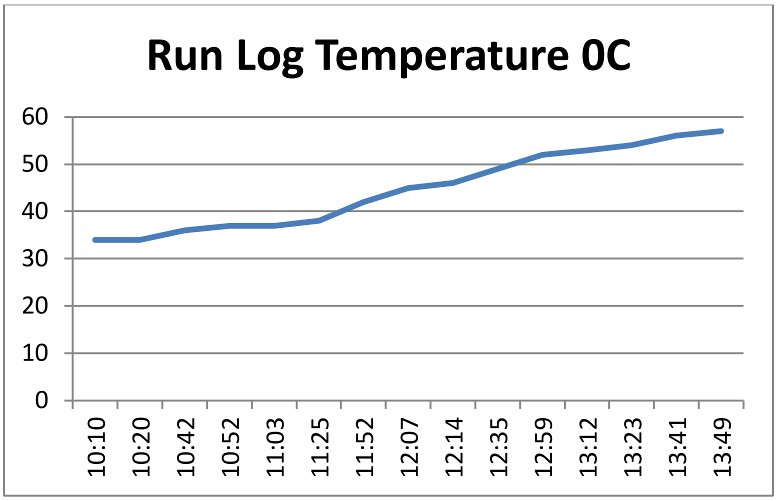
Date		9/03/2012	
Type of sample	Sardine frames frozen		
Source of sample	Catalano		
Weight of samples (Gross)		19.32	kg
Packaging		1.11	kg
Weight of raw sample (Nett)		**18.21**	**kg**
Precook time	NIL		
Machine time on		08:03:00	time
Time start		8:17:00	time
Run finish		13:26:00	time
Time finish		14:23:00	time
Kilowatt hour reading (start)		1653	kwh
Kilowatt hour reading (finish)		1962	kwh
Total Kilowatt hours used		**309**	**kwh**
Solids & Oil recovered		**6.135**	**kg**
Liquid recovered		**12.3**	**ltrs**
Loss		**0.225**	**kg**
Sample drying time		**5:09:00**	**hrs**
Cleaning time		0:57:00	hrs



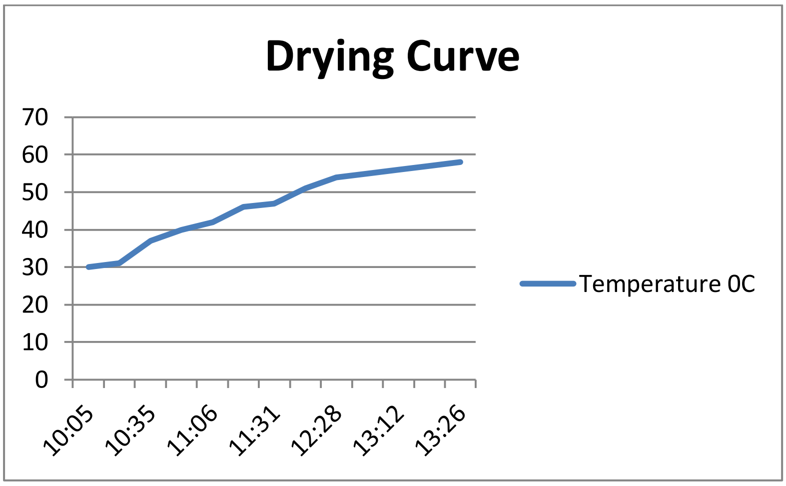
Type of sample	Rosy Threadfin Bream		
Source of sample	Janet		
Weight of samples (Gross)		26.7	kg
Packaging		16.63	kg
Weight of raw sample (Nett)		**10.07**	**kg**
Precook time	NIL		
Machine time on		09:21:00	time
Time start		9:55:00	time
Run finish		13:30:00	time
Time finish		14:28:00	time
Kilowatt hour reading (start)		2081	kwh
Kilowatt hour reading (finish)		2262	kwh
Total Kilowatt hours used		**181**	**kwh**
Solids & Oil recovered		**6.135**	**kg**
Liquid recovered		**5.8**	**ltrs**
Loss		**1.865**	**kg**
Sample drying time		**3:35:00**	**hrs**
Cleaning time		0:58:00	hrs



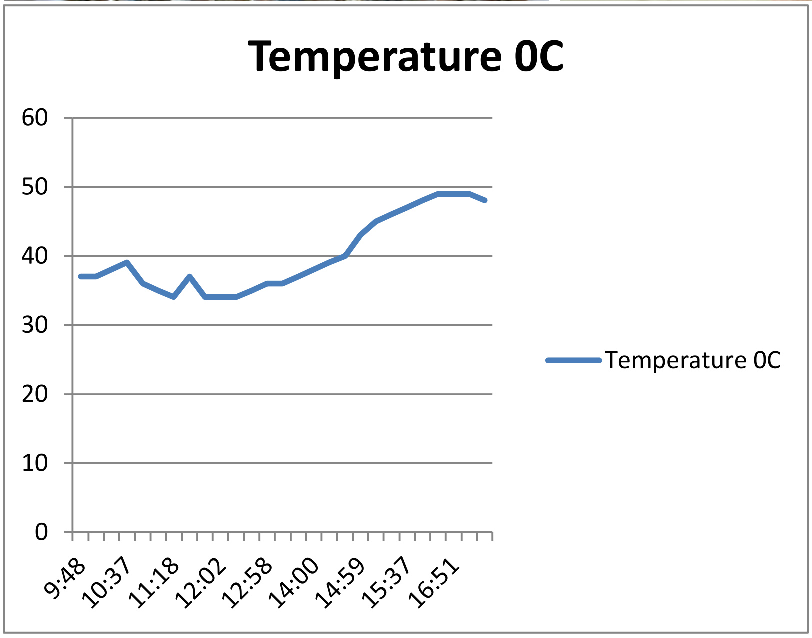
Date	20/03/2012	
Type of sample	Shark Cartilage	
Source of sample	Brad Adams	
Weight of samples (Gross)	9.61	kg
Packaging	0.465	kg
Weight of raw sample (Nett)	**9.145**	**kg**
Precook time	10.00	min
Machine time on	09:48:00	time
Time start	10:10:00	time
Run finish	14:00:00	time
Time finish	16:01:00	time
Kilowatt hour reading (start)	2262	kwh
Kilowatt hour reading (finish)	2467	kwh
Total Kilowatt hours used	**205**	**kwh**
Solids & Oil recovered	**6.135**	**kg**
Liquid recovered	**5.85**	**ltrs**
Loss	**2.840**	**kg**
Sample drying time	**3:50:00**	**hrs**
Cleaning time	2:01:00	hrs



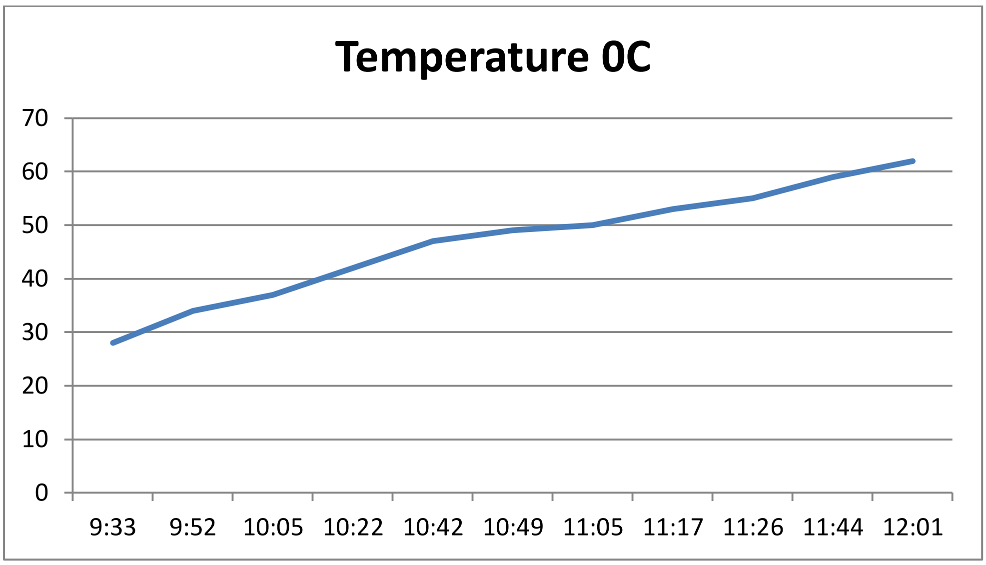
Date	4/05/2012	
Type of sample	Octopus Heads	
Source of sample	Fremantle Octopus	
Weight of samples (Gross)	5.845	kg
Packaging	0.59	kg
Weight of raw sample (Nett)	**5.255**	**kg**
Precook time	NIL	min
Machine time on	09:48:00	time
Time start	9:59:00	time
Run finish	13:26:00	time
Time finish	15:12:00	time
Kilowatt hour reading (start)	2467	kwh
Kilowatt hour reading (finish)	2632	kwh
Total Kilowatt hours used	**165**	**kwh**
Solids & Oil recovered	**1.34**	**kg**
Liquid recovered	**3.65**	**ltrs**
Loss	**-0.265**	**kg**
Sample drying time	**3:27:00**	**hrs**
Cleaning time	1:46:00	hrs



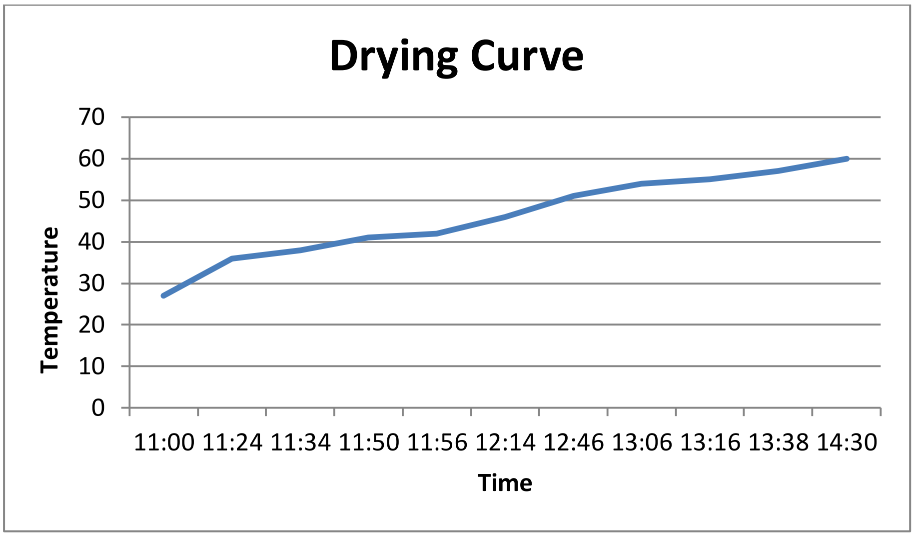
Date	11/05/2012	
Type of sample	Sardine Frames	
Source of sample	Tim Rowe	
Weight of samples (Gross)	42.6	kg
Packaging	1.78	kg
Weight of raw sample (Nett)	**40.82**	**kg**
Precook time	NIL	min
Machine time on	09:13:00	time
Time start	9:31:00	time
Run finish	17:33:00	time
Time finish	18:59:00	time
Kilowatt hour reading (start)	2632	kwh
Kilowatt hour reading (finish)	3169	kwh
Total Kilowatt hours used	**537**	**kwh**
Solids & Oil recovered	**11.64**	**kg**
Liquid recovered	**29.40**	**ltrs**
Loss	**0.220**	**kg**
Sample drying time	**8:02:00**	**hrs**
Cleaning time	1:26:00	hrs



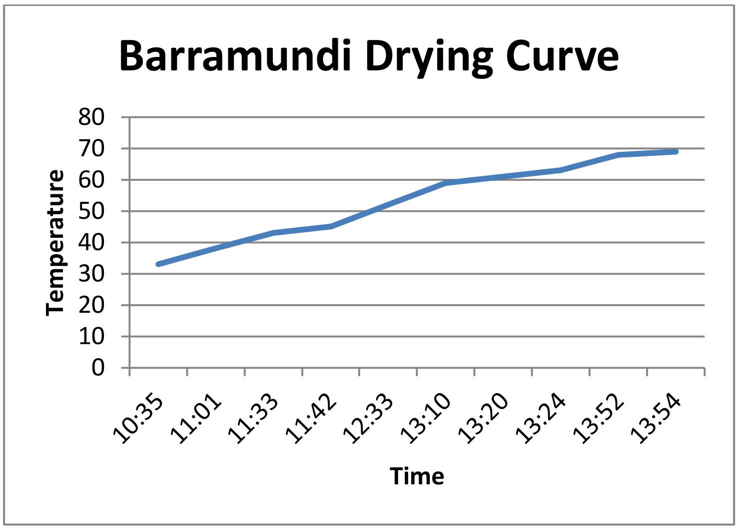
Date	15/05/2012	
Type of sample	Barramundi Frames	
Source of sample	Janet	
Weight of samples (Gross)	11.645	kg
Packaging	7.705	kg
Weight of raw sample (Nett)	**3.94**	**kg**
Precook time	NIL	min
Machine time on	09:12:00	time
Time start	9:23:00	time
Run finish	12:02:00	time
Time finish	13:00:00	time
Kilowatt hour reading (start)	3169	kwh
Kilowatt hour reading (finish)	3295	kwh
Total Kilowatt hours used	**126**	**kwh**
Solids & Oil recovered	**1.55**	**kg**
Liquid recovered	**2.30**	**ltrs**
Loss	**-0.090**	**kg**
Sample drying time	**2:39:00**	**hrs**
Cleaning time	0:58:00	hrs



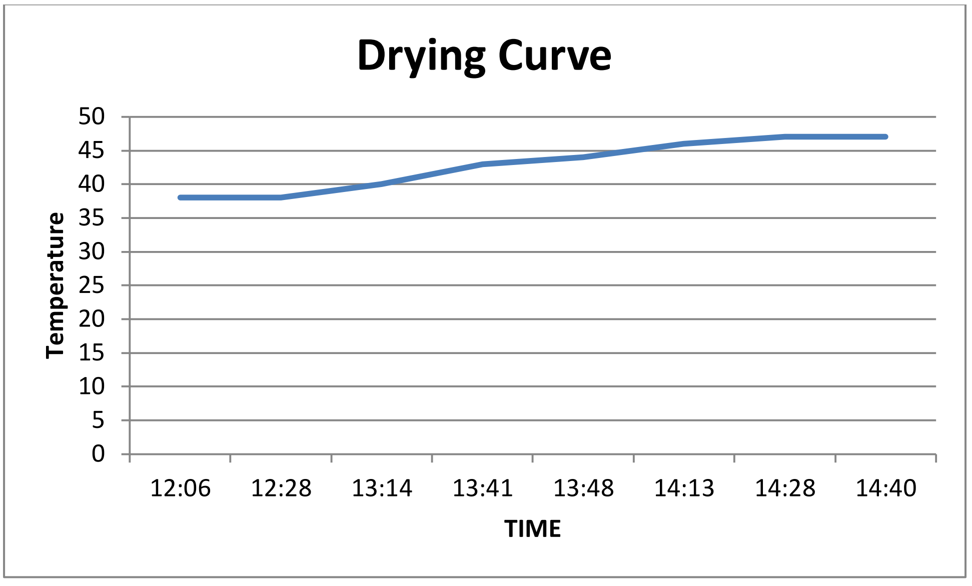
Date	29/05/2012	
Type of sample	Mixed Fish	Salmon and Gold Band Snapper
Source of sample	Catallano	
Weight of samples (Gross)	7.71	kg
Packaging	0.945	kg
Weight of raw sample (Nett)	**6.765**	**kg**
Precook time	NIL	min
Machine time on	10:29:00	time
Time start	10:44:00	time
Run finish	14:30:00	time
Time finish	15:56:00	time
Kilowatt hour reading (start)	3295	kwh
Kilowatt hour reading (finish)	3466	kwh
Total Kilowatt hours used	**171**	**kwh**
Solids & Oil recovered	**2.33**	**kg**
Liquid recovered	**4.50**	**ltrs**
Loss	**0.065**	**kg**
Sample drying time	**3:46:00**	**hrs**
Cleaning time	1:26:00	hrs



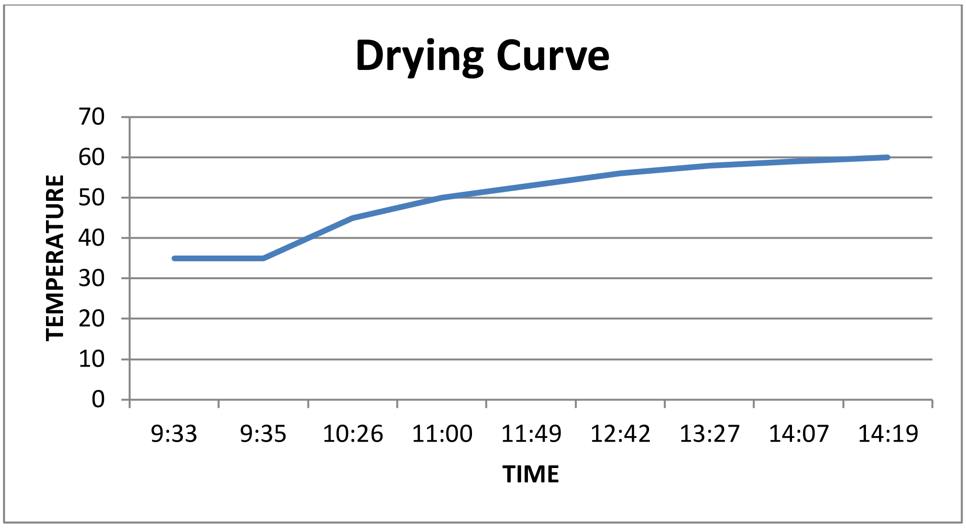
Date	22/06/2012	
Type of sample	Barramundi Frames	
Source of sample	Janet Howieson	
Weight of samples (Gross)	28.3	kg
Packaging	14.28	kg
Weight of raw sample (Nett)	**14.02**	**kg**
Precook time	NIL	min
Machine time on	09:36:00	time
Time start	10:14:00	time
Run finish	13:54:00	time
Time finish	14:44:00	time
Kilowatt hour reading (start)	3466	kwh
Kilowatt hour reading (finish)	3696	kwh
Total Kilowatt hours used	**230**	**kwh**
Solids & Oil recovered	**6.27**	**kg**
Liquid recovered	**7.75**	**ltrs**
Loss	**0.000**	**kg**
Sample drying time	**3:40:00**	**hrs**
Cleaning time	0:50:00	hrs



Date	29/06/2012	
Type of sample	Australian Salmon	
Source of sample	Peta	
Weight of samples (Gross)	16.32	kg
Packaging	7.14	kg
Weight of raw sample (Nett)	**9.18**	**kg**
Precook time	46.00	min
Machine time on	10:27:00	time
Time start	11:27:00	time
Run finish	14:40:00	time
Time finish	15:33:00	time
Kilowatt hour reading (start)	3696	kwh
Kilowatt hour reading (finish)	3899	kwh
Total Kilowatt hours used	**203**	**kwh**
Solids & Oil recovered	**3.63**	**kg**
Liquid recovered	**6.00**	**ltrs**
Loss	**0.450**	**kg**
Sample drying time	**3:13:00**	**hrs**
Cleaning time	0:53:00	hrs

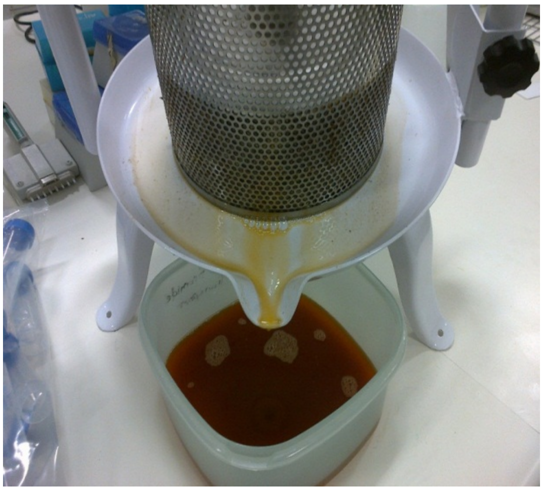


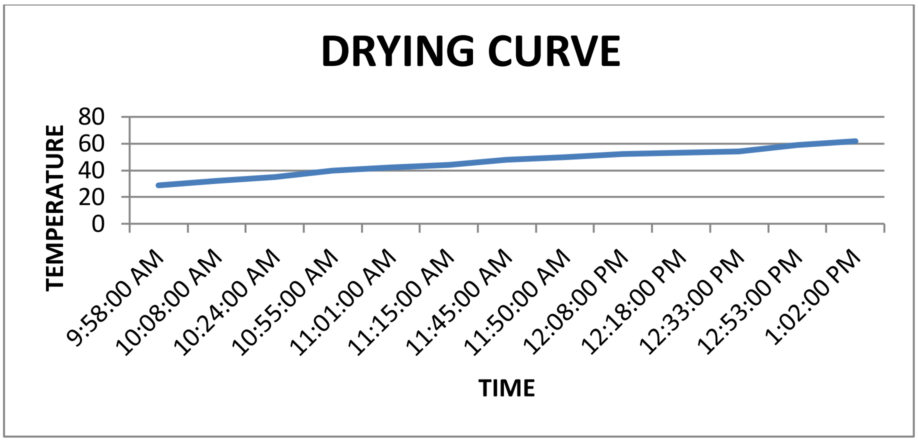
6/07/2012		Date	6/07/2012	
Pearl Meat		Type of sample	Abalone	
WAFIC		Source of sample	WAFIC	
	kg	Weight of samples (Gross)		kg
0.33	kg	Packaging	0.33	kg
0.3007	**kg**	**Weight of raw sample (Nett)**	**0.2333**	**kg**
0.00	min	Precook time	0.00	min
08:46:00	time	Machine time on	08:46:00	time
9:17:00	time	Time start	9:33:00	time
14:20:00	time	Run finish	14:20:00	time
14:56:00	time	Time finish	14:56:00	time
3899	kwh	Kilowatt hour reading (start)	3899	kwh
4078	kwh	Kilowatt hour reading (finish)	4078	kwh
179	**kwh**	**Total Kilowatt hours used**	**179**	**kwh**
0.1382	**kg**	**Solids & Oil recovered**	**0.0794**	**kg**
0.16	**ltrs**	**Liquid recovered**	**0.15**	**ltrs**
0.000	**kg**	**Loss**	**0.000**	**kg**
5:03:00	**hrs**	**Sample drying time**	**4:47:00**	**hrs**
0:36:00	hrs	Cleaning time	0:36:00	hrs



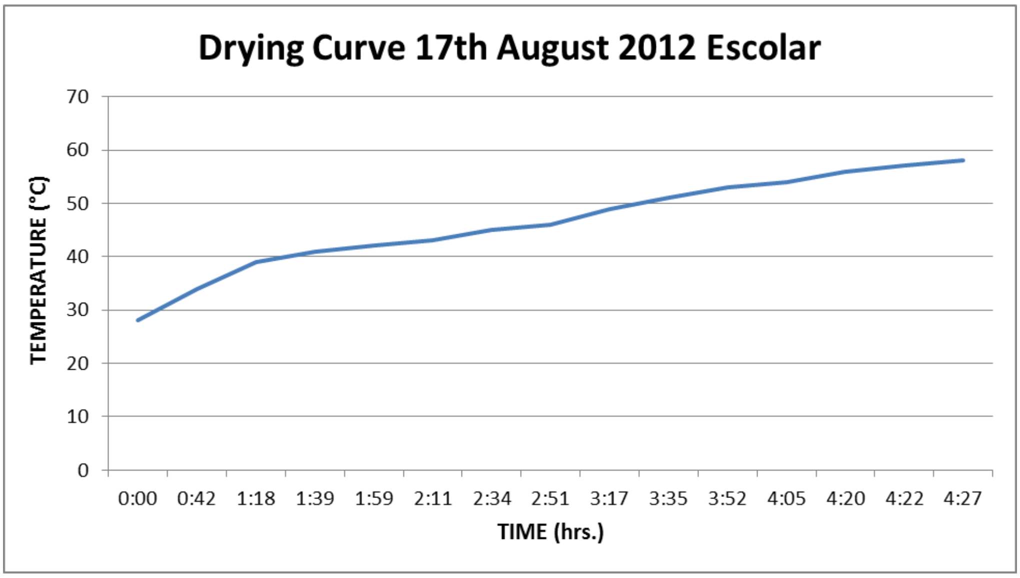
Date	9/08/2012	
Type of sample	Atlantic Salmon Frames	
Source of sample	Kalis	
Weight of samples (Gross)	11.42	kg
Packaging	0.61	kg
Weight of raw sample (Nett)	**10.81**	**kg**
Precook time		min
Machine time on	09:25:00	time
Time start	9:35:00	time
Run finish	13:03:00	time
Time finish	14:00:00	time
Kilowatt hour reading (start)	4078	kwh
Kilowatt hour reading (finish)	4270	kwh
Total Kilowatt hours used	**192**	**kwh**
Solids & Oil recovered	**4.01**	**kg**
Liquid recovered	**6.65**	**ltrs**
Loss	**-0.150**	**kg**
Sample drying time	**3:28:00**	**hrs**
Cleaning time	0:57:00	hrs





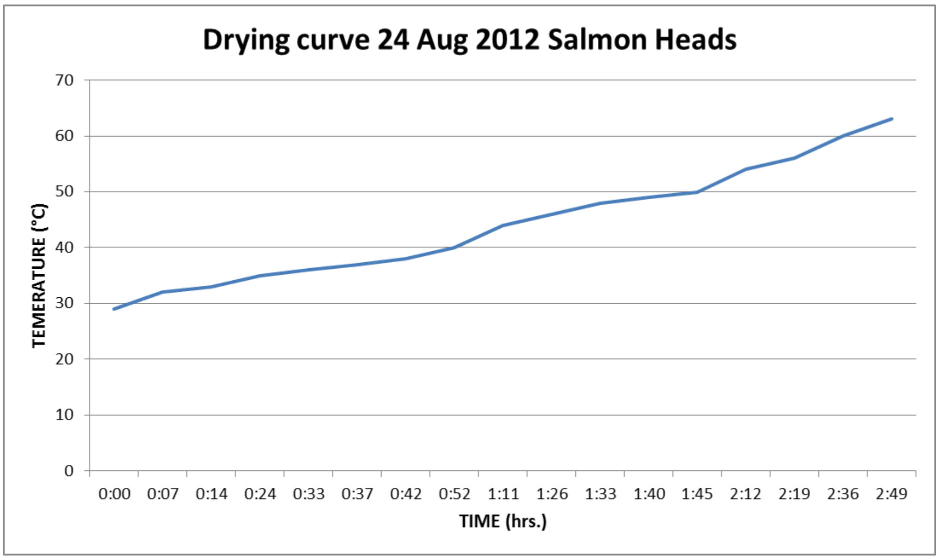



Date		9/08/2012	
Type of sample	Escolar		
Source of sample	WAFIC		
Weight of samples (Gross)		16.41	kg
Packaging		0.34	kg
Weight of raw sample (Nett)		**16.07**	**kg**
Precook time			min
Machine time on		09:12:00	time
Time start		9:26:00	time
Run finish		14:12:00	time
Time finish		15:22:00	time
Kilowatt hour reading (start)		4270	kwh
Kilowatt hour reading (finish)		4534	kwh
Total Kilowatt hours used		**264**	**kwh**
Solids & Oil recovered		**5.87**	**kg**
Liquid recovered		**9.70**	**ltrs**
Loss		**-0.500**	**kg**
Sample drying time		**4:46:00**	**hrs**
Cleaning time		1:10:00	hrs

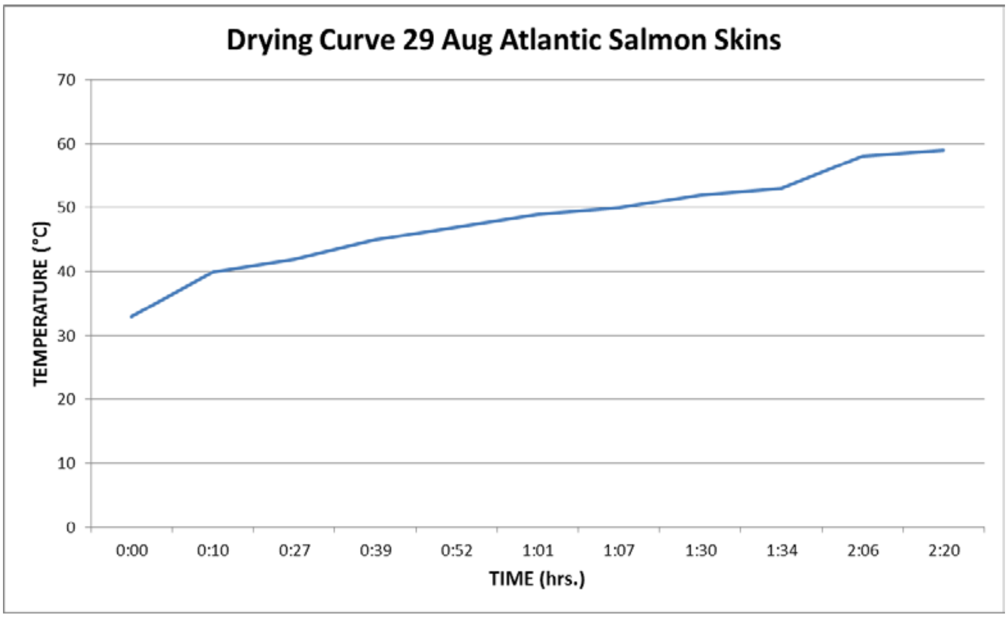


Date	24/08/2012	
Type of sample	Salmon Heads	
Source of sample	Catalanos	
Weight of samples (Gross)	9.93	kg
Packaging	0.97	kg
Weight of raw sample (Nett)	**8.96**	**kg**
Precook time		min
Machine time on	08:42:00	time
Time start	9:00:00	time
Run finish	12:12:00	time
Time finish	13:00:00	time
Kilowatt hour reading (start)	4534	kwh
Kilowatt hour reading (finish)	4717	kwh
Total Kilowatt hours used	**183**	**kwh**
Solids & Oil recovered	**3.56**	**kg**
Liquid recovered	**5.90**	**ltrs**
Loss	**0.500**	**kg**
Sample drying time	**3:12:00**	**hrs**

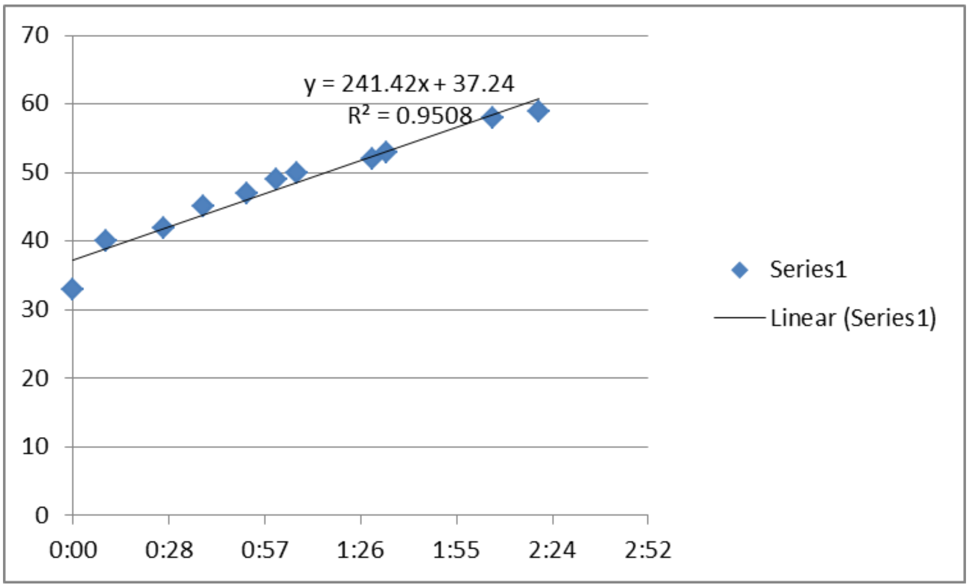
Cleaning time	0:48:00	hrs



Date	29/08/2012	
Type of sample	Salmon Skins	
Source of sample	Catalanos	
Weight of samples (Gross)	5.4	kg
Packaging	0.705	kg
Weight of raw sample (Nett)	**4.695**	**kg**
Precook time	10	min
Machine time on	10:32:00	time
Time start	11:01:00	time
Run finish	13:18:00	time
Time finish	14:08:00	time
Kilowatt hour reading (start)	4717	kwh
Kilowatt hour reading (finish)	4844	kwh
Total Kilowatt hours used	**127**	**kwh**
Solids & Oil recovered	**1.92**	**kg**
Liquid recovered	**2.50**	**ltrs**
Loss	**-0.275**	**kg**
Sample drying time	**2:17:00**	**hrs**
Cleaning time	0:50:00	hrs



Drying Curve 29 Aug Atlantic Salmon Skins
TEMPERATURE (°C)
70
60
50
40
30
20
10
0
0:00
0:10
0:27
0:39
0:52
1:01
1:07
1:30
1:34
2:06
2:20
TIME (hrs.)



y = 241.42x + 37.24
R² = 0.9508
70
60
50
40
30
20
10
0
0:00
0:28
0:57
1:26
1:55
2:24
2:52
Series1
Linear (Series1)

Appendix 8: World Food Bank High Protein Products

WFP's Food Basket

The food that WFP supplies to its beneficiaries depends on the needs of the groups covered and the objectives of the project.

In emergencies or refugee situations, people may be totally dependent on WFP food. In this case, the key components of the WFP food basket are: a staple such as wheat flour or rice; lentils, chickpeas or other pulses; vegetable oil (fortified with vitamin A and D); sugar; and iodised salt. Often these are complemented with special blended foods, such as Corn Soya Blend, that have been fortified with important micronutrients.

The photo below shows an example of a daily ration that provides the required 2,100 Kilocalories (Kcal) of energy.

Ingredients

400g of cereal flour/rice/bulgur

60g of pulses

25 g of oil (vit. A fortified)

50 g of fortified blended foods (Corn Soya Blend)

15g of sugar

15g of iodized salt

Nutritional value

Energy 2,100 Kcal

Protein 58 g

Fat 43g

Besides energy, protein and fat, an adequate food basket supplies micronutrients such as vitamin A, iron, iodine and zinc. The food basket serves to prevent micronutrient deficiencies and other forms of malnutrition, or prevents them from deteriorating.

Supplementary Rations

WFP beneficiaries are not always dependent on us for all their food needs. Sometimes the project only aims to supplement food that is available at the household level, so as to address specific nutritional needs. A “supplementary ration” is mostly given to a vulnerable group such as small children to prevent or treat malnutrition. It often consists of a fortified blended food, sugar and vegetable oil. An alternative ration could be a ready-to-eat food (RUF), which does not require any cooking or preparation and is also fortified with vitamins and minerals.

Special Nutritional Products

Below are five key products used by WFP to improve our beneficiaries' nutritional intake:

Fortified Blended Foods (FBFs)

What are they?

FBFs are blends of partially precooked and milled cereals, soya, beans, pulses fortified with micronutrients (vitamins and minerals). Special formulations may contain vegetable oil or milk powder. **Corn Soya Blend** (CSB) is the main blended food distributed by WFP but Wheat Soya Blend (WSB) is also sometimes used.

When and where used?

FBFs are designed to provide protein supplements. In food assistance programs to prevent and address nutritional deficiencies. They are generally used in WFP Supplementary Feeding and Mother and Child Health programs. Also, to provide extra micronutrients to complement the general ration.

How used?

Usually mixed with water and cooked as a porridge

Nutritional value per 100g:

Energy min 380Kcal

Protein min 18%

Fat min 6%

Micronutrients added: Vitamins A, C, B12, D, E, K, B6, Thiamine, Riboflavin, Niacin, Pantothenic acid, Folic acid plus Zinc, Iron, Calcium, Potassium.

Ready-to-Use Foods (RUFs)

What are they?

RUFs are better suited to meet the nutritional needs of young and moderate malnourished children than FBFs. RUFs distributed by WFP may contain vegetable fat, dry skimmed milk, malt dextrin, sugar and whey.

When and where used?

Mostly in emergency operations or at the beginning of a WFP intervention for prevention or treatment of moderate malnutrition. RUFs are to be used in addition to breast milk and other food for children (6 to 59 months) which are at high risk of developing malnutrition due to severe food insecurity

How used?

One variety (*Plumpy'Doz*, by Nutriset) comes in tubs containing a weekly ration. Another (*Plumpy Sup*, also by Nutriset) comes in one-day sachets. Both can be eaten directly from their containers and are designed to be eaten in small quantities, as a supplement to the regular diet. (News article: Cheaper recipe for treating hungry children)

Ingredients

*Plumpy'Doz***:** peanuts paste, vegetable fat, skimmed milk powder, whey, maltodextrines, sugar.

Supplementary Plumpy: peanut paste, vegetable fat, soy protein isolates, whey, maltodextrines, sugar, cocoa.

Micronutrients: vitamin A, E, B1, B2, Niacin, Pantothenic acid, vitamin C, B6, B12, Calcium, Magnesium, Selenium, Zinc, Iron, iodine, Copper, Phoshorus, Potassium, Manganese, Folic acid (*Supplementary Plumpy* also has Vitamin D, K and Biotin).

Nutritional value (per 100g of *Plumpy'Doz / Supplementary Plumpy*)

Energy 534Kcal / 545Kcal

Protein 12.7g /13.6g

Fat 34.5g / 35.7g

Price

$0.20 / ration of *Plumpy'Doz*

$0.33 / ration of *Supp. Plumpy*

High Energy Biscuits (HEBs)

What are they?

Wheat-based biscuits which provide 450kcal with a minimum of 10 grams and max of 15 grams of protein per 100 grams, fortified in vitamin and minerals.

When and where used?

In the first days of emergency when cooking facilities are scarce. Easy to distribute and provide a quick solution to improve the level of nutrition.

Ingredients:

Wheat flour, Hydrogenate Vegetable Shortening, Sugar, Soy flour, Invert Syrup, High fructose, Corn Syrup, Skimmed milk powder, Sodium and Ammonium, Bicarbonates, Salt, Minerals and vitamins as : Calcium, Magnesium, Iron, Iodine, Folic Acid, Pantothenic Acid, Vitamin B1, B2,B6,B12b C,D,E, Niacine, Vitamin A-retinol.

Nutritional value per 100g:

Energy 450Kcal

Protein 10 to 15g

Fat 15 g

Price $0.12 per 100g packet

Micronutrient Powder or "Sprinkles"

What is it?

A tasteless powder containing the recommended daily intake of 16 vitamins and mineral for one person. Can be sprinkled onto home-prepared food after cooking just before eating.

When and when?

Useful when fortification of cereal flour cannot be implemented or when it is inadequate for specific groups.

How to use it?

One sachet per person is sprinkled onto home prepared food. can also be used in school feeding programmes that provide a hot meal to children.

Nutritional value:

One individual sachet provides the daily intake of 16 vitamins and mineral for one person

Price: $2-3 per 100 sachets

Compressed food bars

What are they?

Bars of compressed food, composed of baked wheat flour, vegetable fat, sugars, soya protein concentrate and malt extract.

When and when used?

Used in disaster relief operation when local food can't be distributed or prepared. Should not be used for children under 6 months and in the first 2 weeks of treatment of severe malnutrition.

How used?

Can be eaten as a bar straight from the package or crumble into water and eaten as porridge. Drinking water must be provided as the bars are very compact and dry. Number of bars to be eaten depends on age, gender, weight and physical activity.

Ingredients : baked wheat flour, vegetable fat, sugars, soya protein concentrate, malt extract. vitamins and minerals: vit A, D3,E, C, B1, B2, B6, B12, Niacin, Folic acid, Pantothemic acid, Biotin, Calcium, Phosphorus, Magnesium, Iron, Zinc, Potassium, Sodium, Copper, Selenium, Iodine.

Nutritional value per 56 g bar:

Energy 250kcal,

Protein 8.1

Fat 9.4 g

Price $1.60 per unit (9 bars)

Emergency Survival Food buckets

Survival Cave Foods 180 serving container for 1 adult for 15 days. Price (US$209.00)

These are the very best freeze dried survival foods provided with 180 servings. These emergency freeze dried foods are great for your food storage program. You can open all these freeze dried foods and take out how many emergency food meals you want and close the packet with the zip lock top and keep your remaining freeze dried dishes for future use. One hundred and eighty adult servings Survival Cave Food fulfills every one of these with an economical, delightful and cost effective freeze dried food as well as a way to get you prepared for the unknown.

- Freeze dried food that lasts for 20 years!
- Light weight - simple to store freeze dried food
- Great tasting survival food
- Zip lock re-sealable pouches keep your freeze dried food fresh
- Delicious emergency food dishes ready in minutes
- Just add water to the freeze dried food to get a quick emergency meal
- Freeze dried emergency food your entire family will love

This light weight freeze dried food is conveniently storable container provides 2000 calories per day for 15 days or 1000 calories per day for 30 days. All of the freeze dried meals are prepared to remain fresh for 20 years. Every pouch of freeze dried emergency food has a re-sealable zip lock which allows you utilize the servings you need and then reseal the pouch for future use. Food prices continue to go up without end in sight and this freeze dried food bucket will be your solution to safeguard your loved ones and save money on emergency food storage. Are you ready for emergencies? Do you have a good Food Storage Approach? Could there be food shortages that freeze dried food will help with? do you think you're spending too much to stock up on emergency foods you recognize you need?

This bucket offers the following nineteen delicious gourmet freeze dried meals, sweets as well as drinks:

- All Natural Delicious Granola (10 servings per pouch) One pouch
- Fruity Apple Blueberry Granola (10 servings per pouch) One pouch
- Wholesome Filling Oatmeal (10 servings in each pouch) One pouch
- Fluffy Scrambled Eggs (10 servings per pouch) 1 pouch
- Creamy Chocolate Pudding (10 servings per pouch) One pouch
- Mixed Fruit (Five servings per pouch) One pouch
- Italian Style Polenta (10 servings per pouch) One pouch
- Beef Flavored Vegetable Soup (10 servings per pouch) One pouch
- Cheesy Cheddar Broccoli Soup (10 servings per pouch) 1 pouch
- Refreshing Orange Drink (10 servings per pouch) One pouch
- Home Style Creamy Mashed Potatoes (10 servings per pouch) 1 pouch
- Chicken Flavored Vegetable Soup (10 servings per pouch) One pouch
- Elbow Macaroni and Cheese (10 servings per pouch) One pouch
- Southwestern Chili (10 servings per pouch) One pouch
- Hearty Potato Soup (10 servings per pouch) 1 pouch
- Mixed Vegetables (5 servings per pouch) One pouch
- Cajun Red Beans and Rice (10 servings per pouch) 1 pouch
- Satisfying Whey Milk (10 servings per pouch) One pouch
- Chocolaty Whey Milk (10 servings per pouch) One pouch

Emergency Food Rations

Mainstay 3600

Non-Thirst Provoking
Withstands Temperatures of -40° F to 300°F (-40°C to 149°C)

Ready to Eat: Each package contains 9 pre-measured 400 calorie meals.

Individualized Portions eliminate the messy breaking-up that occurs with other bars

Allows for on-land emergency consumption in a high-stress active situation.

Contains no cholesterol or tropical oils.
Enriched with vitamins and minerals exceeding the RDA requirements.

Pleasant lemon flavor which appeals to everyone.

Mainstay™ is Kosher and meets the dictates for Halal.

Percentage of U.S. recomended daily allowances

Based on daily consumption of 1-2.67 oz. serving.
Serving Size: 3-2.67 oz. (76gm)
Servings per container: 9

Vitamin A	50%	Calories	1200
Vitamin C	60%	Protein	9 Grams
Vitamin B-6	90%	Carbohydrate	138 Grams
Vitamin B-12	20%	Fat	69 Grams
Vitamin D	50%	Sodium	69 mg
Thiamine B-1 C	15%	Cholesterol	0 mg
Riboflavin B-2	25%		
Folacin	35%		
Niacin	30%		
Calcium	50%		
Iron	10%		
Phosphorous	40%		
Magnesium	30%		
Pantothenic Acid	100%		

INGREDIENTS

Enriched flour, (Added) Vitamins A, B-1, B-2, D, E, B-6, B-12, Niacin, Iron, Folic Acid, Magnesium, Patothenic Acid, Calcium, Phosphorous, Vegetable Shortening (Partially Hydrogenated Soybean and/or Cottonseed Oils), Granulated Sugar, Corn Starch, Corn Syrup, Natural Lemon Flavor, Artificial Butter Flavor, Artificial Vanilla Flavor, (Tartarzine, FD&C Yellow #5, FD&C Red #40), Artificial Color, Asorbic Acid (Vitamin C), Gamma/Delta Tocopherols as a natural antioxidant.

Cost is US$7 per packet.