Seafood processing post doctoral appointment to focus on development and delivery on seafood processing opportunities for Seafood CRC participants

Andrew Barber & Karen McNaughton

AUSTRALIAN SEAFOOD COOPERATIVE RESEARCH CENTRE

Project No. 2008/708

CRC AUSTRALIA

Australian Government

Fisheries Research and Development Corporation

This Australian Seafood CRC: Postdoctoral Research Fellow – Seafood Processing Research position was completed at the South Australian Research & Development Institute (SARDI)

The Australian Seafood CRC is established and supported under the Australian Government's Cooperative Research Centres Programme. Other investors in the CRC are the Fisheries Research and Development Corporation, Seafood CRC company members, and supporting participants.

ISBN: 978-1-925983-22-7

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Non-Technical Summary

2008/708 – Seafood processing post doctoral appointment to focus on development and delivery on seafood processing opportunities for Seafood CRC participants

PRINCIPAL INVESTIGATORS: Andrew Barber & Karen McNaughton

NAME OF POST- DOCTORAL FELLOW: Mohan Raj

ADDRESS: Plant Research Centre
Gate 2b Hartley Grove
Urrbrae, SA 5064

OBJECTIVES:

1. To increase Australian seafood processing capability and capacity.
2. To increase the outcomes in seafood processing activities for CRC participants.

NON TECHNICAL SUMMARY:

This project and the resulting appointment of Mohan Raj led to collaboration with industry to improve seafood processing through a variety of endeavours including on site production evaluation (and recommendations for processing changes), communication through Masterclass workshops as well as the introduction and testing of new technology.

A number of ‘Masterclass’ workshops were delivered on seafood packaging trends. Workshops were presented in four locations including Sydney, Adelaide, Melbourne and Perth. In each location a number of businesses and agencies were visited to understand their issues, suggest solutions, and assimilate information for future Seafood CRC proposals. A production of a DVD showcasing the workshop presentations was also prepared for industry.

Another aim of the project was to use smart processing and packaging techniques to transform the Australian seafood industry. Suggestions to a number of seafood processing companies ranged from process improvements and efficiencies, product shelf life extension, value addition to product lines, process automation techniques, engineering and process management.

Furthermore, there are possible developments of new seafood products now that processing techniques into the use of underutilised fish products have been assessed during this research study.

OUTCOMES ACHIEVED TO DATE

- Successfully developed and conducted master classes in the latest trends in seafood packaging.
- Established parameters with High Pressure Processing equipment to evaluate the shelf life of chilled Abalone meat
- Optimised the use of seafood material in processing
- Reported on optimising processing procedures in a number of seafood processing plants.

KEYWORDS:

Processing, packaging, efficiency, automation, energy costs, labour, High Pressure Processing

Acknowledgments

The authors would like to gratefully acknowledge the support of the Australian seafood industry, particularly the businesses who participated in processing reviews with the postdoctoral fellow.

1 Introduction

"Smart Processing" is a theme that all seafood processors should work towards. This involves working efficiently with new technologies to produce quality and market developed products. There is a need to apply research and development in seafood processing to the processors of Australia. It is required to ensure Australian seafood processors adopt world's best technologies, processes and practices ensuring product quality and marketability and enhancing their competitiveness and profitability.

Knowledge and Principles are required in:

- New Product Development
- Processing Plant Technology (Automation, Packaging, High Pressure Processing, Cooling Techniques) and Market Trends
- Maximising Processing Yield and reducing Waste

Need

To engage with CRC participants to help develop a strategic research and development plan for the "Smart Processing" theme and to establish alliances with other relevant research groups. To integrate with CRC participants to adapt worlds-best technologies, processes and practices to improve

Australian seafood quality and marketability and to seek out future research opportunities within the industry.

Objectives

1. To increase Australian seafood processing capability and capacity.
2. To increase the outcomes in seafood processing activities for CRC participants.

2 Methods

Packaging Systems

Various packaging systems (vacuum packing, modified atmosphere packaging (MAP) and skin packaging) were trialled and also concept product samples were produced for projects 2009/722.10 and 2009/770.
Other packaging trials were performed with Jason Sinclair (invited from UK by Seafood CRC to develop prawn new product concepts for project 2010/744, The Whole Prawn (Stage 1)), including trials with MAP, skin packaging and retail packing for a prawn processor in Queensland.

High Pressure Processing

A proposal was developed to test a process to reduce the microbiological load on seafood using the High Pressure Processing (HPP) technique for extending shelf life of high value products. The HPP process involved subjecting abalone from South Australia and Tasmania to high pressures of 450MPa and 600MPa for 3 minutes to observe the reduction (if any) on viable counts of food spoilage organisms.

Microbiological analyses were conducted at SARDI's, Glenside laboratory to establish total viable counts (TVC), coliforms and lactic acid bacteria (LAB) for HPP treated and control samples. The days of sampling chosen were: day 1, day 7, day 14, day 18, day 21, day 25 and day 28. One replicate was taken for analysis. Sensory evaluation was conducted at Dover fisheries in Adelaide.

Sydney Fish Market (SFM)

Trials conducted as part of a project with SFM included:-

2.1.1 Market Pride Range Optimisation

The optimisation of seafood material, labour and equipment utilisation for the production of retail and food service packs in the form of seafood laksa and chowder products. The final target was the improvement of the batch yield and reduction of the overall cost per pack for the processors of this Sydney Fish Market – Market Pride Range of products.

2.1.2 Optimising Seafood Meat Extraction

Trials were performed using different types of fish and off-cuts to examine the effects of a Baader 696 meat extractor (50Hz, 380V, 1.5kW, Germany, 1981) on fish meat extraction quality and yields.

Examples of seafood used in these trials are below (Figure 1, 2 and 3).

Figure 1: Red Fish H & G (head and guts removed), with skin on

Figure 2: Ocean Jacket (OJ) H & G (head and guts removed)

Figure 3: Luderick, (a) head and gutted, (b) fillet with skin on.

Western Rock Lobster

Trials were conducted in a production environment to improve the processing of Western Rock Lobster. Aspects of the trials included:-

- Detailed analysis and scope of automation of Western Rock Lobster processing for better throughput and profitability.
- Desktop evaluation of automatic cooking and cooler technologies.
- Investigation of techniques used in the production line and identification of opportunities to automate/semi-automate the process to save time and overall processing cost.
- Report on analysis and evaluation listed above.

King Prawns – Process Optimisation

A proposal was submitted to improve the efficiency of peeling and de-heading yields and to improve the final product quality of King Prawns

Procedure: To visit a prawn processing company and identify current processing practices within the working environment, report suggestions of improved processes and procedures with minimal disruption to the production company, but with improved quality and maximum output.

Sardine Production

Work was conducted to provide post-harvest optimisation of sardine product development for human consumption as part of CRC project 2009/774. Aspects of work conducted included:-

- Identification and implementation of optimised post-harvest value-added processes from raw material receipt to final product dispatch.
- Review of current processes and handling for sardine processing
- Assessment of current processing conditions, identification and reporting of improvements.

Cleanseas Tuna's Kingfish

During this project (CRC project 2009/722.10) the Baader unit (discussed above processing a range of other species) was also set up for meat extraction at the facility used for Cleanseas' product processing at Port Lincoln. Trials were conducted to extract useful meat from King fish frame, off-cuts and skins.

Types of kingfish material used for meat extraction included:

1. Frames only

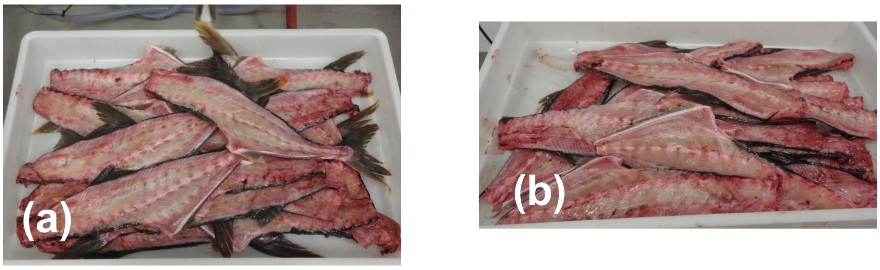

Figure 4: (a) Kingfish frames, with tails, (b) Kingfish frames without tails

2. Off cuts and waste from skinless, boneless loin production (i.e. pin bone line, rib bones, skin and tail/belly cut trim)

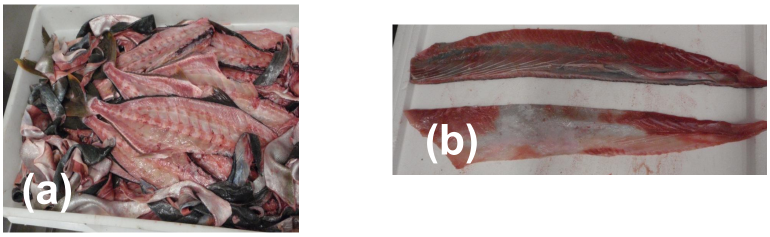

Figure 5: (a) Kingfish frames and skins, (b) Kingfish skins

Meat extracted was packed into pouches and frozen.

3 Results & Discussion

Packaging Systems

The project led to the development and delivery of a series of master class/workshops for the latest trends in seafood packaging. These workshops were successfully conducted in SA, Victoria, NSW and WA.

A DVD was produced with presentations and distributed to Seafood CRC participants.

High Pressure Processing

The High Pressure Processing (HPP) trial was completed for vacuum packed abalone meat sourced from South Australia and Tasmania. When the abalone were HPP treated, there were slight changes in colour observed, however there was no significant change in appearance for up to 4 weeks. The control samples changed colour after two weeks. Control samples from South

Australia appeared satisfactory as per the sensory analysis up to four weeks, but there was significant microbial growth.

The weight of the vacuum packed abalone was recorded to examine changes in drained weight after HPP treatment. Weight loss for control and HPP treated abalone did not differ greatly; with only a slight difference between treatments after day 9. The weight loss for control samples were 8.52% and for HPP treated abalone the weight loss was 8%.

Total viable count (TVC) results for microbial growth measured for abalone showed that the control samples were unacceptable at the end of day 14, it was decided not to test control samples further.

Abalone sourced from South Australia (SA) and HPP treated at 450 MPa for 3 minutes compared with 600 MPa/3 minutes showed similar trends in TVC except on day 14 of testing which may have been an abnormal count. Tasmanian abalone showed similar TVC trends for HPP treated abalone at 450 MPa/3 minutes and 600 MPa/.3 minutes. It may be necessary to analyse several samples at various pressures to establish the ideal HPP procedure. Results indicate that better cool chain management and hygiene practices are critical for HPP processing.

Lactic acid bacteria (LAB) counts recorded for South Australian abalone for days from 1 to 28 indicated that up to 14 days LAB counts for abalone treated with HPP at 450 MPa/ 3 minutes and 600 MPa/ 3 minutes were similar. However, after day 18 LAB counts on abalone treated with HPP at 450 MPa/3 minutes increased until day 25 and then slightly dropped off on day 28, while LAB counts on abalone treated with HPP at 600MPa/3 minutes remained unchanged until day 28. LAB counts recorded for the Tasmanian abalone were similar for both HPP treatments up to day 14. However counts significantly increased after 14 days for abalone treated with HPP at 450MPa/3minutes and after 21 days for abalone treated with HPP at 600MPa/3minutes.

Coliform results showed that for all days from day 1 to day 28 counts recorded were less than 10 for abalone treated with HPP at 450 MPa/3 minutes and at 600 MPa/3 mins. This indicated failure of coliforms to survive the HPP treatments for the times and conditions tested. South Australian control sample coliform counts were 35000 on day 7 and 200 for Tasmanian abalone.

An informal sensory analysis for control samples from South Australia showed the development of off odours above the “not acceptable limit” after 23 days, however, HPP processed abalone retained or was very similar to its original odour up to day 16. Regardless of pressure used, there was slight change in texture from firm to slightly soft. Tasmanian abalone, HPP processed in both formats of 450 MPa and 600 MPa/ 3 mins appeared good up to 16 days, and changes noticed from after 23 days. The smell of HPP processed abalone was acceptable up to 16 days and was still acceptable at day 23 (Table 1).

Table 1 Sensory Analysis for both South Australian and Tasmanian control and HPP treated abalone[z]

	South Australian – Green Lip Abalone						Tasmanian Abalone					
	Odour		Appearance		Texture		Odour		Appearance		Texture	
Day	Control	HPP	Control	HPP	Control	HPP	Control	HPP	Control	HPP	Control	HPP
9	OK	OK	OK	OK	Firm	Slight soft, quite juicy	OK	OK	OK	Slight colour change, Accept.	Very firm, some juice	Slight soft juicy
16	OK	OK	OK	OK	Firm	Firm	Just OK	OK	OK	OK	Firm	Slightly soft
23	Slight off odour	Slight off odour	OK	OK	Firm	Slightly soft	Off odour/ NA	OK	OK	OK	OK	Firm
27	Very strong off odour	Slight off odour	OK	OK	Firm	Slightly soft	Strong off odour	Slight off odour	Not OK	OK	Soft	Slightly soft
33	Very strong off odour	Slight off odour	OK	OK	Firm	Slightly soft	Very Strong off odour	Slight off odour	Obvious blueing	OK	Soft	Slightly soft

[z] NA not acceptable

Overview
Sensory analysis and microbiological results observed similar outcomes. The HPP process did alter the colour and texture of abalone to some extent initially although no further change was noticed for up to 3 weeks. An alternative product in chilled form with a shelf life longer than 2 weeks may provide a market opportunity.

HPP processed abalone showed sufficiently low microbiological counts and good organoleptic results after 2 to 3 weeks, indicating the potential for HPP processed abalone as an export product. These were preliminary findings with limited samples tested and several trials may have to be conducted with further samples analysed before a commercial decision could be made. However, the findings do demonstrate some promise, particularly for fresh abalone that might be exported to China or other relatively near Asian markets.

Sydney Fish Market (SFM)

Field trials were conducted; these included setting up the meat extraction unit, optimising the extraction process, successfully completing the extraction process at the facility and submitting a detailed report on extraction procedures, yields and methods for commercial processes to the Sydney Fish Market. While the results of the work were positively received, the continued development of the Market Pride range of products was delisted and so further work by Sydney Fish Market on the project did not continue.

3.1.1 Market Pride Range Optimisation

Observations of processing procedures and recommendations to the processor for the Market Pride product development were as follows:

Observations

Processing Plant

- Processor receives raw seafood in prepared diced or portioned forms. The raw material was packed in numbered portions of seafood not weight, resulting in batch weight (should be 100kg/batch) inconsistencies.
- Batches were not “topped up” with sauce to make up the 100kg batch size.
- Seafood is stored in chilled and frozen stores.
- Packaging formats consist of 600 g and 2 kg pouches.
- Target yield is 95%
- Actual yield achieved is between 85 to 87 %
- Losses arise in; blanching, mixing, filling (via spillage) and washing with smaller size batches (100 kg batch size).
- At the time of the observation, 5 people ran the processing line (one person to fill the bags, one to check the weight of each bag, two people to seal the packs and one to stack and store the packs in the chiller/pasteuriser).

- Number of pouches filled per minute = 5 to 6 (average of 60 pouches per man-hour).

Raw Seafood Preparation

- This is done in vacuum packed pouches, which are left in hot water for more than 10 minutes. Resulting in weight loss and uneven cooking of seafood through the pack instead of a blanching process.
- Often the seafood is taken out after blanching, leaving the liquor behind; this contributes to weight loss. Total batch weight is based on the material before blanching.
- Double cooking could damage the seafood texture as well as contribute to yield loss (firstly at the time of blanching and then during pasteurisation of the finished product).

Pasteurisation

- Pasteurisation is performed in a tank with hot water; 2 packs are monitored using an invasive temperature probe to monitor the temperature, so out of every 100kg batch, two bags are discarded due to temperature monitoring.
- This contributes to a 4 % yield loss of seafood (for 2 kg pouch packing).

Chilling

- Chilling is completed in a cold water bath; bags are stored overnight in a cold room for drying and further cooling before packing the next day.

Recommendations:

Processing Plant

- Sauce transported from chill store to mixing and filled in the mixing tank area manually; may be more efficient if automated.
- Filling pouches with using only 2-heads of the filler at the rate of 5 to 6 pouches per minute. This could easily be doubled with the filler having a capacity to fill 10+ pouches per minute
- After weighing, topping up and or removal of product if necessary, there is an initial manual sealing process, followed by another manual sealing process crimping the bag top for additional strength. The equipment layout is poorly ordered; there is lot of cross travelling and/or multiple handling which reduces the filling and packing speed.
- Cooling should be by chilled water. Product could be stored and chilled overnight. Pouches are packed into cartons with absorbent liners to soak up any residual moisture in the cartons, if any.

Raw Seafood Preparation

- Dicing of raw seafood could be done onsite with the help of simple dicing equipment to get uniform sized portions rather than seafood bought in pre-diced.

Blanching

- The blanching process could be eliminated to avoid yield loss.

Temperature Monitoring

- There is a possibility to temperature monitor two packs without seafood, saving on seafood material.

3.1.2 Optimising Seafood Meat Extraction

After preliminary meat extraction trials on Red Fish, Ocean Jackets and Luderick (Figure 6, 7, 8), formats for the best meat extraction outcomes based on quality results were selected. These optimal outcomes were Red Fish H&G and Ocean Jacket H&G (with skin off); quality results are highlighted in Table 2. The total meat recovered after two passes through the Baader extractor for Red Fish (H&G) was 52.7kg out of an initial weight of 62.95kg, while 46.85kg out of 53kg of Ocean Jacket fish (with skin off) was recovered after two extractor passes.

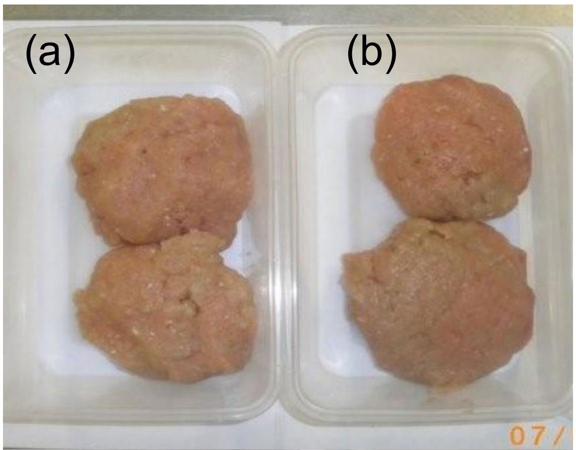

Figure 6: Red Fish meat extraction from (a) Fillet, (b) H&G (chosen) samples

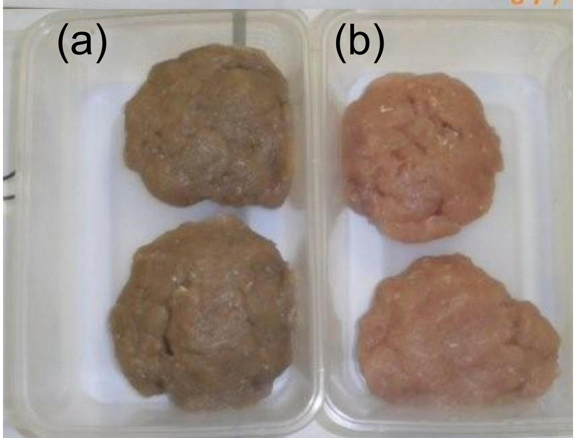

Figure 7: Ocean Jacket meat extraction from (a) Skin on, (b) Skin off (chosen) samples

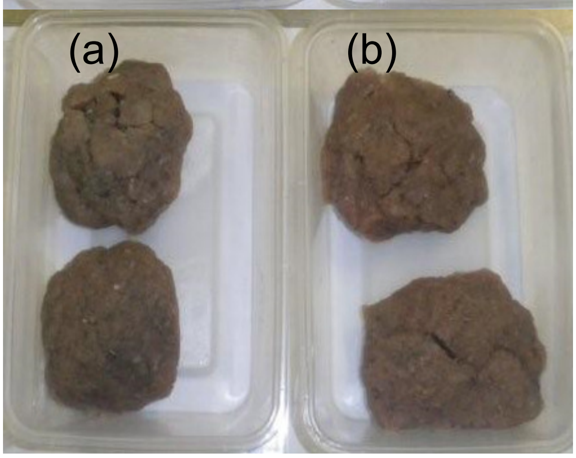

Figure 8: Luderick meat extraction from (a) Fillet, (b) H&G samples

Table 2: Quality assessments of meat extraction results from Red Fish, Ocean Jacket and Luderick samples. Green columns indicate the chosen formats ideal for meat extraction.

Description	Red Fish		Ocean Jacket		Luderick	
	Fillet	**H&G**	**Skin on**	**Skin off**	**H&G**	**Fillet**
1. Colour	Normal, reddish, some white flakes	Normal, reddish, with some white flakes	Grey/light brown, comparatively darker than skin off	Normal, very good, pink/white	Dark brown	Slight dark brown
2. Appearance	Some white flakes	No white flakes found	Cooked appearance is same as skin off	Little white flakes, very good/appealing	Stable	Stable
3. Raw Odour	Normal	Normal.	No fishy odour, weak, normal odour	Normal, good	Muddy	Muddy
4. Cooked Odour	Wheat flavour, nothing undesirable	Fishy flavour, wheat flavour not strong at all, "hint of grittiness"	Appealing, a bit of an egg odour	Egg odour, resembles French toast, appealing, not fishy, chicken flavour	A bit of a muddy odour	A bit of a muddy odour
5. Flavour	Nothing unpleasant	nothing unpleasant, nothing over powering	Nothing unpleasant	Good, nothing unpleasant	Not bad	Not bad
6. Texture	Good, wet, crumbling	moist, crumbly	Moist, slightly crumbly	texture is fine, crispy, moist	Good	Good
7. Overall	Appealing, good, some fine scales found	Given the benefits of processing time, no substantial difference with fillet	Satisfactory	appealing colour after cooking, satisfactory overall		
8. Comments	Need to mix with some binder at some stage	As a finished product need some binder to be mixed for a better texture. **Very promising**	Colour has become lighter after cooking		Appearance after cooking is fine	Appearance after cooking is fine
9. Cooking Time	Each side 4 mins, total time 8 mins	Each side 4.5 mins, total 9 minutes	8 mins, 4 mins each side	8 mins total, 4 mins each side	9 minutes	9 minutes

Western Rock Lobster

Current Rock Lobster Cooling Practice

- Quantity of ice purchased off-site in a year = 1200 MT
- Cost of ice (AU$) = $250,000

Recommendation: Alternative Chilling Method

- Replacing ice with chilled water, by using the existing ammonia refrigeration plant, and having a surplus cooling capacity.
- Invest in a simple water chilling method (plate type) with a circulation pump. Outlay for chilling equipment would include a pump and piping work (no machinery required).
- At the time of production; run the chiller and re-circulate water at +2°C to +4°C to get the lobsters chilled to +5°C within 40 minutes (this is the required time for retaining lobster quality).
- Immediately after cooking, move the crate to the chiller tank feed inlet.
- Crates move automatically; saving on labour
- Ice may be required to layer pack lobsters in store at 10 Tons/day capacity
- An option to produce ice onsite would be ideal to use the surplus refrigeration capacity available.
- An ice plant could be mounted onto a 20 foot reefer container (for ice storage) and produce ice during off- peak hours (overnight or on weekends), reducing cooling costs further.

Benefits:

- Cost of electricity for producing chilled water = $ 16000/ year
- Labour required to maintain the cooking/cooling/ice area would be less than currently required (2 instead of 3 people required)
- Potential labour savings = $ 26,000 per year
- Investment on one chilled water plant = $ 75,000 (Estimated)
- Furthermore, the building of an “Ice Bank” to produce ice onsite during off-peak hours from the spare compressor capacity used for maintaining the storage freezer would also reduce costs with running costs for the ice bank being minimal.

A suitable automated flake ice making system was designed and commercial specifications obtained for the Western Rock Lobster automation project for evaluation of the automated cooling process. A detailed report was submitted to introduce the flake ice system with automated discharge arrangements as part of the automated cooling solutions concept and the estimated pay-back period for the investment was worked out to be approximately 15 months.

King Prawns – Process Optimisation

Original Company Processing Procedure

At the time the volume of prawns handled was about 250 kg/day with processing occurring 2 days in a week. Packed product was raw peeled, de-veined, tail-on prawns for the domestic market. Prawns caught are frozen “whole” on board the trawler and used as raw material for the processing facility. Frozen prawns were then thawed, de-headed, peeled and frozen in 3kg bulk packs (Figure 9)

Figure 9: Bulk 3kg Prawn Cutlet pack

Processing practices observed in the prawn processing factory were as represented in the processing flow chart (Figure 10).

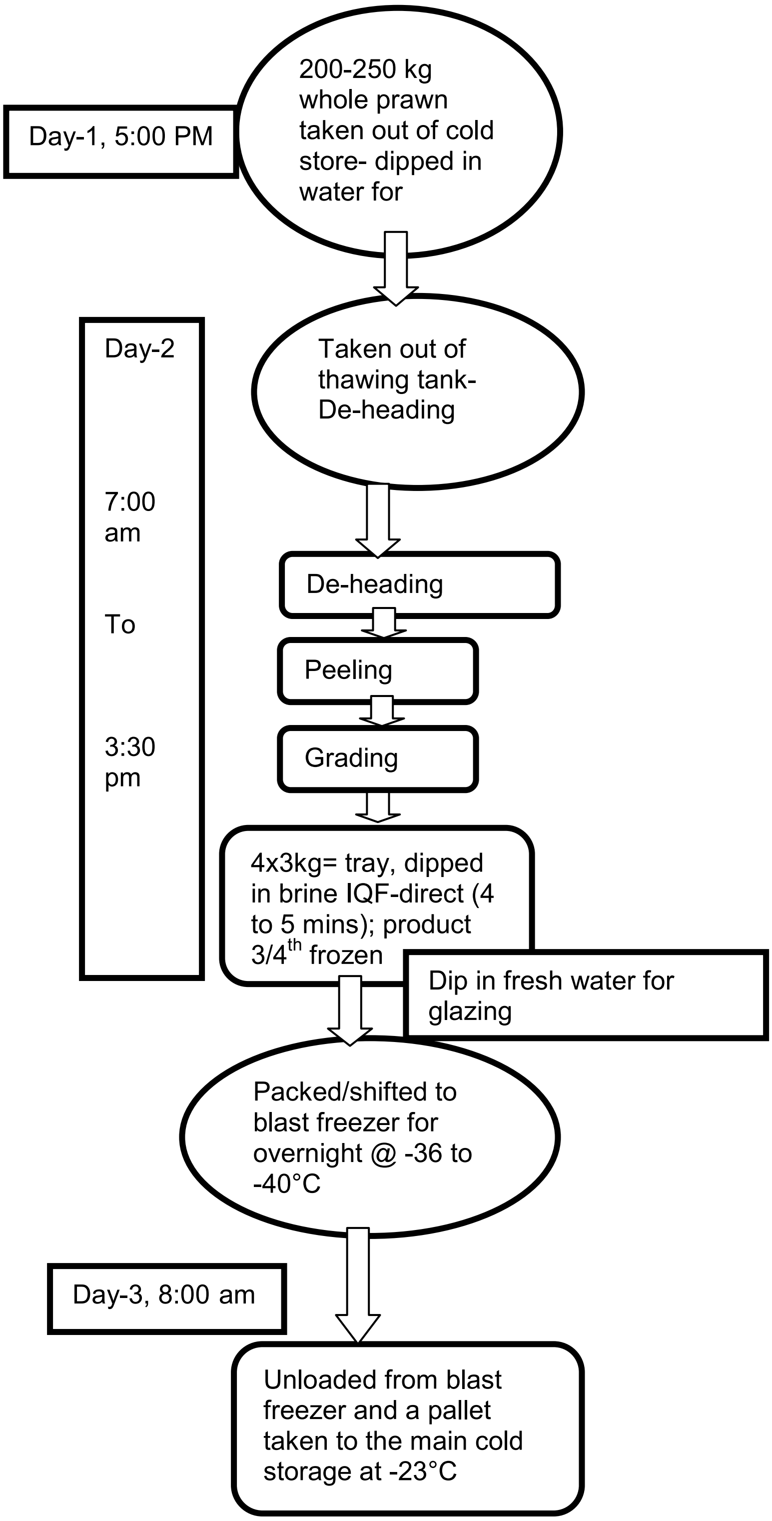

Figure 10: Process flow chart for company's prawn processing actions

Processing issues identified and recommendations suggested

Thawing

- Overnight thawing of frozen prawns in water could cause deterioration of prawn meat texture, soft shell (loose tail +1st segment after peeling) and an increase in the risk of microbial growth due to over 12 hrs in water.
- Subsequent freezing and thawing by consumers is likely to cause further texture degradation resulting in meat toughening.

Recommendation:

- ➢ Rapid thawing process of frozen prawns in running cold water for a period of one hour.
- ➢ Thawing in 50 kg batches

De-heading

- Manual de-heading technique varied amongst staff, resulting in final yield variations from 60.96% to 64.71%.
- The de-heading process was a labour intensive step with inefficient de-heading waste removal processes without appropriate separation between waste and product, giving rise to possible contamination issues. Movement of de-headed prawns to the next processing step manually by staff was inconvenient and time consuming.

Recommendation:

- ➢ A modification to the de-heading work area was proposed (Figure 11).

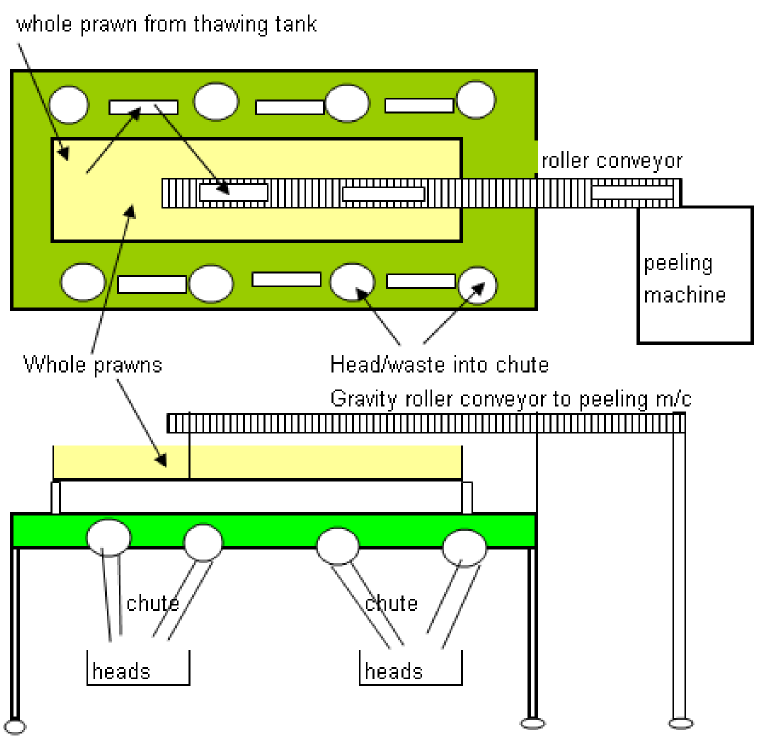

Figure 11: Suggested de-heading work area

- ➢ Whole thawed prawns are loaded over the tray (yellow) on work bench separate from waste material.

- Staff manually de-head prawns, throw the waste into the chute and product in the tray next to them.
- Once the tray is full they position the tray over the roller conveyor
- Gravity assists product and it slides to the peeling area.
- Heads/waste collected in the bin underneath the work bench, need to be cleared 2 to 3 times in the day allowing for a continuous flow with product spending less time on the processing floor

Peeling

- Peeling of prawns is aided by automation, requiring one staff member to load the prawns one by one over the slotted conveyor, while 1 or 2 staff members remove hanging shells and/or veins for quality control purposes. Loading rate of prawns was low and not all of the loading slots were necessarily used at a time.

Recommendations:

- Loading rate could be improved by loading every slot for every automated peel (Figure 12).

Figure 12: Automated peeling machine with all prawn slots filled.

- Only one staff member should be used for the quality control inspection area after automated peeling.
- Peeling machine settings; blade pressure, water jet, cleanliness of de-veining brushes are very important to the appearance and control of meat loss through the peeling machine. These settings need to be continuously monitored; proper training of staff is essential.
- A few trials conducted by monitoring the peeling machine settings indicated that the yield varied from 82.85% (headless shell on to peeled, deveined, tail on) to 87.20% by cleaning the brushes and adjusting blade depth. This indicated that proper tuning of the peeling machine on a continual basis would result in an extra 1- 2 % yield and improve the throughput by up to 50 to 60%.

Brine IQF

- The brine IQF was efficient and froze product quickly. However, the product carried a salty taste with absorption during the 4 to 5 minutes of freezing. This resulted in a product which was judged as not desirable to all consumers.

Recommendation:

- ➢ The brine freezer stage could be eliminated. The preferred process would be to blast freeze the product and take it to storage the same day; reducing labour and improving product quality

Blast freezing after brine freezing

- Blast freezer is well maintained at close to -40°C; the practice was to offload product from the brine freezer and leave it overnight in the blast freezer.
- The final pack is 3 kg (bulk), prawns stick together and the separation of individual prawns is difficult, which is likely to lead to prawn tail breakage during separation.

Recommendation:

- ➢ To avoid prawn tail breakage during separation, product could be processed into individual packs instead of bulk packs (Figure 13).

Figure 13: 1 kg individually frozen pack

Overall Recommendations:

Recommendations for alterations to the prawn processing production included modifications to the prawn processing line (Figure 14) as well as the introduction of ice into the processing line to ensure prawn core temperatures are maintained under +5ºC (core temperatures prior to ice introduction into the processing line averaged +12ºC).

Advantages of the suggested modifications to the prawn processing line would include:

- Speedier processing time, reducing the 3 day process to a same day process and most likely reducing the resultant microbiological counts.
- Maintenance of core temperatures during processing
- Rapid thawing will maintain a better product quality.
- The elimination of the brine freezing step will avoid the “salty taste” in the final product
- Reduced labour use
- Reduced freezing costs

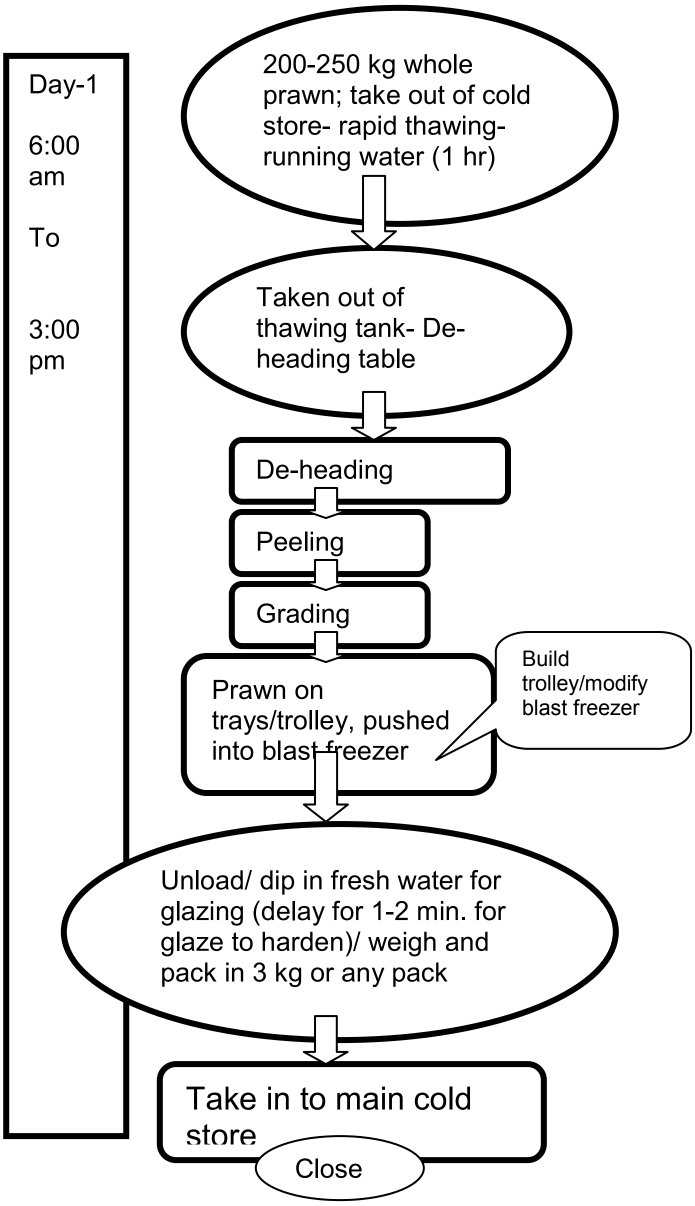

Figure 14: Recommended flow chart of prawn processing actions

Overview of results

The recommendations were positively received by the prawn processing company and follow up actions were requested to implement changes to their freezing and processing practices. A detailed energy audit of their processing premises to identify potential opportunities to eliminate one or more intermediary processes was also conducted with initial estimates revealing an opportunity to save up to $A70,000 per annum by means of improved efficiencies.

Reviews of the processor detailed investigations identifying staff training had been conducted and a few changes suggested in the report had been implemented. These measurable changes could be quantified in terms of an improvement to the quality of the end product (texture, flavour), improvement in yield and other handling practices.

Furthermore, after follow up consultations to the processor a subsequent review of the prawn IQF freezing process identified further areas to improve the quality of the end product and to control yield losses of frozen prawns by introducing a glaze hardening process. Glazing of prawns would improve the final prawn quality and add value during long term storage.

Sardine Production

Processes for Sardine Product Development

<u>Selection of fish</u>

- Critical factors in choosing fish for human consumption are size and efficient post harvest handling.
- Larger boats take a longer time to fill their tanks and by the time they offload their catch the fish has lost quality and become unfit for processing for human consumption.
- Smaller boats hold up to 5 MT; these size boats can trawl for larger size sardines with limited travel time.

<u>IQF processing</u>

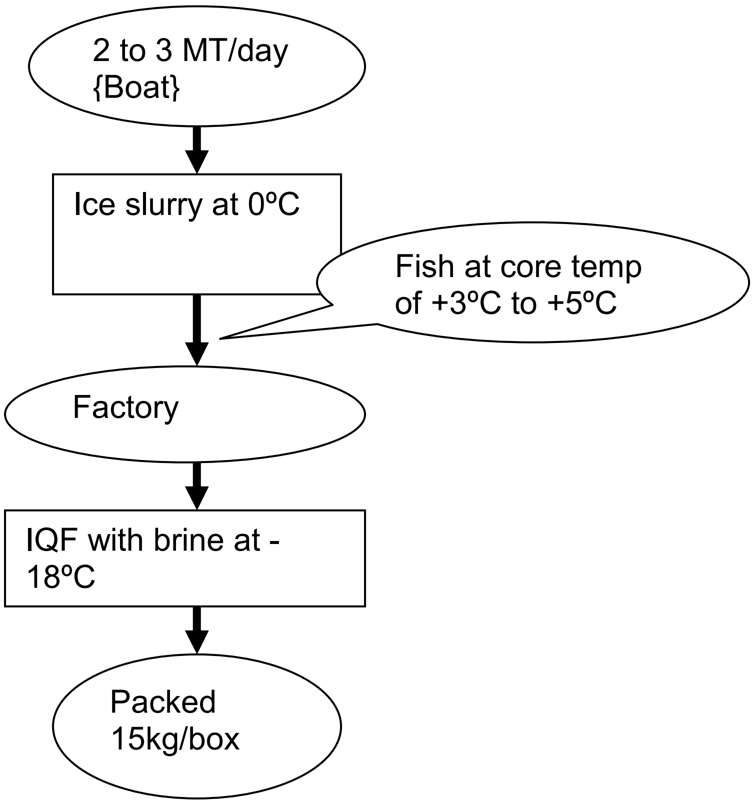

Figure 15: Flow chart of Sardine processing procedures

Observations

- Fish is caught and stored in an ice slurry (onboard the boat) and is transported to factory.

- The fish arrives at factory with core temperature of +3ºC to +5ºC
- IQF brine is maintained at -18ºC
- Freezing time is 15 to 20 minutes; the core temperature of fish is attained at -12°C. But at times the average core temperature noticed is only around -6°C
- Brine quality is not maintained consistently, the main issues are blood, guts and other wastes such as detached scales mixing in the brine from broken fish.
- There is a sand filter installed to filter the brine.

Fish are filleted with an automatic filleting line

Observations

- Only large size fish are selected for filleting.
- Issues are freshness and uniform size which helps maintain the filleting machine setting for example, curled fish create problems for automatic feeding, increasing labour costs.
- The core temperature of fish is around +5°C at the feeding buffer tank for the filleting line
- The temperature rises rapidly to +8°C at the entry point of the fillet machine
- The fillets reach +13°C at the time of setting and to +19°C after packing.
- The trays are taken to chill store to drop the temperature.
- The in feed fillet conveyor is too fast; it is hard to align fish into the slots.

Recommendations

- ➢ Reduction of feeding conveyor speed would likely aid in increasing the throughput.
- ➢ All slots should be filled to get the best possible capacity through the filleting line.
- ➢ Maintaining core temperature below +6°C will help retain the fillets' freshness and shelf life.
- ➢ A chilled water spray <+4°C over the filleting machine line will help maintain the temperature.

Fillet line efficiency

Observations

- The filleting line conveyor is moving at the rate of 200 slots/minute
- One staff member is able to align up to 80 pieces/ minute leaving 120 slots going empty (Figure 16).

Figure 16: Feeding conveyor issues (inefficient use of fish slots)

- Ungraded fish in the filleting machine, fillets sardines inefficiently (Figure 17)

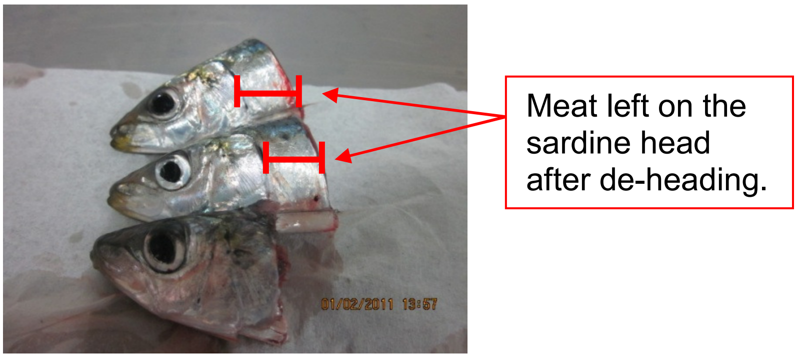

Figure 17: Meat left on the head of some sardines when placed in the filleting machine without being graded

Recommendations

- Grade fillets and set filleting machine to accurately cut heads. This could potentially yield up to 5 to7% more sardine flesh.
- Install a variable speed drive unit for the feeding conveyor.
- With practice and trials achieve the best throughput by setting up the optimum speed of the conveyor
- Changing gears to change the speed helps only with one option and optimum capacity will not be possible

<u>Fresh chilled Sardines for human consumption</u>

Observations

- Fresh sardines packed in 10 kg esky boxes in chilled form
- Sardines received in bins with ice slurry
- Sardines taken out of ice slurry, weighed and packed in esky with liner bags
- Approximately 2 kg of ice is topped up inside the esky to maintain the temperature
- These eskies are stored chilled and transported to Melbourne
- The fish received and opened after 2 days from packing for sale in the market do not retain freshness (belly cracks, unacceptable to consumers).

- The core temperature of fish received in bins is not consistently below +5°C.
- Bulk 10 kg quantities crush bottom layer fish, also ice melts when packaged on top of fish resulting in bottom layer fish covered in water causing considerable spoilage.

Recommendations

- ➢ Further trials/investigations have to be conducted
- ➢ Fish received in bins from boat have to be chilled instantly from harvest to ≤+2°C.
- ➢ Fish have to be rinsed/sanitised/chilled before packing
- ➢ Instead of ice topping directly on top of fish, may need to consider the use of ice in sealed bags or gel packs
- ➢ Consider packing fish in 5 kg eskies using a wider esky rather than a deeper esky.

Good manufacturing practices

Observations

Staff entry

- There is no provision for staff entry arrangement separately
- People enter through packing store
- There should be a foot dip at staff entry point

Staff hygiene

- Often staff walk without head gear or product handled without gloves

Figure 18: No head gear or gloves being worn in processing line

Position of tool rack

- There is a tool rack positioned next to filleting line
- Tools were left near machines
- Tools should be kept separately in enclosures, and need to be cleared immediately after maintenance. There is a risk of metals, bolts; nuts, etc being mixed into final packed product.

General hygiene

- Conditions need improvement

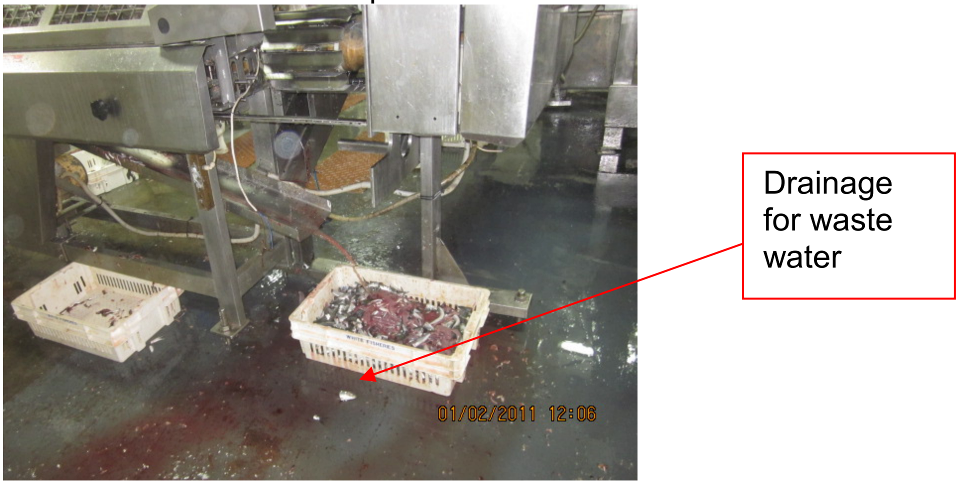

Figure 19: A floor drainage system could prevent slippery floors

<u>Overview</u>

Discussions were held with management and staff relating to following "good manufacturing practices". Evaluation of process and costing in detail were also assessed as part of the project and is currently being progressed through the Sardine CRC project 2010/774.

Cleanseas Tuna's Kingfish

King fish Trials

A basic yield from 1 fish from the loin production:

Whole Fish :	4.70kg (100% yield)
Head and Guts	1.30kg (not utilised in meat extraction)
Collars	0.45kg (not used, has more value sold elsewhere)

Frame	0.45kg (9.58%)
Skin	0.40kg (8.51%)
Rib bones/Pin bone line/trim	0.40kg (8.51%)
Total Yield from Whole	26.60%
Skinless Loins	1.70kg (36.17% yield of finished product)

Trial 1
Frames tail on: 21.50kg
Meat Extracted: 11.70kg, Yield 54.41%
It was noted that some of the tails came through the Baader intact into the bones side, and did not pass through the sieve. Some of the frames fed tail first did not go through the machine and had to be rotated to be put through. Larger trials with a full hopper would be required to evaluate any impact this might have on the throughput.

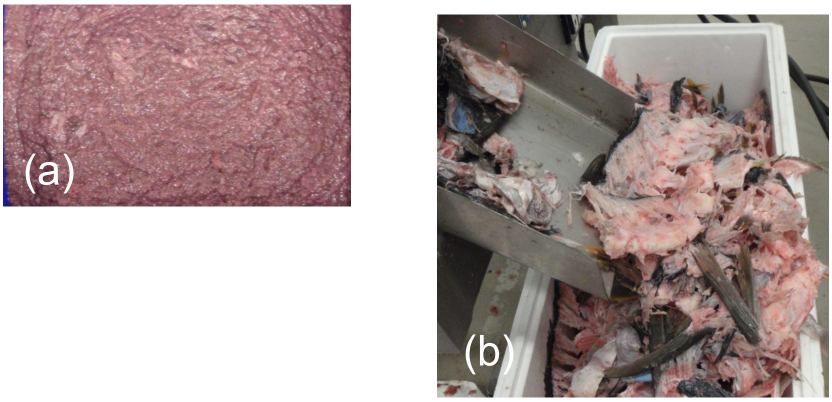

Figure 20: (a) Meat extracted from trial 1 and (b) waste collected

Trial 2
Other off cuts: 29.20kg
Meat Extracted: 20.80kg, Yield 71.23%
The meat from this trial was quite different to the first trial. A much higher yield was achieved and the resultant meat was paler in colour and of a thicker texture, not as sloppy/wet as trial 1 meat.

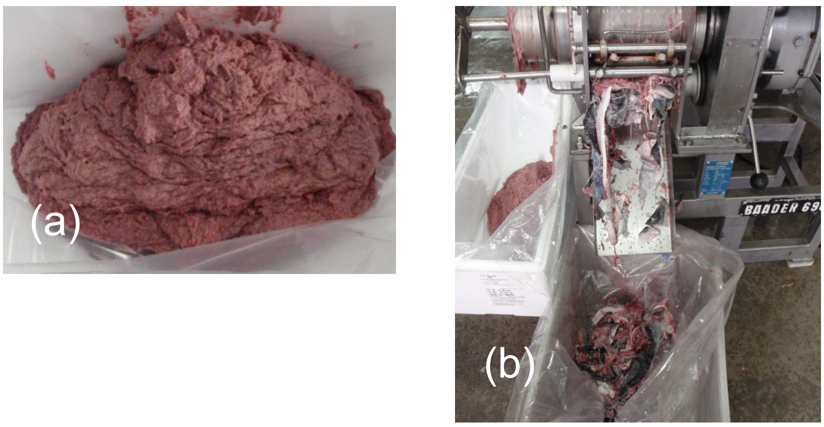

Figure 21: (a) Meat extracted from trial 2 and (b) waste collected

Labour and Throughput

Trial 1: It took approximately 7 minutes to feed the 21.50kg of frames through the machine and collect the meat with 2 labour units (1 feeding and 1 collecting meat and bones).
This equates to approx 185kg/hour of input, 100kg of output.

Trial 2: It took approximately 15 minutes to feed the 29.20kg of off cuts through the machine and collect the meat with 2 labour personnel (1 person feeding and 1 person collecting meat and bones).
This equates to approx 115kg/hour of input, 80kg of output. It was slower than the first trial as the yield was much greater and also, due to the irregular nature of the material, the hopper could not be overloaded as it would not feed through. This may need further investigation and validation over a larger trial.

Summary

- Meat extracted successfully from kingfish frames
- Yields from different combinations were established, and meat samples frozen.
- The samples were used in trials for potential new products, with promising outcomes.
- The provision of high quality products from the extraction trials led to an acceptance by industry partners of the value of the new product development activities.

4 Benefits and Adoption

- Improved layout, energy saving opportunities and optimisation of labour use for various processing plants (Seafood CRC participants).
- Meat extraction trials from low value Australian species successfully completed
- Value addition by high pressure processing for Abalone, achieved encouraging positive results, leading to scope for future work
- Conducted meat extraction trials from Kingfish waste products
- Partly-commissioned automatic bagging and weighing line for Sardine association to develop a new product format for human consumption
- Organised ideal layout (next phase of development) of several seafood processing plants, saving labour costs, improving product quality and throughput.
- Instrumental in developing cost control models for seafood CRC participants, to improve their overall manufacturing efficiencies

5 Further Development

Further research into new technologies should be examined to improve seafood processing, such as HPP (High Pressure Processing) and CAS (Cell Alive System) of freezing for observing the effects these methods have on seafood quality. Also, detailed market research is essential to understand the acceptance of HPP processed and vacuum packed abalone as well as other seafood product in this chilled form. The other important area where seafood processing industries should improve is “process automation”; there is a long way to go to achieve greater control over product quality and operational costs.

6 Planned Outcomes

Public Benefit Outcomes

Raj, M.; Carragher, J.; Holds, G.; Barber, A.R.; Eddie, S.R. Product and process improvement in a seafood processor; a case study. *Abstracts*, 42nd Australian Institute of Food Science and Technology Convention, July 13-16, 2009. Brisbane, Australia.

Raj, M.; Hubbard, T.; Carragher, J.F.; Eddie, S.R.; Barber, A.R. Improved manufacturing practices in Australian seafood processing. *Abstracts*, 42nd Australian Institute of Food Science and Technology Convention, July 13-16, 2009. Brisbane, Australia.

Raj, M. (2008). Seafood Technical Workshop, 28th November 2008. Sydney, New South Wales.

Raj, M. (2008). Seafood Technical Workshop, 26th November 2008. Melbourne, Victoria.

Raj, M. (2008). Seafood Technical Workshop, 2nd December 2008. Adelaide, South Australia.

Raj, M. (2008). Seafood Technical Workshop, 4th December 2008. Perth, Western Australia

Barber, A., Raj, M. and Carragher, J. (2008) “Trends in Seafood Packaging”. Seafood CRC Master Class DVD, South Australian Research And Development Institute (SARDI) and Seafood CRC, December.

Private Benefit Outcomes

This project provided the postdoctoral fellow with opportunities to observe and work in various areas of the seafood processing industry across the country. By improving the manufacturing abilities of several processing firms (Seafood CRC participants) in the areas of process improvement, efficiency, product shelf life extension, value addition, process automation, engineering and process management, this research added to the postdoctoral fellow’s industrial experience. Finally, by gaining access to different seafood processing units it also allowed for the development of the post doctoral fellow’s knowledge and skill sets, which allowed him to further his career by accepting a position in an Australian seafood processing business at the completion of this project.

Linkages with CRC Milestone Outcomes

Half yearly reports submitted once every six months. Process review reports submitted for individual Seafood CRC participants following site/factory visits.

7 Conclusion

From this research study a number of process improvement reports have been developed for Australian seafood processors. These reports have aided Australian seafood processors in their processing efficiency via automation, reorganisation of production line layout, product value addition and ultimately reduction in product producing costs due to the implementation of recommendations from this report. A range of other seafood processors have been exposed to best practice in seafood packaging through workshops provided in four states.

Author Acknowledgement

The principal investigators wish to thank Nancy Leo for her assistance in consolidating this final report.