Value Adding to the School Prawn Industry: Clarence River Case Study

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NON-TECHNICAL SUMMARY

Project 2011/746 Value Adding to the School Prawn Industry: Clarence River Case Study

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PROJECT OBJECTIVES:

1. To identify and pilot an economically feasible end-use/new market for extracted green school prawn meat
2. To increase profitability for the commercial school prawn fishery

OUTCOMES ACHIEVED

- Determination of the processing methods and costs for the extraction of cooked school prawn meat using the Baader separator. This information could be further developed and utilised by the prawn industry to open up new market opportunities, especially for the development of value added products including liquid based prawn flavoured products (prawn broths and bisques).
- Determination of the nutritional panel data and an indication on the expected frozen and thawed shelf lives of vacuum packed extracted cooked school prawn meat. These findings could assist the industry in establishing product specifications.

LIST OF OUTPUTS PRODUCED

- Nutritional panel data for extracted school prawn meat.
- Recipes for Asian style prawn stock, French style prawn stock, prawn bisque and hot and sour prawn soup.

ACKNOWLEDGEMENTS

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- Janet Howieson from the Centre of Excellence for Science, Seafood and Health
- Sydney Fish Market for loan of the Baader 696 soft meat separator that was used to extract the prawn meat.

EXECUTIVE SUMMARY

This project aimed to investigate the mechanical extraction of meat from whole school prawns as a means to develop a new revenue stream for the industry. Five extraction trials were undertaken and the quality and shelf-life of the extracted products assessed through sensory, microbiological and biochemical methods.

The initial extraction trials considered green prawns, however the extracted product rapidly degraded. Enzymes normally contained in the prawns' digestive tract were thought to have dispersed throughout the product during the extraction process, and the resulting reaction with the prawn meat caused product degradation. Cooking the extracted meat (sous vide style) or use of chemical additives (1% solutions of sodium metabisulphite, sodium ascorbate, citric acid or sodium bicarbonate) did not provide desirable outcomes. The meat recovered from the extraction of green prawns was not regarded as a viable product.

Latter trials considered the extraction of meat from cooked prawns as heat is capable of inactivating enzymes. The extracted meat was more stable and under the conditions examined had an indicative chilled shelf-life of two-three days. The meat recovered from the cooked prawns was described as having a fresh prawn flavour and aroma.

The commercial value and properties of the cooked extracted meat were determined with the assistance of a consultant chef. The cooked prawn meat was also used to develop eight application concepts. The extracted meat and four of these concepts were shown to six commercial food manufacturers in the Sydney area. Four of the manufacturers indicated that they would consider using the extracted meat. The suggested pack size varied between manufacturers but ranged from 2-10 kg, whilst purchase price (what they would be prepared to pay for the extracted meat or thought it was worth) varied from \$9/kg (one manufacturer) up to \$11/kg (three manufacturers). The most important factors identified in the decision making process when choosing a product were price, sustainability, flavour, provenance and shelf-life.

1 INTRODUCTION

School prawns (*Metapenaeus macleayi*) are marine and estuarine prawns found along the east coast of Australia, between southern Queensland and eastern Victoria (Rowling et al., 2010). School prawns are generally small in size, averaging 9 cm in total length and are low to medium priced (Sydney Fish Market, 2013). Maximum body lengths are 17.5 cm for females and 14.6 cm for males (Food and Agriculture Organization of the United Nations, 1998).

The Clarence River Fisherman's Co-operative (CRFC) is one of the largest suppliers of school prawns along the east coast of Australia with fresh product supplied from October to late April/early May. Approximately half of their annual landing[1] is currently supplied as bait for commercial and recreational fishers. However, this bait market is being eroded by the use of artificial baits and the industry is seeking alternative markets and revenue streams for school prawns.

Given that school prawns are low to medium priced, there is significant opportunity to increase the margin for this species by value adding. The 'Whole Prawn' project (Project 2010/744) identified an opportunity for the extraction of green school prawn meat to be used as an ingredient for the restaurant and catering trade. It was identified in Project 2008/793.10 (Optimising quality and value in the domestic prawn value chains) that labour costs to peel school prawns were high; however, approximately 50% of Sydney chefs interviewed indicated that extracted school prawn meat was of interest.

The initial focus of this project was to determine the market potential of extracted green school prawn meat and any resulting product concepts. The project was to use the successful end-user consultation methods from Project 2010/708 (Accelerated new product development: blue swimmer crab pilot study) to facilitate a path to market. However, during the course of the investigations the extracted green prawn meat rapidly degraded during processing, handling and/or storage and was not a viable product. The project scope subsequently shifted to determine the market potential of extracted meat from cooked school prawns. This market potential was evaluated by determining the products' indicative cost, likely applications, and seeking feedback from respected food manufacturers.

1.1 NEED

Project 2010/744 investigated the development opportunities for wild capture prawns in the Australian market. For school prawns, Project 2010/744 identified an opportunity to extract prawn meat from whole school prawns. This extracted product could potentially be marketed as an ingredient/product solution for the restaurant and catering trade. The market opportunity of the extracted product, when examined as part of Project 2008/793.10, was seen to be positive and worth further investigation.

The CRFC believed that extracted prawn meat could add another avenue of value-add to the prawn industry and freezing the product could enable year-round supply. However,

[1] Annual landing (calculated on a three year average from 2010/11, 2011/12 and 2012/13) is approximately 300 tonnes

information on production costs, product shelf-life, specifications and quality attributes and market potential was required.

1.2 OBJECTIVES

- To identify and pilot an economically feasible end-use/new market for extracted green school prawn meat
- To increase the profitability for the commercial school prawn fishery

2 METHODS

At the commencement of the project, the project team met with key personnel from the Clarence River Fishermen's Co-operative (CRFC) to discuss the major components of the project and commence a commercialisation pathway. During the course of the project five extraction trials were undertaken with a Baader soft meat separator. Data collected from the trials were used to determine and validate the cost of production, recovery rates, packaging requirements, shelf-life, nutritional composition and product specifications. Market opportunities for the extracted prawn meat and market feasibility were determined with the support of Diana Thompson (a consultant chef), and a seafood marketing expert, John Susman (Fisheads Seafood Strategy). Diana Thompson and John Susman were contracted to assist in this project based on their experience and input in Project No 2010/706.

2.1 RAW MATERIALS

All of the product extraction trials were conducted at CRFC's Maclean Depot (New South Wales). The school prawns had been caught by commercial fishers using standard commercial methods, and were green/chilled, green/thawed or cooked/thawed. Specific details on the raw materials used for each trial are contained in the respective trial reports (see Appendices 3, 4, 5, 6, 7 and 8).

2.2 PROCESSING EQUIPMENT

In all trials, the whole school prawns were processed by passing them through a Baader 696 soft meat separator (Baader Food Processing Machinery, Lübeck Germany). The assembly steps of the Baader separator are shown in Figure 1. This separator can process a wide range of raw materials and could also be useful for the prawn industry to produce an extracted meat from soft and broken product. The material flow and counter-rotating belt and perforated drum in the separator are highlighted in Figure 2. Raw material (whole prawns) were fed through the hopper into the machine and the counter-rotating belt squashed the soft tissue (prawn meat) into a perforated drum. The extracted tissue (prawn meat) was removed from the drum with the aid of a stationary auger. Hard tissue (prawn shell) that did not pass through the perforations was removed from the outside of the perforated drum with a scraper for collection.

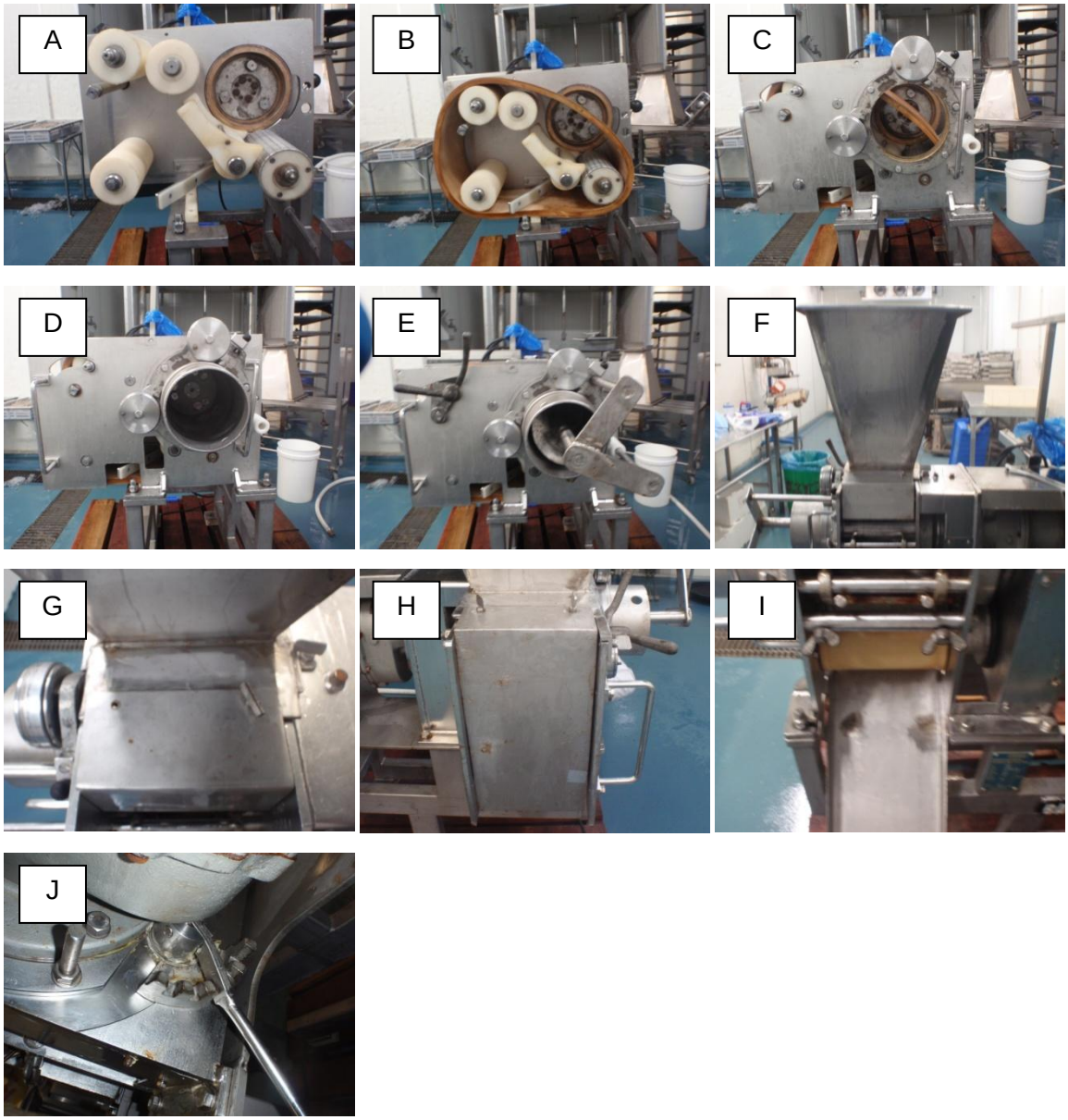

Figure 1 Baader extractor during assembly; (A) Rollers installed; (B) Belt installed; (C) Front plate installed; (D) Drum installed; (E) Stationary auger and front tension adjuster installed; (F) Hopper installed; (G) right hand side guard installed; (H) left hand side guard installed; (I) chute and scraper installed; (J) rear belt tension adjuster

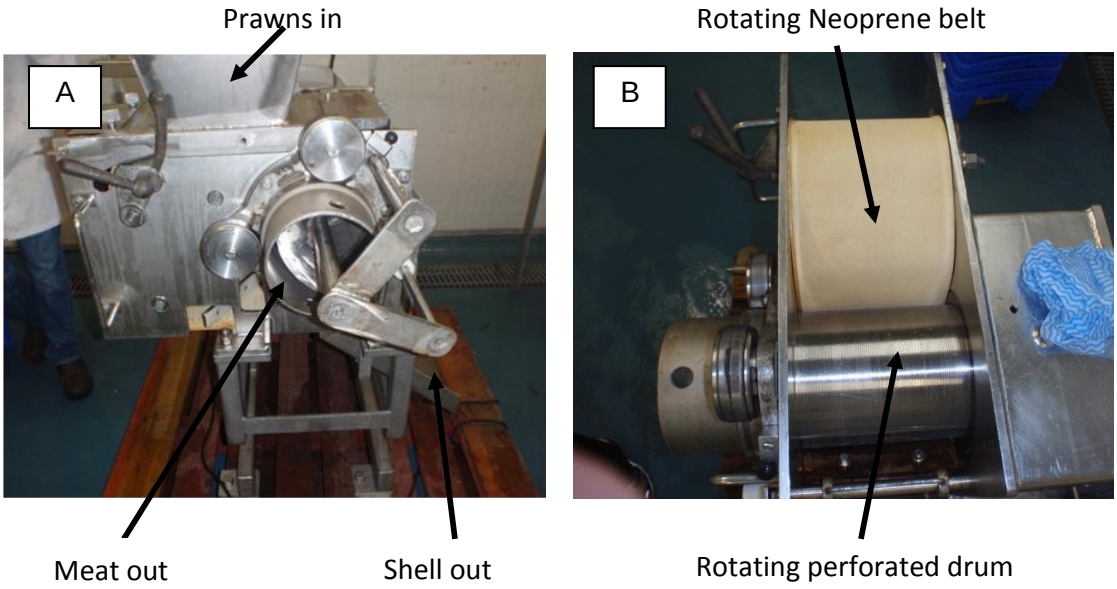

Figure 2 Baader 696 soft meat separator highlighting; (A) product flow, (B) Mechanism of operation – the Neoprene belt squeezes the prawn meat into the perforated drum (hopper and auger removed)

The Baader separator was washed and/or sanitised prior and after use. Specific details of the sanitisation procedure used for each trial are contained in the trial reports (see Appendices 3, 4, 5, 7 and 8). Photographs of the Baader extractor during operation are shown in Figure 3.

Figure 3 Baader separator during processing of green chilled prawns (Trial 2); (A) collection of the extracted prawn meat, (B) collection of the shell

2.3 SHELF-LIFE ASSESSMENT PROGRAM

The shelf-life assessment program for the trials involved a number of different measurements during the chilled, frozen or thawed shelf-life periods. The main evaluations and analysis undertaken included microbiological, informal sensory and

biochemical, and are outlined in the sections below. Details on the specific assessments undertaken in each trial are outlined in the trial reports (see Appendices 3, 4, 5, 7 and 8).

2.3.1 Microbiological Evaluation

This evaluation involved microbiological analysis of the product concepts using:

a) **Standard plate count (SPC)** using AOAC Official method 990.12 (for 96 hours ± 3 hours at 25°C ± 1°C for seafood, or 72 hours at 30°C),

b) ***Salmonella*** using AS 5013.10-2009,

c) **Coagulase-positive *Staphylococci*** using AOAC Official Method 2003.11,

d) **Total coliforms** using AS 5013.3-2009

e) ***E. coli*** using AOAC Official method 998.08,

Coagulase-positive *Staphylococci*, *Salmonella* and SPC were measured to get an understanding of the product quality and compare with the prescribed limits for both cooked and raw crustacean in the Australia New Zealand Food Standards Code (Standard 1.6.1). Total coliforms and *E. coli* were measured as indicators of product hygiene. All analyses were undertaken at the SARDI Food Safety and Innovation Laboratories (Urrbrae, South Australia). The Australia New Zealand Food Standards Code stipulates that SPCs must be quantified at 30°C for 72 hours. A lower incubation temperature of 25°C for SPCs was also examined as the International Commission on Microbiological Specifications for Foods (ICMSF) reported that SPCs at 25°C were the most widely accepted microbiological criteria for chilled and frozen raw fish (Ángas et al., 1998).

2.3.2 Sensory Evaluation

To gain an understanding of the stability of the extracted meat in chilled and frozen storage conditions, sensory evaluations were undertaken with informal panels which consisted of three to thirteen members from the SARDI Food Safety and Innovation team. In all panels, the extracted prawn meat was rated using a seven point category scale (1 = extremely poor, 2 = very poor, 3 = poor, 4 = neither good nor poor, 5 = good, 6 = very good, 7 = excellent). Raw products were assessed for appearance, colour, aroma and texture. Cooked products were dry fried (in a non-stick frying pan without any additional ingredients) and assessed for appearance, colour, aroma, flavour and texture.

2.3.3 Biochemical Analysis

Biochemical assessments were used to assist in developing product specifications and determining the stability of the extracted meat in chilled and frozen storage conditions.

a) **Lipid oxidation**

An assessment of lipid oxidative rancidity was undertaken by the measurement of thiobarbitric acid-reactive substances (TBARs). Product samples were stored at -80°C

and dispatched to the Lincoln Marine Science Centre (Port Lincoln, South Australia) on dry ice. The analysis was undertaken using a spectrophotometric method based on Wong et al. (1991). Absorbance was measured at 540 nm and readings were compared to a calibration curve with malonaldehyde as the standard.

b) Nucleotide degradation

Nucleotide degradation is an autolytic process during which adenosine triphosphate (ATP) is broken down by a series of dephosphorylation and deamination reactions to hypoxanthine (Hx). Product samples were stored at -80°C and dispatched to the Lincoln Marine Science Centre (Port Lincoln, South Australia) on dry ice. Nucleotides were extracted on ice in 0.6M perchloric acid for 30 minutes and the recovered nucleotides were separated and quantified by high performance liquid chromatography (HPLC) methodologies. The extent of ATP degradation was determined on k-value, calculated by the concentration of unphosphorylated to phosphorylated nucleotides:

$$\text{k-value} = \frac{\text{HxR} + \text{Hx}}{\text{ATP} + \text{ADP} + \text{AMP} + \text{IMP} + \text{HxR} + \text{Hx}} \times 100$$

where ATP is adenosine triphosphate, ADP is adenosine diphosphate, AMP is adenosine monophosphate, IMP is inosine monophosphate, HxR is inosine, and Hx is hypoxanthine

c) Moisture content

The moisture content was determined by comparing the initial weight to the dried weight. Drying was achieved at 105°C with a MLS-50 moisture analyser (Kern & Son GMbH, Balingen, Germany) until constant weight (<1 mg change in 2 minutes) was recorded.

d) Nutritional composition

The nutritional composition of the extracted green and cooked school prawn meat was evaluated by Food Laboratories (Aust) Pty Ltd in Victoria. Product samples were dispatched to the Food Laboratories by commercial transport and analysed for energy value, protein, fat (including total fat, saturated fat, monounsaturated fat, trans-unsaturated fat, polyunsaturated fat, total Omega-3 fatty acids, alpha-linolenic acid, eicosapentaenoic acid and docosahexaenoic acid), carbohydrate (total and sugars), sodium, calcium and moisture. Information obtained could be used in developing a nutritional information panel.

e) pH

The pH was measured with a WP80 pH meter with a calibrated Ag/AgCl intermediate junction pH sensor (TPS Pty Ltd, Springwood, Queensland) after a 1:10 dilution in demineralised water (Diggers, Reochem Inc, Lyton, Queensland).

2.3.4 Statistical Analysis

All statistical analyses were performed with the statistical software R (version 3.0.1). Analysis of variance, based on a significance level of 0.05, was used to assess whether there were statistically significant differences between treatments and sensory responses. For any significant differences, pairwise comparisons were performed using t-tests.

2.4 EVALUATE MARKET FEASIBILITY

The market feasibility of the extracted meat was evaluated with the assistance of an industry food consultant, Diana Thompson, and a seafood business development expert, John Susman. These consultants were also involved in Project 2010/706. The market feasibility of the extracted meat was assessed by determining:

- indicative cost of production
- products' potential and likely uses
- drivers for manufacturers' decision to purchase the extracted meat.

2.4.1 Indicative Production Cost

The indicative cost of production was determined from data collected during the trials and feedback from the CRFC. The cost of production included the average cost of raw materials (cooked prawns), product recovery yield, labour requirements, packaging requirements and overheads.

2.4.2 Products' Potential and Likely Usage

The products' potential and likely usage was determined through a three stage process. In the first stage extracted product was assessed by SARDI Food Safety and Innovation staff and used in the development of some prawn-based wontons. In the second stage Diana Thompson received samples of the green, cooked and sous vide product versions from Trial 4. Diana Thompson evaluated the product concepts in their original form for potential viability and sensory quality (appearance, texture, aroma and flavour). The cooked and green product concepts were used as a key component in several application concepts which were appraised for quality and performance using her technical skills and experience.

In the third stage Diana Thompson received samples of the cooked product concept from Trial 5. Following discussions with Diana Thompson and John Susman it was decided that due to product specific limitations (particularly visual appearance and presence of grit) an ideation session was not appropriate. Information and knowledge gained from the second stage was used to develop eight different application concepts. The extracted product was assessed for quality and application concepts were appraised with the assistance of John Susman.

2.4.3 Feedback on Product Concept from Respected Food Manufacturers

Eleven targeted commercial stock, soup and pasta sauce manufacturers (predominately based in New South Wales) were contacted by Diana Thompson to determine their level of interest in the product. The food manufacturers were provided background information on the project and product concept. Face to face interviews were arranged with manufacturers that were responsive to the request and samples of the top four value-added application ideas (two stocks and two soups) were provided to these manufacturers. The food manufacturers were asked to rate the value-added products' attributes for prawn flavour, colour, clarity and aroma.

After evaluating the value-added application ideas the food manufacturers were then shown a sample of the cooked extracted meat. The face to face interviews and a questionnaire (which was developed in consultation with the CRFC) were used to determine the willingness of the targeted manufacturers to uptake the new product (i.e. could they see themselves using the cooked extracted prawn meat within their range?). Opinions were also sought on preferred product and packaging format (i.e. chilled/frozen, pack size, and type of pack presentation) and its wholesale market value.

The questionnaire also sought feedback from the food manufacturers on the importance of the following factors in their own decision making process when choosing a product:

(a) Price
(b) Sustainability
(c) Pack size
(d) Convenience
(e) Provenance/source
(f) Year-round availability
(g) Farmed seafood
(h) Wild-caught seafood
(i) Fresh
(j) Frozen
(k) Taste
(l) Other

2.5 Path to Market

A potential path to market was developed using information obtained from the extraction trials, knowledge of the products characteristics and potential, feedback gained from the targeted commercial stock, soup and pasta companies and discussions with the CRFC.

3 RESULTS AND DISCUSSION

3.1 Product Extraction Trials

During the course of this project five extraction trials were undertaken. A summary of the projects' progression through the trials is below and separate trial reports are included in Appendices 3, 4, 5, 7 and 8:

- Trial 1 (27 October 2011) demonstrated the Baader soft meat separator to key personnel at the CRFC.
- Trial 2 (18 April 2012) extracted green prawn meat had an unacceptable microbiological load and was discarded.
- Trial 3 (17 May 2012) extracted green prawn meat had an acceptable microbiological load, but rapidly degraded.
- Trial 4 considered a range of treatment options to improve product stability. Product was used to generate several initial application concepts.
- Trial 5 validated the process and data were collected to determine the cost of production. Product was used to generate additional application concepts and determine the market and commercial viability of the extracted meat.

3.1.1 Equipment Throughput

The throughput and yield from cooked and green prawns were determined from data collected in the trials. The throughput of whole prawns varied significantly during the trials and depended on the rate at which prawns were fed into the hopper. In all trials the whole prawns were manually loaded into the hopper.

- Manual loading of the whole prawns with significant start-stop operation to transfer the extracted product to the chiller resulted in a throughput of approximately 285 kg/hour (Trial 5). However, higher throughputs were achieved, i.e. 850 kg/hour (Trial 2) and up to 1,800 kg/hour (Trial 5).
- If too many prawns were loaded into the hopper at any one time, occasionally the prawns would not flow between the belt and perforated drum and this would prevent them from being processed. On the other hand, if too few prawns were loaded into the hopper, than the separator would run out of prawns.
- Consequently, the throughput with a commercial processing line remains unknown; however, a conservative estimate is that a throughput of at least 850 kg/hour is achievable.

3.1.2 Product Yield

A summary of the extracted meat yields are reported in Table 1. Logistical constraints (inability to weigh all inputs and outputs due to time and space limitations caused by working in an industry environment during commercial production) during Trials 4 and 5 meant that there is some uncertainty over the yield from cooked prawns. The summary of the product yields reported below are the best estimate based on data collected. The actual yield should be reviewed as it would have a significant impact on the commercial viability, see Section 3.2.1.

Table 1 Summary of the product yields

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Yield of green extracted meat (% of green prawns)	81.9%	85.9%[A]	86.8%	86.0%	-
Yield of cooked extracted meat (% of cooked prawns)	-	-	-	60.8%[B]	64.4%[C]

[A] Weight of recovered product was not recorded (calculated by difference)

[B] Weight of cooked prawns not measured (assumed 15% weight loss during cooking of green prawns). Weight of recovered product not recorded (weight of product estimated based on the number of bags packaged to a minimum weight of 500 grams).

[C] Weight of cooked prawn not measured (assumed to be weight of prawns as packaged). Total weight of recovered product not recorded (weight of product estimated based on the mean weight of approximately 30% of packaged bags).

3.1.3 Indicative Product Shelf lives

The indicative shelf lives of the extracted prawn meats were determined through microbiological, biochemical and sensory assessments.

Green prawn meat

Green prawn meat was extracted in Trials 1, 2, 3 and 4. Images of the unpackaged and vacuum packaged product are shown in Figure 4. Trial 1 was a preliminary trial to demonstrate the operation of the Baader and the extracted product was not kept for assessment. The product from Trial 2 had unacceptable microbiological contaminants and was discarded. Improvements were made to equipment cleaning and sanitisation procedures and the quality and indicative shelf-life of the green prawn meat from Trials 3 and 4 were assessed. A summary of the results and discussions are below, and additional details are contained in Appendices 3, 4, 5 and 7.

Figure 4 Unpackaged and vacuum packaged green prawn meat (Trial 4)

Standard plate count (SPC)

Chilled product from Trials 3 and 4 were assessed for SPC at 25°C for 96 hours.

- Product from Trial 3 was assessed on day 1 (day of extraction + 1 day of storage at <2°C) and the SPCs were $\log_{10}$ 5.67, 5.86, 5.90, 5.93, 5.97 and 6.15 cfu/g. After being frozen for 7 weeks at -18°C, retention samples from Trial 3 had SPCs of $\log_{10}$ 4.36, 4.48, 4.49, 4.53, 4.69 and 4.86 cfu/g. Freezing is known to reduce microbiological loads by destroying or sub-lethally injuring microbiological cells and the frozen products had lower SPC concentrations.
- Product from Trial 4 (after being frozen for 2 weeks) had SPCs of $\log_{10}$ 5.11, 5.28 and 5.41 cfu/g.
- SPCs in excess of $\log_{10}$ 6.0 cfu/g are usually indicative of extended and/or inadequate refrigeration (Ángas et al., 1998)

Sensory assessment

The extracted prawn meat from Trials 3 and 4 were assessed raw (green) and after being dry fried (cooked in a non-stick frying pan). Images during the sensory assessment are shown in Figure 5.

- Product from Trial 3 was assessed by informal sensory on a 7-point scale[2] after approximately 4 and 8 weeks of frozen storage, the evaluation scores were not significantly different (p-value>0.5) for the products' appearance, colour, aroma, texture and flavour were mostly between 3 (poor) and 4 (neither good nor poor). The extracted prawn meat was characterised as providing strong prawn flavour and aroma, however the product was not visually appealing, contained grit, and exhibited a mealy mouthfeel with lingering unpleasant metallic and bitter aftertastes. Overall, the panellists considered the product from Trial 3 to be unacceptable in the form provided.
- Sensory assessment of the product from Trial 4 (after cooking) by a consultant chef revealed a bitter aftertaste had developed within 1 day of chilled storage. Informal sensory assessments on the chilled (undertaken on days 1, 3, 6 and 8) and thawed (undertaken after 1, 2, 4 and 12 weeks of frozen storage) products did not reveal any noticeable changes in the products appearance, texture and aroma.

[2] 1 = extremely poor, 2 = very poor, 3 = poor, 4 = neither good nor poor, 5 = good, 6 = very good, 7 = excellent

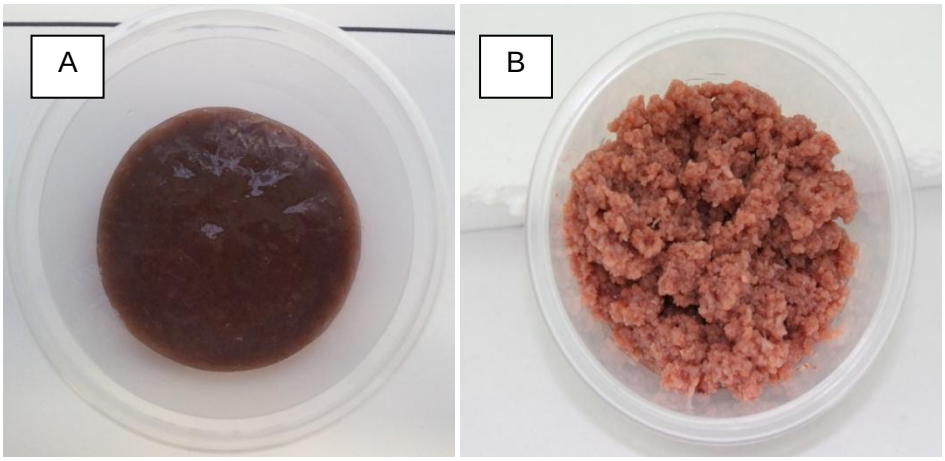

Figure 5 Photographs of the extracted meat during sensory assessment; (A) raw; (B) dry fried

K-value and nucleotide degradation

The k-value is an indicator of nucleotide degradation, which generally proceeds through an enzymatic catalysed process. The k-value is calculated from the concentration of ATP-related nucleotides. For peeled prawns a k-value of 20% has been proposed as the limit to freshness and a k-value of 60% as the limit of acceptability (Sriket, 2006). The concentration of ATP-related nucleotides and the k-value were determined from manually peeled prawns and extracted product recovered from Trial 3 and Trial 4. The effect of the chilled and frozen storage on the k-value of the extracted product recovered from these trials is shown in Figure 6 and Figure 7, respectively.

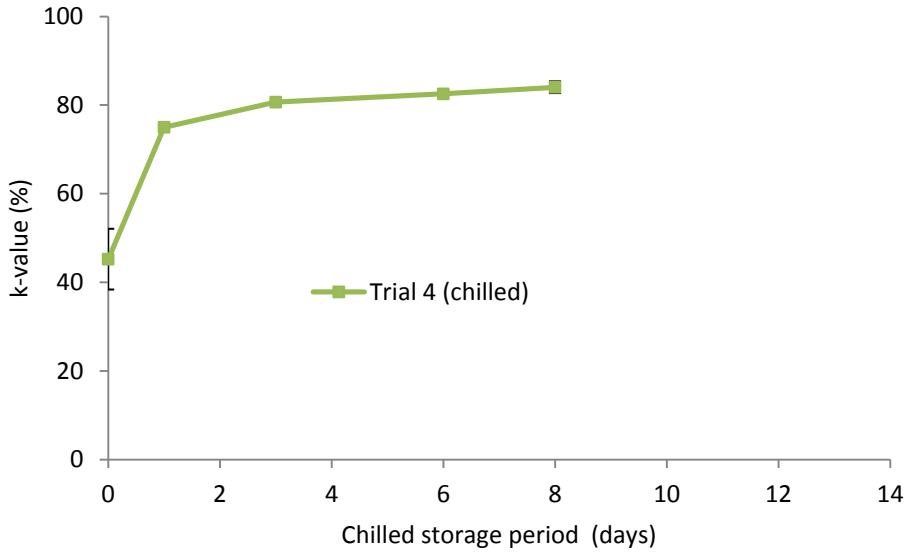

Figure 6 Effect of chilled storage time on the k-value of green extracted prawn meat

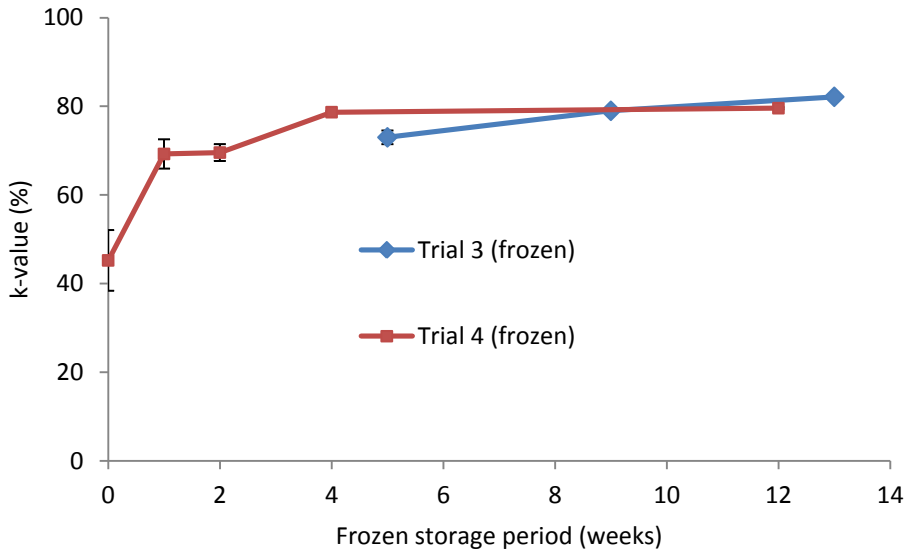

Figure 7 Effect of frozen storage time on the k-value of green extracted prawn meat

- The tail meat (from peeled green prawns in Trial 3) had k-values of between 13.9% and 23.2%.
- The extracted green prawn meat recovered from Trial 4 had an initial k-value of 45.2% which increased during chilled and frozen storage. Whilst the k-values for the extracted meat are above the 20% freshness limit proposed by Sriket (2006), the extracted meat also contained tissue recovered from the hepatopancreas. Consequently the limits proposed by Sriket (2006) may not be applicable for the extracted prawn meat.
- The weight of tissue recovered from the hepatopancreas (from peeled green prawns in Trial 4) was approximately 35% of the weight of the extracted meat. Blending the hepatopancreas (initial k-value 76.1%) with the tail meat (initial k-value 24.4%), as would have occurred when using the Baader separator, the extracted meat should have had a theoretical minimum k-value of approximately 42%. This theoretical k-value is comparable to the measured initial k-value of approximately 45% and indicates that processing and freezing the extracted product at -80 degrees could adequately prevent product enzymatic degradation.
- Hypoxanthine (Hx) is one of the ATP-related degradation products and is frequently noted in the development of bitterness. Hx was detected in all of the extracted prawn meat and its concentration increased during chilled and frozen storage. This product degradation, as illustrated by increases in the concentration of Hx and k-value, were linked to enzymatic activity. The enzymes would have originated from the prawns digestive tract and dispersed through the product during the extraction process.

TBARS

TBARS are an indication of lipid peroxidation and were measured in the extracted green prawn meat recovered in Trial 4.

The concentration of TBARS were low (average <0.075 mg malonaldehyde/kg) and did not increase during chilled and frozen storage. Whilst there is no information on TBARS in school prawns, the levels were well below the 3 mg malonaldehyde/kg limit that has been suggested to indicate good quality seafood (Cadun et al., 2005).

Summary

The extracted green prawn meat was not visually appealing and degraded during storage. Some bitter taste due to enzymatic degradation developed within 1 day of chilled storage. Freezing (at -18°C) did not prevent the degradation (as seen by an increase in k-value) and the processing of whole green prawns with the Baader separator is not recommended.

Treatment options of extracted green prawn meat

A range of treatment options were examined in Trial 4 in an attempt to improve the quality and stability of the extracted green prawn meat. These treatments included cooking the extracted meat or soaking the whole green prawns (prior to extraction) in 1% solutions of sodium metabisulphite, sodium ascorbate, citric acid or sodium bicarbonate. A summary is given below and additional details are contained in Appendix 7.

- Cooking the prawn meat after extraction (sous vide style) reduced the rate of product degradation (based on k-value assessment). However, the sous vide product had very poor appearance and texture and was regarded as a product format that was not worth developing.
- Soaking the whole prawns in sodium metabisulphite, sodium ascorbate, citric acid or sodium bicarbonate did not reduce the rate of product degradation (based on k-value assessment). These treatment options did not provide the desired outcomes and were discontinued from further development and assessment.

Cooked prawn meat

Cooked prawn meat was extracted in Trials 4 and 5. In Trial 4 green prawns were thawed, cooked, held and then processed, whereas in Trial 5 cooked prawns were thawed and processed. There were no noticeable visual differences between the cooked product extracted in Trials 4 and 5. An image of the unpackaged product from Trial 4 is shown in Figure 8. The quality and indicative shelf-life of the cooked extracted meat from Trials 4 and 5 were assessed. A summary of the results and discussion are below, and additional details are contained in Appendices 7 and 8.

Figure 8 Unpackaged cooked prawn meat (Trial 4)

Standard plate count (SPC)

Product from Trial 4 was assessed for SPC at 25°C for 96 hours.

- Product from Trial 4 (after being frozen for 2 weeks) had SPCs of $\log_{10}$ 5.46, 5.58 and 5.62 cfu/g. The extracted product may be at risk of unacceptable high levels of microbiological load. Cooking the whole prawns should have reduced the microbiological load. However, the cooked prawns were stored for 20 hours in a chiller prior to being processed.

Product from Trial 5 was also assessed for SPC at 25°C for 96 hours and at 30°C for 72 hours. The two incubation conditions were used as the Australia New Zealand Food Standards Code stipulates that SPCs must be quantified at 30°C for 72 hours, whereas the International Commission on Microbiological Specifications for Foods (ICMSF) reported that SPCs at 25°C were the most widely accepted microbiological criteria for chilled and frozen raw fish (Ángas et al., 1998).

- Product from Trial 5 (after being frozen for approximately 4 weeks) was thawed and the SPCs were measured during the thawed storage period. The SPCs from samples incubated at 30°C for 72 hours and the acceptable limits prescribed in the Australia New Zealand Food Standards Code for cooked crustacean are shown in Figure 9. By day 3, three samples exceeded the acceptable SPC level prescribed in the Australia New Zealand Food Standards Code.

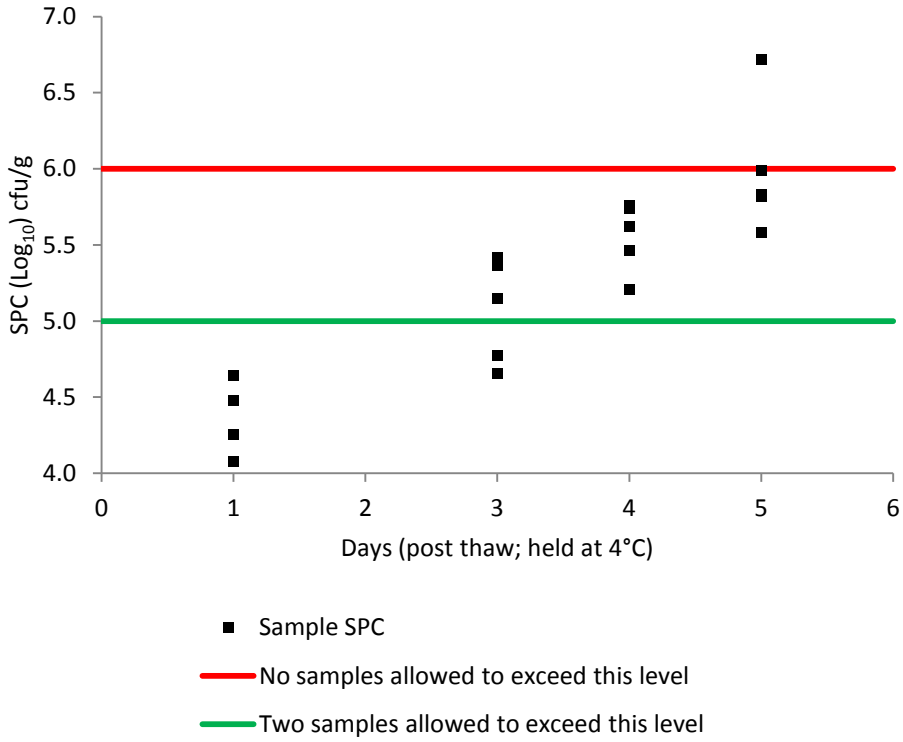

Figure 9 SPC (Log_{10} cfu/g)) results from Trial 5. Samples assessed at 30°C for 72 hours after approximately 4 weeks of storage at -18°C

Sensory assessment

The extracted cooked prawn meat from Trial 4 was assessed by an informal sensory panel for appearance, colour, aroma and texture during chilled storage (undertaken on days 1, 3, 6, and 8) and frozen storage (undertaken after 1, 2, 4, 12 and 24 weeks).

- There were no noticeable changes in the appearance, colour and texture during the chilled storage period. On day 1 the chilled product was described as providing a pleasant fresh prawn flavour and aroma, however, on day 8 the aroma was offensive.
- Sensory assessment of the frozen product did not reveal any noticeable changes in the products' appearance, colour, texture and aroma. After 12 weeks the cooked meat was characterised as providing some sweetness (no bitter or off-flavours). Grit was detected in the extracted meat.

The extracted cooked prawn meat from Trial 5 was assessed over an 8 day post-thaw storage period.

- There were no noticeable changes in the appearance, colour and texture of the thawed product. In all cases the cooked extracted meat was pink/orange in colour with purple/black flecks throughout. The texture of the cooked extracted meat was dry and crumbly and some grit was also detected. The aroma of the product changed during the assessment period and slight sulphurous odours emerged after 4-5 days.

K-value and nucleotide degradation

The k-value of extracted prawn meat from Trial 4 (chilled and frozen storage) and Trial 5 (chilled storage; post thaw) were determined during the storage trials. The effect of the duration of chilled and frozen storage on the k-value of the extracted product is shown in Figure 10 and Figure 11, respectively.

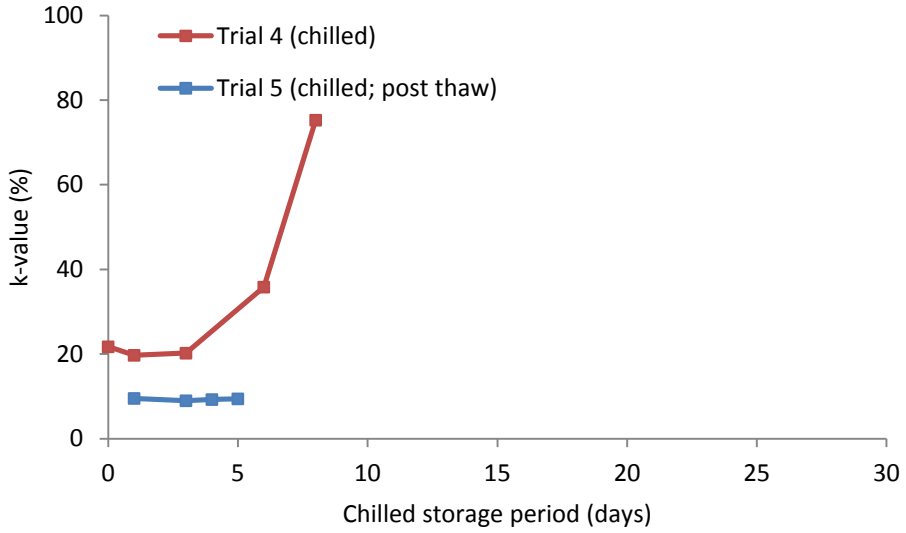

Figure 10 Effect of chilled storage time on the k-value of extracted cooked prawn meat

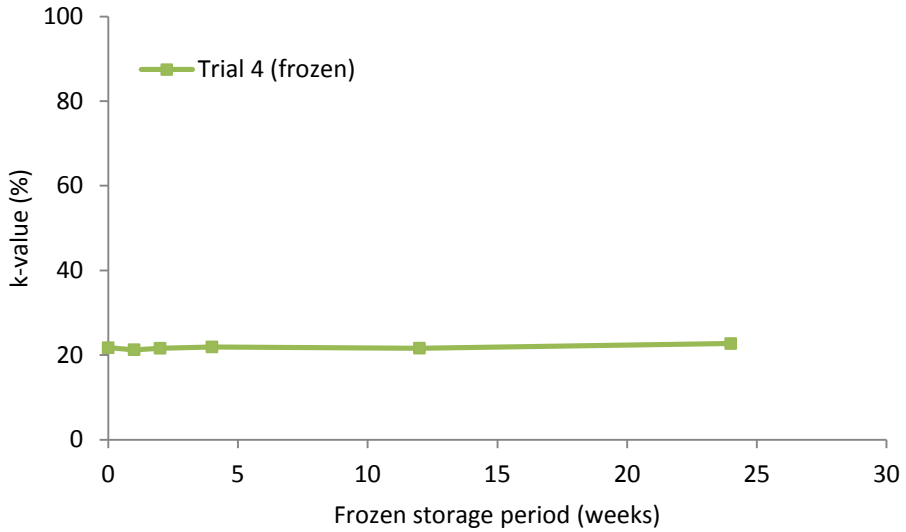

Figure 11 Effect of frozen storage time on the k-value of extracted cooked prawn meat

- The k-value remained stable for the first three days chilled and five days post thaw. Unlike the green extracted prawn meat the k-value of the cooked prawn meat did not increase during the frozen storage period. The three day lag, followed

by an exponential increase in the k-value of the chilled product is likely to be due to microbiological activity.

TBARS

TBARS were measured in the extracted cooked prawn meat recovered in Trial 4.

- The concentration of TBARS were low (average <0.040 mg malonaldehyde/kg) and did not increase during chilled and frozen storage. Whilst there is no information on TBARS in school prawns, the levels were well below the 3 mg malonaldehyde/kg limit that has been suggested to indicate good quality seafood (Cadun et al., 2005).

Summary

Cooking the prawns prior to extraction helped to stabilised the product, however some grit was detected in the product, limiting the range of applications. Under the conditions examined an indicative chilled shelf-life in the range of two-three days could be expected. To achieve a further extension in shelf-life, the initial microbiological load in the extracted prawn meat should be reduced. Some key considerations would be to validate the effectiveness of the sanitisation program used on the processing equipment and the hygiene of the incoming raw materials (cooked prawns).

3.1.4 Product Specifications and Nutritional Assessment

To aid in identification of the grit, the organic matter in a sample of the extracted meat from Trial 5 was solubilised by acid hydrolysis. The grit could be seen by the naked eye and was also viewed under a microscope. Some of the recovered grit is shown in Figure 12. Based on the visual sub-rounded appearance the grit is likely to be sand from the ocean/riverbed. This grit has arisen from the ecological nature and feeding behaviour of the prawns and would be intrinsic to the Baader extraction of meat from whole (head on/non-deveined) prawns.

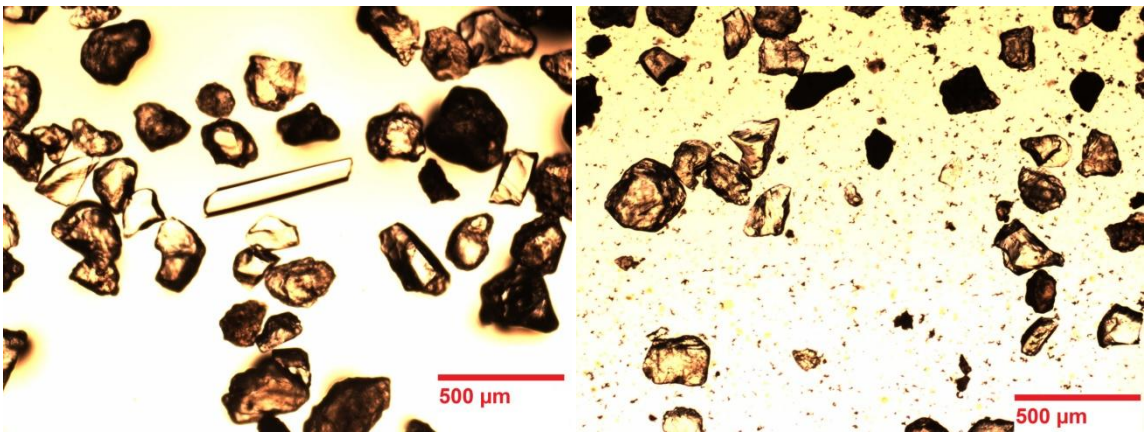

Figure 12 Grit recovered from the extracted meat (as viewed under microscope)

The key nutritional components of the green and cooked extracted school prawn meats were determined and are reported in Table 2. Based on these results the extracted prawn meats meet a 'low fat' claim (total fat <3g/100g) and if the serving size is >25 g would meet a 'good source of Omega-3' claim (>60 mg total eicosapentaenoic acid and docosahexaenoic acid/serving).

Table 2 Nutritional composition of the extracted prawn meat

Analyte **Values per 100 g**	**Extracted green meat** **(Trial 3)**	**Extracted cooked meat** **(Trial 5)**
Moisture	81.7 g	81.0%
Energy Value	324 kJ	318 kJ
Protein	15.7 g	15.9 g
Fat, Total	1.4 g	1.3 g
Saturated	0.6 g	0.6 g
Trans	<0.1 g	<0.1 g
Polyunsaturated	0.5 g	0.4 g
Omega-3 Total	290 mg	340 mg
alpha-linolenic acid	30 mg	< 1 mg
eicosapentaenoic acid	130 mg	170 mg
docosahexaenoic acid	120 mg	140 mg
Monounsaturated	0.3 g	0.3 g
Carbohydrate	0.3 g	< 0.1 g
Sugars	0.3 g	< 0.1 g
Sodium	130 mg	310 mg
Calcium	130 mg	210 mg

3.2 MARKET FEASIBILITY

3.2.1 Production Cost

The cost of production was determined from data collected during the trials and feedback from the CRFC. The production cost for extracted cooked prawn meat was estimated and included the average cost of raw materials ($5.00/kg for cooked prawns (Sinclair, 2010)), product recovery yield, labour requirements, packaging requirements and overheads. The production cost excluded the cost of shell removal and any costs incurred with accessing a Baader separator.

The indicative production cost was $8.64/kg. A summary of the costings have been made available to the CRFC. It is noted that there is some uncertainty over the yield of extracted meat from cooked prawns. A conservative product yield of 64.4% has been used and a sensitivity analysis of product yield on the cost of production is shown in Figure 13. This sensitivity analysis shows that if a higher yield could be achieved then the cost of production would decrease. Product yield requires the measurement of material inputs and outputs. Maximising the yield would also occur by minimising losses. For example, at a yield of 85% (as was achieved with the green prawns) then the indicative cost of production would be reduced to $6.71/kg.

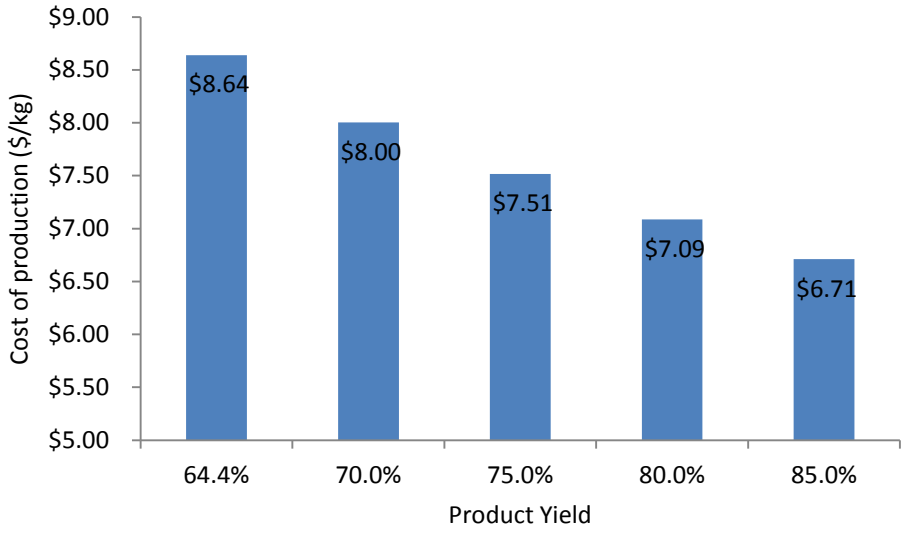

Figure 13 Effect of product yield on the cost of production.

3.2.2 Products' Potential and Likely Usage

The products' potential and likely usage was determined through a three stage process. In the first stage manually peeled and extracted green prawn meat from Trial 3 was used in an attempt to develop prawn-based wontons. In the second and third stages extracted green and cooked prawn meats from Trials 4 and 5 were evaluated by Diana Thompson and used as key components in the development of several application ideas.

Stage One – Prawn Wontons

Six prawn wonton recipes were developed with different proportions of manually peeled and extracted green prawn meat. Some of the cooked wontons are shown in Figure 14. The cooked wontons were assessed through informal sensory for flavour, texture and appearance. Additional details are contained in Appendix 9.

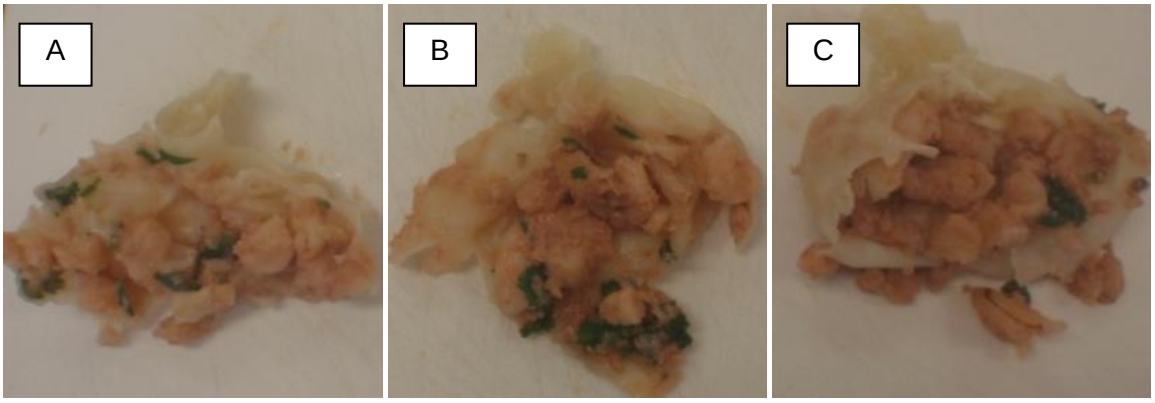

Figure 14: Fillings from cooked wontons; (A) recipe 4; (B) recipe 5; (C) recipe 6

Whilst the extracted green prawn meat provided a very strong prawn flavour, metallic and bitter aftertastes were noted. The texture of the fillings in most of the wontons was not satisfactory; some grittiness was detected and when green extracted meat was used to fill the wonton wrappers the cooked fillings were described as pasty. Precooking the filling prior to filling the wonton wrappers overcame the pasty characteristics; however, the detection of grit, and the metallic and bitter aftertastes remained.

Stage Two – Evaluation and Potential Applications of Products from Trial 4

The consultant chef (Diana Thompson) was contracted to provide feedback on the product concepts. The green, cooked and sous vide style product concepts produced in Trial 4 were evaluated for their visual quality, texture, aroma and flavour. A summary of the assessments are reported in Table 3. Grit was detected and while it was indicated that the green and cooked extracted meats may present opportunities for use as ingredients, appeal may be based on the price and volume of product available.

Table 3 Evaluation of product concepts by Diana Thompson (assessed one day after extraction)

Product	Visual Quality	Texture	Aroma	Flavour	Comments
Cooked (extracted)	Pink/orange with purple/black flecks	Mealy (with some shell/ grit)	Fresh prawn	Pleasant fresh prawn flavour Some aftertaste (possibly iodine?)	Product had flavour and aroma of fresh school prawns and the overall colour is what would be expected of school prawns. The purple/black flecks and presence of grit make it a product that cannot be consumed on its own.
Sous vide (extracted then cooked in bag)	Pink/purple/grey	Mushy	Not assessed	Not assessed	Cooking (sous vide style) created some product separation and it was regarded that there were no likely applications for this product concept.
Green (extracted)	Dark purple/grey	Mealy (with some shell/ grit)	Fresh prawn	Strong fresh prawn flavour Slightly bitter aftertaste and tongue coating (possibly enzymes?)	The visual appearance (dark purple/grey colour) of the extracted green prawn meat is not what would be expected from a prawn mince. This colour along with the presence of grit could present major obstacles for uptake by consumers/end users. When the extracted prawn meat was cooked (pan fried with a small amount of rice bran oil) a purple colour remained. Noticeable aroma of head and shell as it cooked.

Diana Thompson developed several potential application concepts from the extracted green and extracted cooked meats. Some of the concepts are shown in Figure 15. The potential application ideas were appraised for quality and performance using her technical skills and experience. The presence of grit was identified as a potential barrier to some applications but the extent of this barrier was not determined.

Extracted Cooked Meat

- When mixed with some mayonnaise, the oil in the mayonnaise considerably improved the 'mouthfeel' as the mealiness and grit were less detectable. It could be further improved with the addition of whole peeled school prawns and crisp elements such as celery and fresh herbs.

Extracted Green Meat

- The comsommé method failed to produce the desired colour and clarity. However, there could be potential to develop Asian broths and French style soups (such as bisques) that do not require the same clarity and incorporate more robustly flavoured herbs and spices.
- The product would be unsuitable for farces (mince preparations) for pasta or dumplings where a delicate prawn flavour is expected.

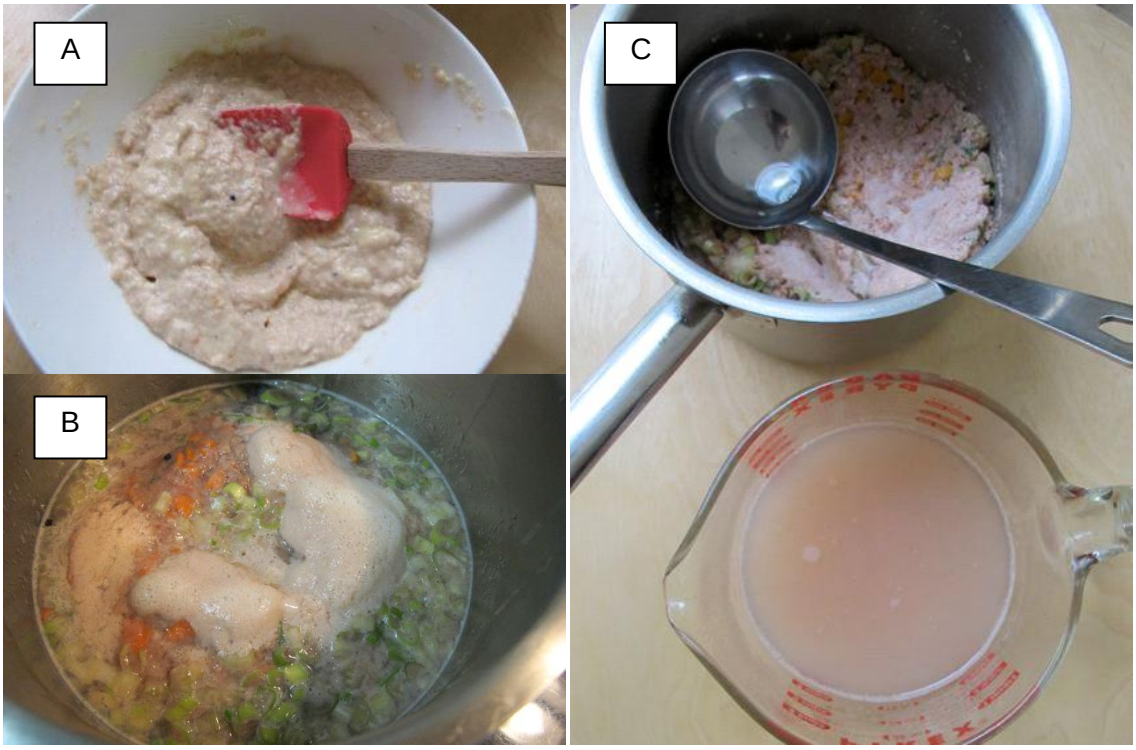

Figure 15 Potential application concepts; (A) Extracted cooked prawn meat mixed with mayonnaise; (B) Extracted green prawn meat being used in a prawn broth; (C) Prawn broth and spent ingredients after straining

Stage Three – Evaluation and Potential Applications of Product from Trial 5

The extracted cooked prawn meat from Trial 5 was evaluated by the consultant chef (Diana Thompson) and used to develop a number of additional value-added concepts. The potential of the extracted meat and these value-added concepts were appraised by Diana Thompson and John Susman. A summary of the assessments are reported in Table 4. Whilst the flavour of the extracted cooked prawn meat was sweet and concentrated; the product contained grit and the addition of a range of crisp or crunchy textured foods did not disguise the grit.

The presence of this grit has meant that the extracted cooked prawn meat is not viable for use as an ingredient in mixtures and fillings. However, liquid based products (i.e. stocks, soups and bisques) which could be strained were highly acceptable. The Asian style prawn stock, prawn farce for gyoza and cooked gyozas are shown in Figure 16. It was recommended that the extracted product was most suited for the manufacture of stocks and soups and that commercial stock and soup manufacturers should be contacted.

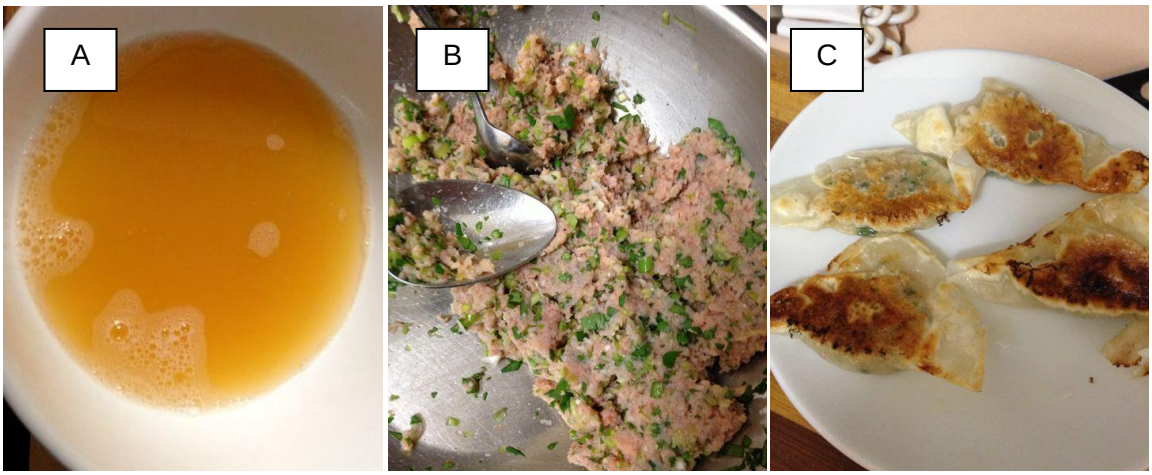

Figure 16 Some of the potential application concepts that were trialled; (A) Asian style prawn stock; (B) Prawn farce for gyoza; (C) Cooked gyozas

Knowing that the extracted product is not viable as an ingredient in mixtures and fillings, a preliminary assessment was undertaken to determine if it would be more effective to leave the shells in the prawn mince. Two variants of the Asian style prawn stocks were prepared, one variant used the extracted cooked prawn meat (minimal shell) from Trial 5 and the other used whole cooked prawns from Trial 4 that had been homogenised in a food processor (with shell). The two prawn meats are shown in Figure 17. There was a distinct colour difference with the prawn meats with the extracted cooked prawn meat darker in colour.

Table 4 Evaluation of extracted cooked prawn meat and value-added concepts by Diana Thompson and John Susman

Product	Description	Flavour	Texture	Appeal	Comments
Extracted cooked prawn meat	Clarence River school prawns, cooked and extracted	Good sweet flavour	Mealy and detectable sand/grit	Not visually appealing	Should be presented to end users after presenting product concept samples
French style prawn stock	Classical recipe	Good sweet flavour	Good	Good orange/pink colour Good clarity	Makes great stock, product lends itself well to French flavours
Asian style prawn stock	Classical recipe	Good sweet flavour	Good	Good orange/pink colour Good clarity	Makes great stock, product lends itself well to Asian flavours
Prawn bisque	French soup/ sauce finished with cream	Good sweet flavour Rich and full prawn taste	Good	Excellent	Makes great soup, product lends itself well to bisque base, sauce and soup flavours
Hot and sour prawn soup	Thai clear soup flavoured with lemongrass, lime leaves, galangal, chilli	Good sweet flavour Rich and full prawn taste	Good	Excellent	Makes great soup, product lends itself well to Thai soup base and sauce flavours

Product	Description	Flavour	Texture	Appeal	Comments
Prawn laksa	Rich and spicy Malaysian soup finished with coconut milk	Good sweet flavour Rich and full prawn taste	Good	Excellent	Makes great Laksa soup, product lends itself well to Malay soup base and sauce flavours
Prawn toast	Chinese hors d'oeuvre of prawn farce, sesame fried on toast	Good sweet flavour Rich and full prawn taste	Grit was detectable even with the sesame seeds and crunchy toast	Not appealing due to grit	Good flavour but grit was unacceptable
Prawn and cabbage gyoza	Japanese "pot sticker" dumpling	Good sweet flavour Rich and full prawn taste	Grit was detectable even with the cabbage and shallots through the filling mixture and crisp wonton	Not appealing due to grit	Good flavour but grit was unacceptable
Prawn, pork and peanut relish	Thai hors d'oeuvre served with fried wonton or prawn crackers	Good sweet flavour Rich and full prawn taste	Grit was just slightly detectable even with the pork and peanuts through the recipe	Not appealing due to grit	Good flavour but grit was unacceptable

Figure 17 Sample of the two prawn meats used in the development of the Asian style prawn stocks; (A) Prawn meat (extracted – minimal shell); (B) Whole prawns (homogenised – with shell)

The two Asian style prawn stocks, shown in Figure 18, were evaluated by an informal panel from the SARDI Food Safety and Innovation team using a 10-point scale[3]. The panel (n = 11) assessed the clarity, colour, aroma and flavour of the two variants stocks. A summary of the results are shown in Figure 19. There were no significant differences in the panels' preference of clarity (P=0.3093), colour (P=0.6289), aroma (P=0.6046) and flavour (P=0.0629). However, when prompted, 82% of the panellists had an overall preference for the stock created from the extracted prawn meat.

General comments made by some of the panellists were a clear preference for the colour and flavour of the stock that used the extracted prawn meat. However, there were a number of uncontrolled variables which could have attributed to some of these variations. Difficulties in sourcing raw materials meant that the prawns used for each stock had been caught at different times, were of different size grading, and had been cooked and handled differently and frozen for different durations. One of the panellists indicated that the stock with the extracted prawn meat contained more salt which improved the flavour. It is recommended that the stocks be recreated and reassessed using prawns that have been cooked and stored under identical conditions.

[3] with 1 being unpleasant and 10 being very appealing

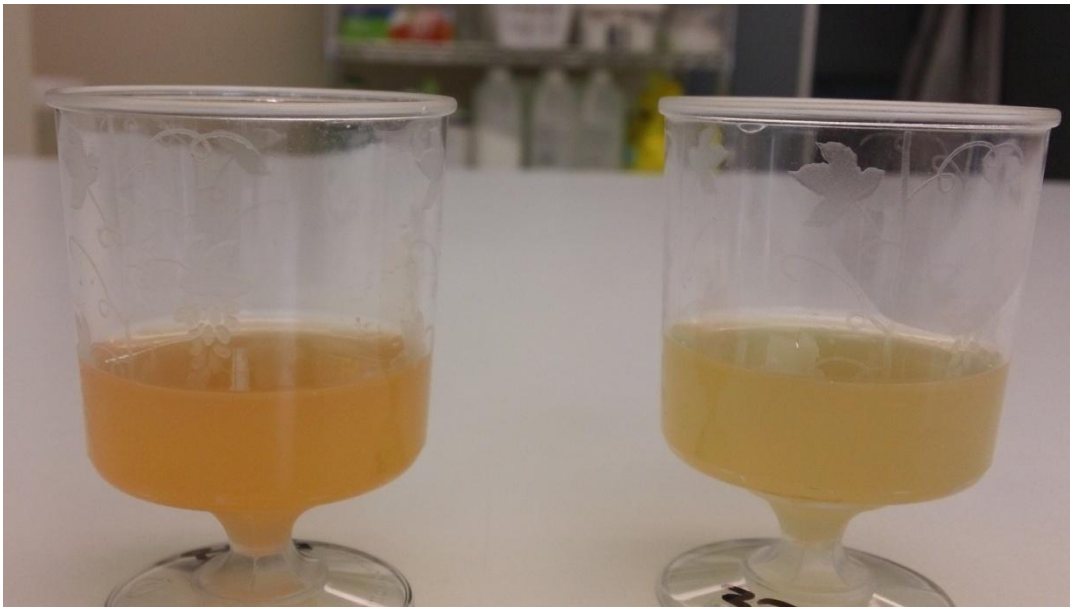

Figure 18 Sample of the two Asian style prawn stocks; (A) Stock using prawn meat (extracted – minimal shell); (B) Stock using whole prawns (homogenised – with shell)

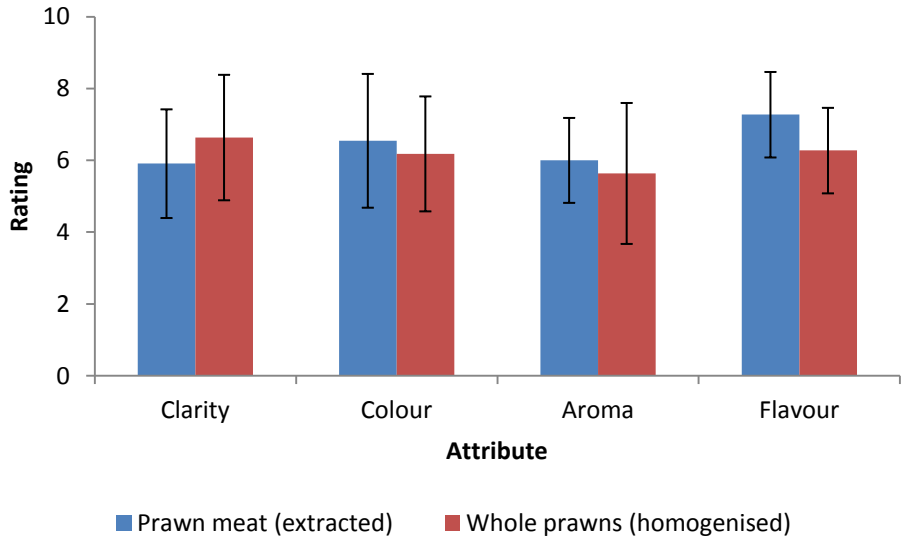

Figure 19 Sensory assessment of Asian style prawn stock made from extracted prawn meat and homogenised prawns (data expressed as mean ± standard deviation; (n = 11)

3.2.3 Feedback on Product Concept from Respected Food Manufacturers

Following discussions with Diana Thompson and John Susman it was decided that due to product specific limitations (particularly the visual appearance and presence of grit), an ideation session as initially proposed was not appropriate. Instead, a targeted group of commercial stock and soup manufacturers were approached to provide feedback on four application concepts (two soups and two stocks) developed from the extracted cooked prawn meat and determine their level of interest in the extracted meat. The recipes for the four application concepts are reported in Tables Table 5, Table 6, Table 7 and Table 8.

Table 5 Recipe for French style prawn stock

French style prawn stock	
Ingredients ▪ 500g cooked prawn mince ▪ 100g onion ▪ 100g leek ▪ 80g celery ▪ 80g carrot ▪ 1 small / ½ bay leaf ▪ 1n thyme sprig ▪ 6n peppercorns ▪ 10g parsley stalk ▪ 1500mL water	*Method* ▪ Place all ingredients in pot ▪ Bring to the boil, reduce heat and simmer for 20 minutes ▪ Stand 10 minutes ▪ Strain through a fine mesh sieve

Table 6 Recipe for Asian style prawn stock

Asian style prawn stock	
Ingredients ▪ 500g cooked prawn mince ▪ 100g shallot tops (green end) ▪ 150g onion, diced ▪ 20g ginger, sliced ▪ 10g lemongrass top ▪ 6n peppercorns ▪ 1500mL water	*Method* ▪ Place all ingredients in pot ▪ Bring to the boil, reduce heat and simmer for 20 minutes ▪ Stand 10 minutes ▪ Strain through a fine mesh sieve

Table 7 Recipe for hot and sour prawn soup

Hot and Sour Prawn Soup	
Ingredients ▪ 200g cooked prawn mince ▪ 1L Asian style prawn stock ▪ 10g garlic, sliced ▪ 44g lemongrass, root end sliced, top end bruised ▪ 15g galangal, thinly sliced ▪ 2 lime leaves (whole) *Seasoning* ▪ Lime juice ▪ Red chilli, sliced ▪ Fish sauce	*Method* ▪ Place all ingredients(except seasonings) in pot ▪ Bring to the boil, reduce heat and simmer for 20 minutes ▪ Stand for 10 minutes ▪ Strain through a fine mesh sieve ▪ To finish, reheat soup and add seasoning to taste

Table 8 Recipe for Prawn bisque

Prawn bisque	
Ingredients ▪ 25g unsalted butter ▪ 40g brown onion, sliced ▪ 30g carrot, sliced ▪ 30g celery, sliced ▪ 30g leek, sliced ▪ black pepper ▪ 25g tomato paste ▪ 25mL brandy ▪ 110mL white wine ▪ 250g crab mince ▪ 1 small / ½ bay leaf ▪ 1n parsley stalk ▪ 1n thyme spring ▪ 1L French style prawn stock *Coulis* ▪ 5mL brandy ▪ 220mL cream ▪ 20mL unsalted butter	*Method* ▪ Melt butter in saucepan and sauté onions, carrot, celery and leek until soft and caramelised ▪ Add pepper and tomato paste and cook for 1 minute, stirring constantly ▪ Deglaze with brandy, add wine and simmer for a few minutes ▪ Add the prawn mince, bay leaf, parsley stalk, thyme and stock ▪ Bring to boil, reduce heat and simmer for 20 minutes ▪ Stand for 15 minutes ▪ Strain through a fine mesh sieve ▪ To finish, reheat base and add brandy, cream and mount with butter

Ten out of the eleven commercial food manufacturers responded to the approach. Whilst the manufacturers generally thought the project was good, four didn't want to, or were too busy, to be involved. Six commercial food manufacturers based in the Sydney area agreed to be involved and were represented by a mix of owners, chefs, purchasing and product development staff. These manufacturers produce a range of high-end boutique products. During the face-to-face interviews five of the six manufacturers assessed the French style prawn stock, Asian style prawn stock, prawn bisque and hot and sour prawn soup and provided a rating between 1 (unpleasant) and 10 (very appealing) for flavour, colour, clarity and aroma. A summary of their sensory evaluations are reported in Figure 20.

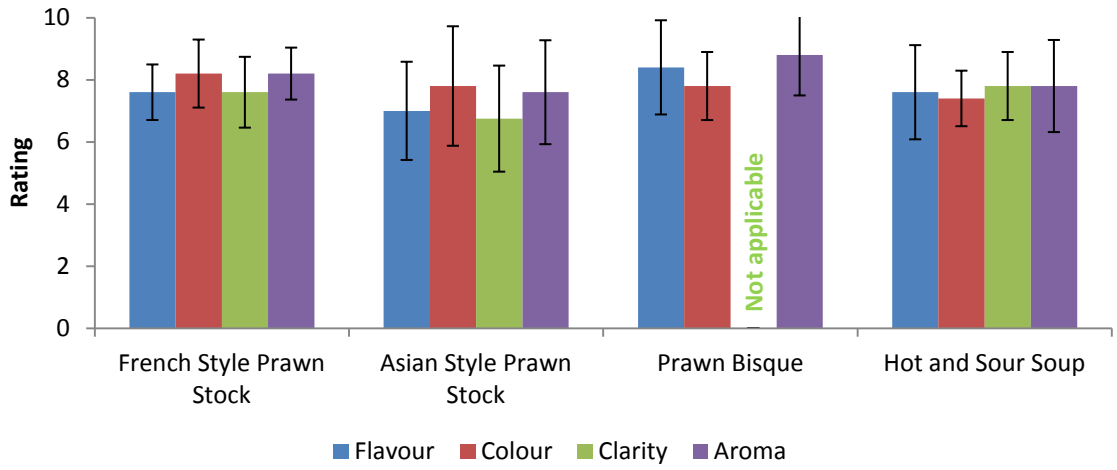

Figure 20 Sensory evaluation of four application concepts by commercial food manufacturers (data expressed as mean ± standard deviation; (n = 5)

Overall, comments from the commercial food manufacturers were supportive that the extracted cooked meat could be used as an ingredient in liquid based products. Four of the six manufacturers would consider using the extracted meat. The remaining two manufacturers stated that they would not use the extracted meat in their range; one of whom referred to food safety requirements as an obstacle. All of the manufacturers were concerned with the grit/sand and considered it a major obstacle for applications other than soup, stock or sauce bases. Another obstacle, though not identified in the feedback would be that manufacturers who don't currently use any crustaceans may need to reprint all existing packaging in accordance with allergen labelling laws. Those that were open to considering the product were enthusiastic about using Australian seafood and recognised the Clarence River as a quality sustainable source of supply.

Regardless of whether they currently use any prawn products in their range, or if they would consider using the extracted meat, most manufacturers recommended that the product should be provided frozen, in cardboard carton with vacuum sealed bags. One manufacturer has no preference if the extracted meat was sold fresh or frozen. Two manufacturers preferred the extracted meat to be packaged in plastic tubs in cardboard shippers.

Suggested pack size varied between manufacturers but ranged from 2-10 kg, whilst purchase price (what they would be prepared to pay for the extracted meat or thought it was worth) varied from $9/kg (one manufacturer) to $11/kg (3 manufacturers). One manufacturer also cited it would depend on final stock yield. The most important factors identified in the decision making process when choosing a product were price, sustainability, flavour, provenance and shelf-life.

The food manufacturers also suggested other avenues to value-add to the school prawn industry. One manufacturer could see potential in dehydrating the prawns into a prawn powder and developing a powdered prawn stock. Another manufacturer would like green school prawns graded and sold in an individual quick frozen (IQF) format.

3.3 COMMERCIALISATION PLAN

The project identified that the extracted meat from cooked prawns was suitable for the manufacture of liquid based products. Several Sydney-based companies have shown interest in the product and their contact details have been passed on to key personnel at the Clarence River Fishermen's Co-operative so that they can pursue potential commercial ventures.

The indicative production cost for the extracted cooked prawn meat was $8.64/kg and a number of recommendations have been made in order to assist the commercialisation (see Section 5).

4 BENEFITS AND ADOPTION

Benefits

The preliminary trial work has resulted in a number of benefits:

- The Baader separator was successful in extracting and recovering cooked prawn meat. Vacuum packaging and freezing the cooked extracted meat appeared to provide adequate protection against product degradation during storage.
- Whilst the presence of grit (sand) in the extracted meat was identified as a barrier for use as an ingredient in mixtures and fillings; the meat had potential to be used in the manufacture of a number of liquid based products, namely soups and stocks.
- A number of liquid based products were manufactured using the extracted cooked prawn meat as a key ingredient. Two stocks and two soups were prepared and evaluated by product development staff at a number of targeted food manufacturers, which generally rated them highly.
- Initial market assessment revealed Sydney-based food manufacturers that do not use or handle seafood (especially crustaceans) are less willing to trial the product. Some of the manufacturers cited price, whilst others referred to potential food safety requirements. Effort should be spent identifying and working with those manufacturers that already handle seafood, especially crustaceans, or wish to develop a range containing the product.

Adoption

A number of product concepts were developed and evaluated from the extracted prawn meat. Although some of these showed potential, they were not taken to completion or tested in a large market due to the difficulty in stabilising the extracted green prawn meat. There are a number of results and recommendations that the CRFC could adopt in future business development plans to assist in increasing the utilisation of school prawns for human consumption.

5 FURTHER DEVELOPMENT

The presence of grit has meant that the cooked extracted prawn meat is not viable for use as an ingredient in mixtures and fillings. Feedback from six commercial soup and stock manufacturers confirmed that the product could be used as an ingredient in liquid based products (stocks, soups and sauces). The liquid based products developed and accessed by the commercial manufacturers were highly regarded. Four of these six manufacturers would consider using the extracted meat. Manufacturers that did not already have seafood in their product range were less willing to consider purchasing the extracted product.

It is recommended that the following should be investigated as part of future plans.

- Identify and make contact with commercial stock, soup, pasta sauce manufacturers that already have seafood in their product range. Determine their preferences for product format (whole, mince without shell, minced with shell), state (chilled, frozen) and pack size. In addition, the prawns could be advertised in relevant trade magazines that reach retail and hospitality markets.
- Undertake a trial to obtain product samples and review the production costs, giving high consideration to the product yield.
- Completion of trials that aim to reduce the initial microbiological load of the extracted prawn meat. Some key considerations would be to validate the effectiveness of the sanitisation program used on any processing equipment and the hygiene of the incoming raw materials (cooked prawns).
- Consider other avenues to increase the utilisation of the prawns for human consumption. This could include but is not limited to improved communication with their existing and any new customers to discuss product and packaging formats, supply of product samples, development and distribution of product information (sustainability of fishery, recipes), improved quality and more consistent grading of the green prawns.

6 PLANNED OUTCOMES

This research has involved undertaking trials on preliminary shelf-life evaluation, assessing application concepts and market assessment. These results could be used by the Clarence River Fishermen's Co-operative and other members of the Australian Council of Prawn Fisheries in future business development plans.

Public Benefit Outcomes

- Increased understanding of the market opportunities for extracted school prawn meat could lead to a better utilisation of this public resource.

Private Benefit Outcomes

- Preliminary shelf-life indications of extracted cooked school prawn meat in chilled and frozen forms could assist the industry in the storage and retail of the extracted prawn meat.
- The entry of the CRFC into new markets or new market segments with product concepts identified and developed.
- Increased profits to the CRFC through a transfer of school prawns from a lower valued bait market to higher valued alternative markets.

Linkages with CRC Milestone Outcomes

This project has provided data to support the completion of the following Seafood CRC Outcomes, Outputs and Milestones:

Outcome 2 – Increased access to premium markets through fulfilment of consumer demands for safe, high quality, nutritious Australian seafood

Output 2.7 – Removal or reduction of barriers to seafood consumption

- **Milestone 2.7.2 –** Individually tailored approaches to overcoming barriers trialled and evaluated in at least two new domestic or overseas consumer groups annually

Output 2.8 – Smart processing technologies and practices

- **Milestone 2.8.2 –** Innovative technologies for controlling spoilage to enhance shelf-life and marketability developed and evaluated for each of three types of seafood per annum
- **Milestone 2.8.8 –** Technology and capability to support innovation of new seafood products developed

7 CONCLUSION

The project has investigated the production of an extracted school prawn meat from green and cooked prawns. The prawns were processed in a Baader separator which squashed the soft tissue (prawn meat) into a perforated drum. The extracted products were collected, packaged and the shelf life assessed through sensory, microbiological and biochemical methods.

The extracted green prawn meat rapidly degraded during processing, handling and/or storage. This product degradation was linked to enzymatic activity. The enzymes would have originated from the prawns digestive tract and dispersed through the product during the extraction process. The green extracted product was not regarded as a viable product.

Cooking the prawns prior to extraction helped to stabilised the product. The market feasibility of the cooked extracted prawn meat was evaluated by determining the products indicative cost, potential and likely usage, and seeking feedback from respected food manufacturers. The presence of grit (sand) in the extracted meat was identified as a barrier for use as an ingredient in mixtures and fillings; the meat had potential to be used in the manufacture of a number of liquid based products, namely soups, stocks and sauces.

Six targeted commercial food manufacturers based in the Sydney area agreed to be involved and provided information that helped to assess the products' market requirements. Four of the six manufacturers would consider using the extracted meat and their contact details have been passed on to key personnel at the Clarence River Fishermen's Co-operative so that they can pursue potential commercial ventures.

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APPENDIX 1: INTELLECTUAL PROPERTY

There was not recorded background or third party intellectual property. The project has identified processing and packaging options for the extraction of school prawn meat, indicative shelf-life and possible applications for the extracted meat.

APPENDIX 2: STAFF

SARDI

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APPENDIX 3: TRIAL 1 (27 OCTOBER 2011)

BACKGROUND

Clarence River Fishermen's Co-operative (CRFC) had not seen the Baader separator in operation and an opportunity arose after Seafood Directions 2011 to demonstrate the separator to the key CRFC personnel. This demonstration occurred prior to the project's contract being finalised.

OBJECTIVE

The objective of Trial 1 was to demonstrate the operation of the Baader separator to key CRFC personnel.

METHODS

Raw Materials

Approximately 20 kg of chilled green school prawns were used in the demonstration.

Equipment and Sanitisation

The Baader separator visually appeared clean. As this trial was to demonstrate the operation of the machine and not aimed at investigating the product, the equipment was not sanitised before use as the recovered product was not kept for assessment.

Treatments

No treatments were investigated within Trial 1.

Assessment Criteria

The product was visually assessed on the day of processing, but no product was kept for additional assessment.

RESULTS AND DISCUSSION

The Baader separator successfully processed the green school prawns. The whole prawns, recovered prawn meat and recovered shell are shown in Figure 21. A summary of the Baader results are reported in Table 9. The product yield (recovered extracted meat) was 81.9%. There was a small loss of potential yield associated with a small quantity of extracted meat that was retained in the drum. This loss can be considered as a fixed loss, unrelated to batch size.

The processing time was very short and consequently the throughput was not measured. No product was kept for assessment.

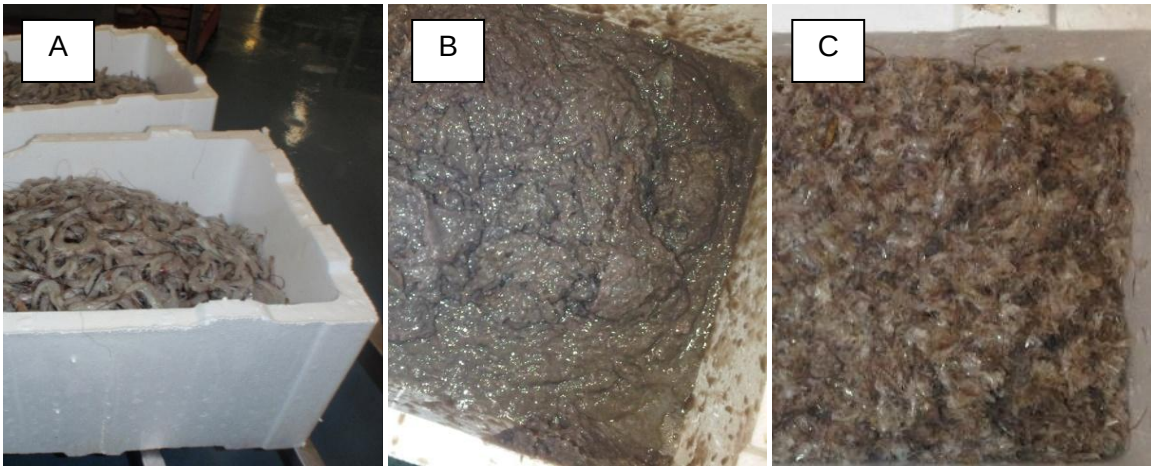


Figure 21 Photographs from Trial 1; (A) initial whole prawns, (B) recovered prawn meat, (C) recovered prawn shell

Table 9 Summary of Baader results from Trial 1

Item	Weight
Whole green prawns	17.70 kg
Recovered extracted meat	14.50 kg
Unrecovered (by difference)[A]	0.35 kg
Shell	2.85 kg

[A] The unrecovered component would fluid that is squashed from the prawns during processing and extracted meat retained in the drum.

KEY FINDINGS

- The Baader separator could successfully recover an extracted prawn meat from whole green prawns
- Product yield was 81.9%

APPENDIX 4: TRIAL 2 (18 APRIL 2012)

BACKGROUND

Trial 1 demonstrated the Baader separator to key CRFC personnel but given the timing of the trial (before the project's contract had been finalised) no product evaluation was undertaken.

OBJECTIVE

The objectives of Trial 2 were to:

a) record measurements for costing and product specifications including labour, throughput, product yield and packaging options

b) produce product for frozen shelf-life evaluation and nutritional composition

c) produce product for end user assessments

METHODS

Raw Materials

The school prawns used in Trial 2 were caught by commercial fishers on 16 April 2012. Approximately 30 kg of green prawns had been stored on ice in Styrofoam boxes in the chiller. The prawns were ungraded by the CRFC and by the time of processing most of the ice had melted and the prawns were sitting in an ice/water slurry (Figure 22). The residual ice was manually removed from the Styrofoam boxes and prawns were drained of free water for approximately 5 minutes prior to being weighed and processed.

Figure 22 One of the Styrofoam boxes of green prawns prior to use

Equipment and Sanitisation

The Baader separator was partially disassembled (belt and drum remained in place), cleaned with high pressure water and wetted surfaces were sprayed with Freedom No-Rinse Sanitiser (Tasman Chemicals Limited, Braeside, Victoria). Trial 2 was undertaken with two people processing and packaging.

Treatments

No treatments (per se) were investigated in Trial 2. The green prawns were manually loaded into the hopper and the extracted prawn meat was packaged into approximately 1 kg bags which were weighed and manually heat sealed. The bags were flattened, placed into the blast freezer to freeze and then stored at -18°C. The temperature of the factory, blast freezer, chiller, initial prawns and extracted prawn meat were measured and recorded with either a temperature probe or iButton data loggers (Maxim Integrated, San Jose, CA, USA).

Assessment Criteria

Triplicate samples of the initial prawns, extracted prawn meat collected at the start and extracted prawn meat collected at the end were taken, kept chilled (<1°C) and analysed on day 1 (day of extraction + 1 day) for SPC, *E. coli*, *Salmonella*, coagulase-positive *Staphylococci* and total coliforms.

RESULTS AND DISCUSSION

The Baader separator processed the green school prawns and the recovered prawn meat from Trial 2 is shown in Figure 23. The processing time was approximately 2 minutes. The meat collected from the start of the trial contained a significant quantity of free water. This free water was collected immediately after starting the separator and is a likely result of an insufficient drain time. Future trials should use a longer draining time to prevent this free water pooling which would reduce product appearance. A summary of the Baader results are reported in **Error! Reference source not found.**. The product yield (extracted meat) was estimated to be 85.9% and the average throughput was approximately 850 kg/h.

Table 10 Summary of Baader results from Trial 2

Item	Weight
Whole green prawns	30.2 kg
Extracted meat (calculated by difference)[A]	25.9 kg
Shell	4.3 kg

[A] Weight of extracted meat calculated by difference between weight of whole green prawns and shell.

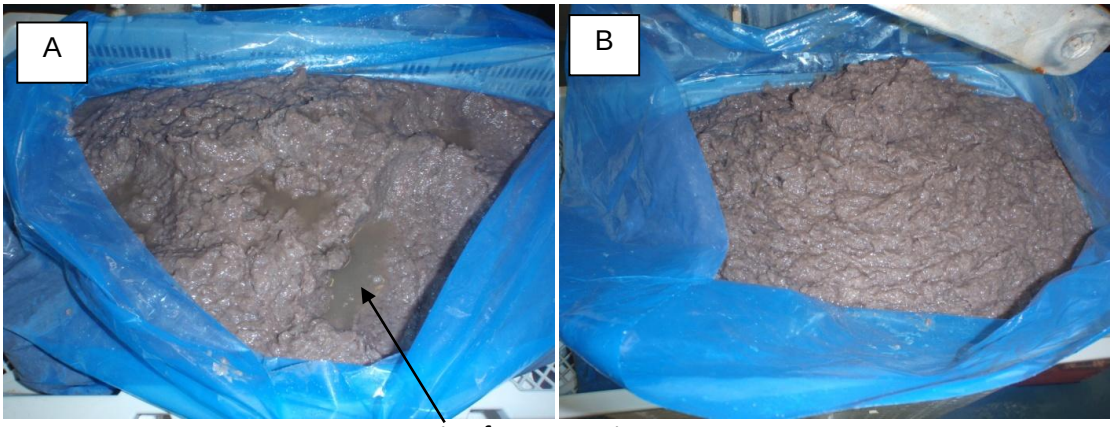


Figure 23 Prawn meat recovered from Trial 2; (A) meat collected at the start of trial, (B) meat collected at the end of trial

The product recovered from Trial 2 was packaged into approximately 1 kg bags. Temperature loggers were used to monitor the processing conditions and freezing profile from one of the bags. The average temperature of the initial prawns, extracted prawn meat, blast freezer, chiller and factory are reported in Table 11. The core temperature profile during the blast freezing process of one of the bags of product from Trial 2 is shown in Figure 24. For this bag of product the thermal arrest time (duration it takes for the product temperature to reduce from -1°C to -5°C) was approximately 8 hours and it took approximately 16 hours for the core temperature to reach -18°C. This thermal arrest time is slow and is an indication that the freezing process for this bag could be enhanced by better positioning of the bags in the blast freezer. Improving the freezing process could increase product quality by reducing the rate of product degradation.

Table 11 Summary of average temperatures recorded during Trial 2

Item	Temperature
Whole green prawns	1.0°C
Extracted meat (immediately after extraction)	3.5°C
Chiller	0.5 to 1.0°C
Factory	15 to 18°C
Blast freezer	-18 to -21°C

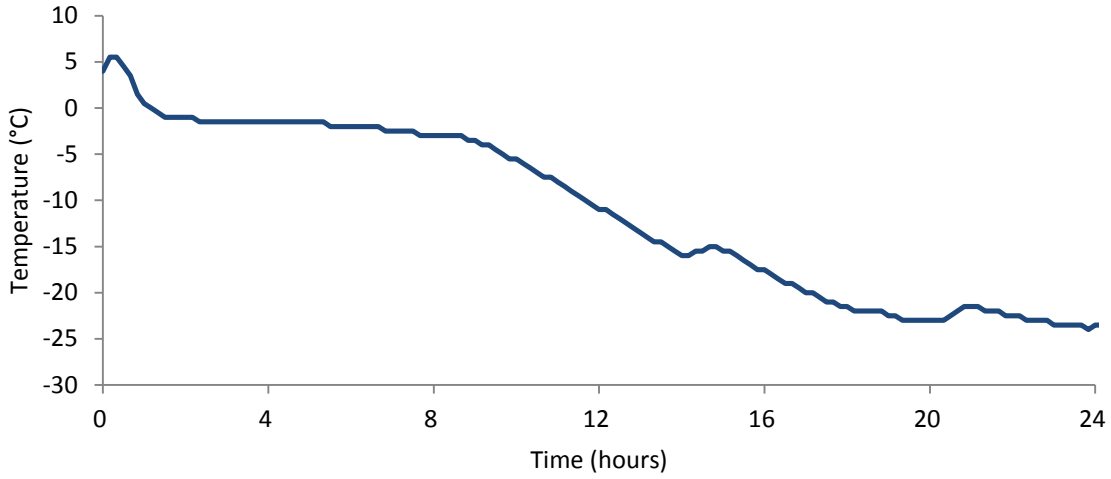


Figure 24 Core temperature profile during blast freezing of one bag of product from Trial 2

Product samples were analysed on day 1 (day of extraction + 1 day) for SPC (25°C for 96 hours), *E. coli*, *Salmonella*, coagulase-positive *Staphylococci* and total coliforms. The microbiological results are shown in Table 12. The average SPCs from the samples were towards the upper end of an acceptable range. The SPCs in the product may be due to the natural microbial flora of the prawns, and/or cross contamination of prawns or prawn meat prior to, during or after processing. The total coliforms and *E. coli* were measured and used as indicators to the overall hygiene of the process. The substantial increase in the total coliforms and *E. coli* in the recovered product compared to the initial product is indicative that the extracted prawn meat was contaminated by the Baader separator.

Due to the elevated microbiological levels, the extracted meat from Trial 2 was not utilised for any shelf-life evaluation and end user assessments. The extraction trial should be repeated with an improved equipment sanitisation program in an attempt to obtain extracted prawn meat with a lower microbiological load.

Table 12 Indicative microbiological results from Trial 2 (assessed on day 1)[A]

Sample	Replicate	SPC (Log_{10} cfu/g)[B]	*Salmonella* (detection/25g)	Coagulase-positive *Staphylococci* (cfu/g)	*E. coli* (cfu/g)	Total coliforms (cfu/g)
Whole green prawns	1	5.77	negative	<100	10	20
	2	5.51	negative	<100	<10	<10
	3	5.53	negative	<100	<10	<10
Green prawn meat – start	1	5.77	negative	100 (presumptive)	11,000	11000
	2	5.67	negative	<100	6,500	6600
	3	5.64	negative	<100	7,000	7000
Green prawn meat – end	1	5.67	negative	<100	50	80
	2	5.66	negative	<100	390	460
	3	5.63	negative	<100	10	50

[A] The Australia New Zealand Food Standards Code stipulates that a minimum of five sample units from a lot should be examined for microbiological criteria for regulatory purposes. Consequently the results presented in this table are indicative only when comparing to the limits prescribed in the Australia New Zealand Food Standards Code.

[B] Samples for SPC were incubated at 25°C for 96 hours which is different to the methods stated in the Food Standards Code (30°C for 72 hours). The lower incubation temperature of 25°C was examined as this assay is more sensitive and can produce significantly higher numbers of bacteria in fish and fishery products (Nickelson and Finne, 1992).

KEY FINDINGS

- Average throughput (excluding start-up and clean-up) could be up to 850 kg/h with two people processing and packing
- Product yield was 85.9%
- Extracted meat had unacceptable *E. coli* levels that indicated the meat had been contaminated by the Baader extractor.
- The freezing rate in one of the bags was slow and the freezing rate could be improved by better utilisation of the capacity of the blast freezer.

APPENDIX 5: TRIAL 3 (17 MAY 2012)

BACKGROUND

The meat recovered from Trial 2 had unacceptable microbiological contaminates and was not utilised for shelf-life evaluation and end user assessment. Trial 2 was to be repeated with an improved equipment sanitisation program in an attempt to obtain extracted prawn meat with a lower microbiological load.

OBJECTIVE

The objectives of Trial 3 were to:

a) record measurements for costing and product specifications including labour, throughput, product yield and packaging options

b) produce product for frozen shelf-life evaluation and nutritional composition

c) produce product for end user assessments.

METHODS

Raw Materials

The school prawns used in Trial 3 were caught by commercial fishers on the 15th and 16th May 2012. Approximately 40 kg of green prawns had been stored on ice in Styrofoam boxes in the chiller. The prawns were ungraded by the Clarence River Fishermen's Co-operative (CRFC) and by the time of processing some of the ice had melted and the prawns were sitting in an ice/water slurry. The residual ice was manually removed from the Styrofoam boxes and the prawns were drained of free water for approximately 75 minutes prior to being weighed and processed.

Equipment and Sanitisation

The Baader separator was disassembled (drum and belt removed), and the wetted surfaces cleaned and soaked overnight in a solution of Sanifoam (Tasman Chemicals Limited, Braeside, Victoria). The wetted surfaces were rinsed with potable water and the Baader separator reassembled. This sanitisation program was more comprehensive than what was used in Trial 2 (separator partially disassembled, rinsed and sanitised). Trial 3 was undertaken with two people processing and packaging.

Treatments

No treatments (per se) were investigated in Trial 3. Approximately 1 kg sample of the green prawns were packaged and frozen for retention purposes. The remaining prawns were manually loaded into the hopper and the extracted prawn meat was packaged into approximately 1 kg bags which were weighed and manually heat sealed. The bags were flattened, placed into the blast freezer to freeze and stored at -18°C. The temperature of the factory, blast freezer, chiller, initial prawns and extracted prawn meat were measured and recorded with either a temperature probe or iButton data loggers (Maxim Integrated, San Jose, CA, USA).

Assessment Criteria

Triplicate samples of the initial prawns, extracted prawn meat collected at the start and extracted prawn meat collected at the end were taken, kept chilled (<2°C) and analysed on day 1 (day of extraction + 1 day) for SPC (96 hours at 25°C), *E. coli*, *Salmonella*, coagulase-positive S*taphylococci* and total coliforms. Retention samples were also collected and stored at -18°C.

Sensory evaluation of the product was assessed after approximately one (21 June 2012) and two (19 July 2012) months of frozen storage. Prior to assessment the product was thawed over a 36 hour period at 4°C. After approximately two months of frozen storage a portion of the whole (retention) prawns and extracted prawn meat was used in several recipes of wontons to appraise its suitability.

Compositional analysis was undertaken for nutritional information panel labelling.

Biochemical analysis (nucleotide degradation) was undertaken from product samples (extracted meat) collected during the shelf-life assessment program. Samples were packed in zip-lock bags, air evacuated and stored at -80°C until analysis. Retention samples of the whole prawns were also thawed after approximately one (21 June 2012) and three and a half (03 September 2012) months of frozen storage. These prawns were manually peeled, and the head and tail meat homogenised separately and homogenates stored at -80°C until analysis.

RESULTS AND DISCUSSION

The green prawns were drained for 75 minutes in plastic mesh trays prior to being processed through the Baader separator. A summary of the Baader results are reported in Table 13 and the product yield (recovered extracted meat) was estimated to be 86.8%. The extended drainage time (75 minutes, up from 5 minutes in Trial 2) resulted in no visually apparent free water being incorporated into the extracted product. The green prawns during drainage and the extracted meat are shown in Figure 25.

Table 13 Summary of results from Trial 3

Item	Weight
Whole green prawns	35.1 kg
Recovered extracted meat	30.4 kg
Shell (calculated by difference)[A]	4.6 kg

[A] Weight of shell calculated by difference between weight of whole green prawns and recovered extracted meat

Figure 25 Prawns from Trial 3 (A) whole prawns prior to processing; (B) extracted meat

The product recovered from Trial 3 was packaged into approximately 1 kg bags. The average temperature of the initial prawns, extracted prawn meat, blast freezer, chiller and factory are reported in Table 14. The core temperature profiles during the blast freezing process of two bags of product from Trial 3 are shown in Figure 26. For these bags the thermal arrest time (duration it takes for the product temperature to reduce from -1°C to -5°C) was approximately 4¼ and 7 hours, and it took between 9½ to 10 hours for the core temperature to reach -18°C. The large variation in the thermal arrest times is a result of the placement of the bags within the blast freezer, as some bags were stacked on top of each other. Improving the freezing process could increase product quality by reducing the rate of product degradation.

Table 14 Summary of average temperatures recorded during Trial 3

Item	Temperature
Whole green prawns	2.0 to 5.0°C
Extracted meat (immediately after extraction)	7.5 to 10.5°C
Chiller	0.5 to 1.0°C
Factory	12.0 to 14.0°C
Blast freezer	-19.5 to -24.5°C

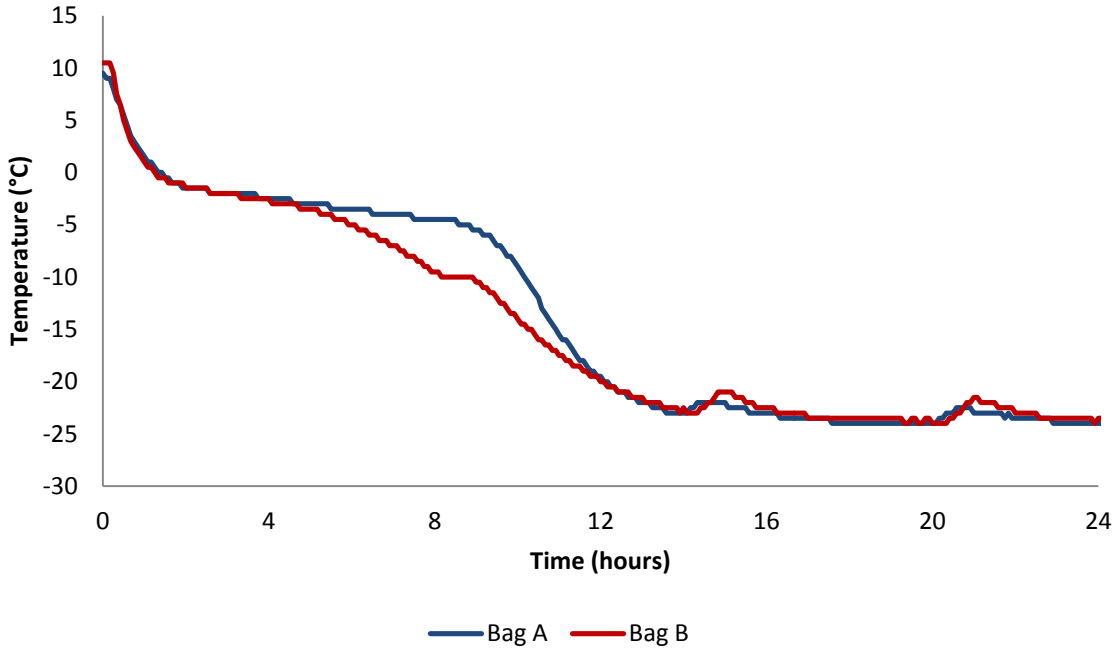


Figure 26 Core temperature profiles during blast freezing of two bags of product from Trial 3

Chilled and retention product samples were analysed for SPC, *E. coli*, *Salmonella*, coagulase-positive *Staphylococci* and total coliforms. The microbiological results for the chilled and retention samples are shown in Table 15 and Table 16, respectively. The *E. coli* and total coliforms were significantly lower than what was observed in Trial 2 (Appendix 4) and could potentially be attributed to equipment disassembly (drum and belt removal) and the sanitisation program. Whilst some of the chilled samples from all stages of processing had high levels of SPCs and coagulase-positive *Staphylococci* (often an indicator of poor hygiene), the microbiological load from retention samples was acceptable. Freezing can reduce microbiological loads by destroying or sublethally injuring microbiological cells.

The frozen extracted prawn meat was used for shelf-life evaluations and compositional analysis for nutritional panel labelling.

A portion of the frozen (whole) prawns and extracted prawn meat was also used to appraise the suitability of the extracted prawn meat in several Wonton recipes. The information and results from this assessment are reported in Appendix 9.

Table 15 Microbiological results from Trial 3; chilled samples (assessed on day 1)[A]

Sample	Replicate	SPC (Log_{10} cfu/g)[B]	*Salmonella* (detection/25g)	Coagulase-positive *Staphylococci* (cfu/g)	*E. coli* (cfu/g)	Total coliforms (cfu/g)
Whole green prawns	1	5.56	negative	100 (presumptive)	<10	110
	2	5.70	negative	<100	<10	40
	3	5.57	negative	300 (presumptive)	<10	30
Green prawn meat – start	1	5.86	negative	400 (presumptive)	80	160
	2	5.97	negative	100 (presumptive)	30	100
	3	5.90	negative	300 (presumptive)	<10	10
Green prawn meat – end	1	6.15	negative	100 (presumptive)	<10	30
	2	5.93	negative	<100	<10	10
	3	5.67	negative	200 (presumptive)	<10	40

[A] The Australia New Zealand Food Standards Code stipulates that a minimum of five sample units from a lot should be examined for microbiological criteria for regulatory purposes. Consequently the results presented in this table are indicative only when comparing to the limits prescribed in the Australia New Zealand Food Standards Code.

[B] Samples for SPC were incubated at 25°C for 96 hours which is different to the methods stated in the Food Standards Code (30°C for 72 hours). The lower incubation temperature of 25°C was examined as this assay is more sensitive and can produce significantly higher numbers of bacteria in fish and fishery products (Nickelson and Finne, 1992).

Table 16 Microbiological results from Trial 3; retention samples (assessed after 7 weeks of storage)[A]

Sample	Replicate	SPC (Log_{10} cfu/g)[B]	*Salmonella* (detection/25g)	Coagulase-positive *Staphylococci* (cfu/g)	*E. coli* (cfu/g)	Total coliforms (cfu/g)
Whole green prawns	1	5.04	negative	<100	<10	20
	2	4.46	negative	<100	<10	10
	3	4.20	negative	<100	<10	<10
Green prawn meat – start	1	4.49	negative	<100	<10	60
	2	4.48	negative	<100	40	70
	3	4.36	negative	<100	50	90
Green prawn meat – end	1	4.86	negative	<100	20	180
	2	4.69	negative	<100	60	230
	3	4.53	negative	<100	40	110

[A] The Australia New Zealand Food Standards Code stipulates that a minimum of five sample units from a lot should be examined for microbiological criteria for regulatory purposes. Consequently the results presented in this table are indicative only when comparing to the limits prescribed in the Australia New Zealand Food Standards Code.

[B] Samples for SPC were incubated at 25°C for 96 hours which is different to the methods stated in the Food Standards Code (30°C for 72 hours). The lower incubation temperature of 25°C was examined as this assay is more sensitive and can produce significantly higher numbers of bacteria in fish and fishery products (Nickelson and Finne, 1992).

The nutritional composition results for the green extracted prawn meat obtained from Trial 3 are reported in Table 17. The extracted prawn meat would meet the Omega 3 fatty acid claim 'a good source of Omega 3' as highlighted in the Super Seafood Factsheet (provided that the serving size is >20g).

Table 17 Nutritional composition of extracted green prawn meat from Trial 3

Analyte	Values per 100 g
Moisture	81.7 g
Energy Value	324 kJ
Protein	15.7 g
Fat, Total	1.4 g
Saturated	0.6 g
Trans	<0.1 g
Polyunsaturated	0.5 g
Omega-3 Total	290 mg
alpha-linolenic acid	30 mg
eicosapentaenoic acid	130 mg
docosahexaenoic acid	120 mg
Monounsaturated	0.3 g
Carbohydrate	0.3 g
Sugars	0.3 g
Sodium	130 mg
Calcium	130 mg

The sensory shelf-life of the extracted meat from Trial 3 was assessed in green (raw) and cooked formats. During the cooking process the extracted prawn meat (dry fried in non-stick frying pan) cooked up like 'scrambled eggs' and finished as a 'wet mince'. The extracted prawn meat during and after the cooking process are shown in Figure 27.

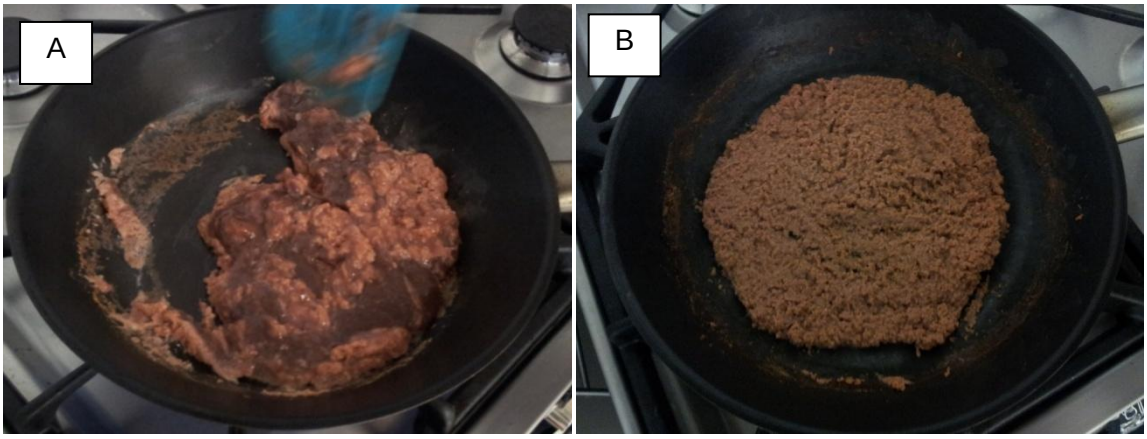


Figure 27 The extracted prawn meat (A) during the cooking process; (B) after cooking

The sensory evaluation results for raw and cooked formats are shown in Figure 28 and Figure 29, respectively. There were no significant differences (p-value>0.5) in the appearance, colour, aroma, texture and flavour when assessed after approximately 4 and 8 weeks of frozen storage. No panel assessment was undertaken on the freshly extracted meat immediately after processing; however after thawing, the product seemed to appear darker in colour and glossier in appearance. Whilst the product provided a strong (but not unpleasant) prawn aroma and an exceptionally strong prawn flavour, the sensory evaluation scores for the various attributes in both the green (raw) and cooked formats were mostly between 3 (quite poor) and 4 (neither good nor poor), and overall the panellists considered the product to be unacceptable in the forms provided. Criticism of the product was received on its textural properties (pasty/floury and grainy/gritty) and lingering unpleasant metallic and bitter aftertastes. The panellists indicated that with improvements the product could potentially be used in seafood pâté and dips, fishcakes, or as a flavour enhancer in Thai and Vietnamese dishes.

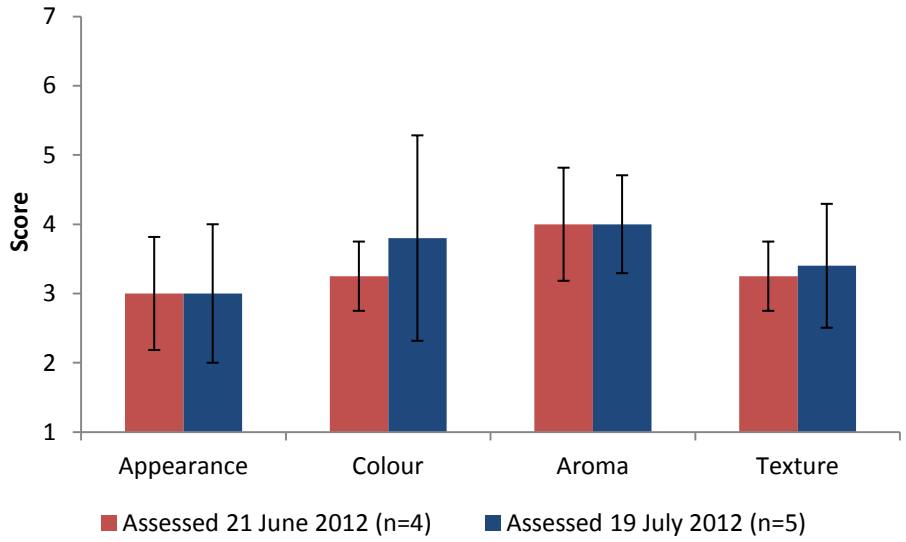


Figure 28 Sensory scores by panellists for extracted green (raw) prawn meat (data expressed as mean ± standard deviation)

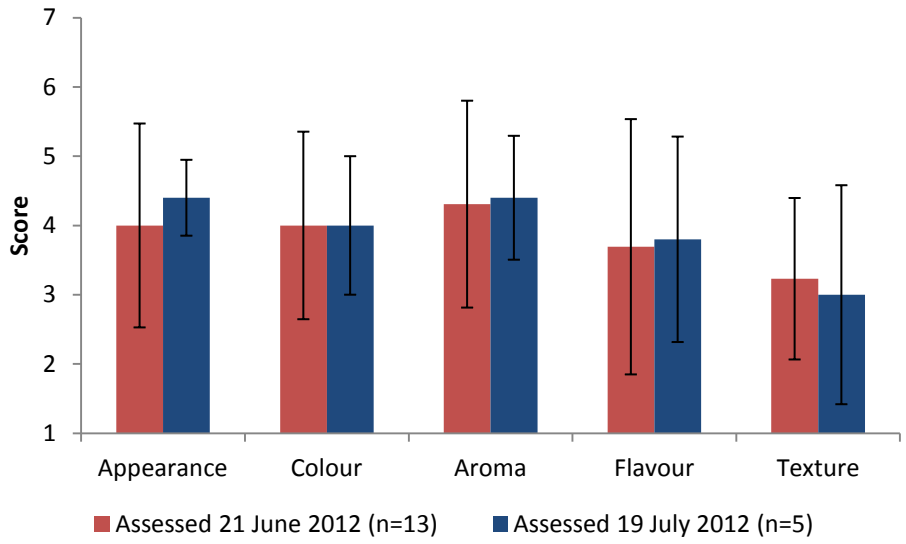


Figure 29 Sensory scores by panellists for dry-fried prawn meat (data expressed as mean ± standard deviation)

Informal tastings (not scored) completed as part of Project 2010/744 in 2010 and at a Australian Seafood CRC event used extracted school prawn meat as an ingredient in dim sims. The extracted meat was consumed within 2 days of processing and no negative comments were received. Therefore, it is possible that changes could be occurring prior to, or during, the first month of frozen storage which are causing physical alterations (colour, texture, flavour) to the extracted meat.

The nucleotide profiles and calculated k-value of the extracted meat after approximately one, two and three months of frozen storage are reported in Table 18. The presence of hypoxanthine (Hx) is usually characterised by the development of undesirable bitter flavours (Huss, 1988; Bremner, 2012). Unthawed samples (after 3 months of storage) had a 20% improvement in the k-values, over thawed samples. For peeled prawns a k-value of 20% for the tail meat has been proposed as the limit to freshness and a k-value of 60% as the limit to acceptability (Sriket, 2006). The results for the extracted prawn meat have k-value results well above the proposed freshness limit and above the proposed acceptable limit, however the extracted prawn meat contained the tissue from the prawn heads. When assessed the k-value of the prawn heads were significantly higher than that of the tail meat and would have contributed to the overall k-value of the extracted meat.

The nucleotide profiles and calculated k-value of manually peeled tail meat and prawn heads during storage are reported in Table 19. The k-value of the tail meat remained at acceptable limits (23.2%) even after 3.5 months of storage. This implies that the green prawns used in the study were initially of good quality and degraded during or after processing. The weighted average (or theoretical) k-value after 3.5 months of frozen storage (assuming no interactions between the tissues from the tail and head) was significantly lower than what was measured in the extracted meat.

Given that the thawing process showed a significant effect on the k-value, the high k-value after one month of storage, the low rate of degradation after one month and a moderate

theoretical k-value after 3.5 months, the initial product handling, including the freezing rate, of the extracted prawn meat is likely to be critical.

Table 18 Nucleotide profiles and k-value of extracted prawn meat (n = 3)

	Thawed extracted meat – 1 month	Thawed extracted meat – 2 months	Thawed extracted meat – 3 months	Unthawed extracted meat – 3 months
ATP (µmoles/g)	0.00±0.00	0.00±0.00	0.09±0.01	0.08±0.07
ADP (µmoles/g)	1.28±0.05	1.24±0.01	0.53±0.02	0.62±0.06
AMP (µmoles/g)	0.00±0.00	0.00±0.00	0.51±0.02	0.25±0.09
IMP (µmoles/g)	2.96±0.19	1.97±0.05	1.55±0.15	4.29±0.21
HxR (µmoles/g)	3.87±0.22	4.30±0.02	5.54±0.15	7.11±0.10
Hx (µmoles/g)	7.58±0.18	7.79±0.05	6.79±0.28	2.88±0.15
k-value	73.0±1.5	79.0±0.2	82.1±0.5%	65.6±0.8%

Table 19 Nucleotide profiles and k-values of tail meat and head (n = 3)

	Tail meat – 1 month	Tail meat – 3.5 months	Prawn heads – 3.5 months	Theoretical [A] extracted prawn meat – 3.5 months
ATP (µmoles/g)	0.06±0.05	0.00±0.00	0.12±0.06	0.04
ADP (µmoles/g)	0.57±0.04	0.73±0.02	0.48±0.03	0.65
AMP (µmoles/g)	7.16±0.18	7.18±0.27	0.51±0.10	4.89
IMP (µmoles/g)	8.88±0.09	8.39±0.42	1.49±0.25	6.02
HxR (µmoles/g)	1.56±0.08	2.33±0.17	4.57±0.22	3.10
Hx (µmoles/g)	1.13±0.25	2.61±0.89	4.44±1.01	3.23
K-value	13.9±1.2%	23.2±2.9%	77.6±3.5%	35.3%

[A] Calculated using a weighted average from the prawn tail meat and head

KEY FINDINGS

- Product yield was 86.8%.
- Initial microbial results indicated a chilled product may be at risk of unacceptable high levels of SPCs and (presumptive) coagulase-positive *Staphylococci*. Additional monitoring and/or pre-treatment of the chilled prawns may be required and will be investigated for future trials.
- Sensory assessment scores were low, and comments regarding the unpleasant metallic and bitter aftertaste are of concern. The bitter aftertaste could potentially be linked to enzymatic degradation as indicated by the high k-values in the extracted products after approximately one, two and three months of frozen storage.
- Initial product handling, including freezing rate, of the extracted prawn meat is likely to be critical.

APPENDIX 6: PRELIMINARY ASSESSMENT OF ADDITIVES

BACKGROUND

Samples of extracted green prawn meat in Trial 3 showed elevated k-values after storage at -18°C for one, two and three months which was linked to autolytic enzymatic activity. The Australia New Zealand Food Standards Code (Standard 1.3.1) contains a list of additives and regulatory limits that are permitted for use with uncooked crustaceans. The use of these permitted additives may reduce the rate of product degradation.

OBJECTIVE

To determine the likely effect of some of the permitted additives on the quality of the extracted prawn meat.

METHODS

Raw Materials

The school prawns used in the preliminary assessment of additives were supplied by the Clarence River Fishermen's Co-operative (CRFC). These prawns had been caught by commercial fishermen in February 2012, packaged in 1 kg bags and frozen for approximately 8 months. The prawns were thawed overnight at 4°C.

Equipment

This trial was undertaken in one of SARDI's Food Safety and Innovation laboratories. When required prawns were diluted 1/10 weight/volume in reverse osmosis water and homogenised in a laboratory blender (Bag Mixer 400, Interscience, France). The pH of the homogenised prawn meat was measured with a WP80 pH meter with a calibrated Ag/AgCl intermediate junction pH sensor (TPS Pty Ltd, Springwood, Queensland).

Treatments and Assessment Criteria

The Australia New Zealand Food Standards Code – Standard 1.3.1 – lists the additives and their regulatory limits that are permitted for use with uncooked crustaceans. From this list, sodium metabisulphite (preservative), citric acid (pH regulator), carbonates (pH regulator) and ascorbates (antioxidant) were examined with different methods of application and treatment times. The pH regulators were considered as pH can affect enzymatic activities and thus the rate of product degradation.

<u>Concentrations of additives in dip process</u>

Prawns were soaked (ratio prawns to dip 1:4 weight/volume) at 4°C in 0.5% weight/volume and 1% weight/volume solutions of ascorbic acid, citric acid, sodium carbonate and sodium metabisulphite for 90 minutes. The prawns were visually assessed after each treatment and the pH of the homogenised prawn meat determined.

Contact time of additives in dip process

Prawns were soaked (ratio prawns to dip 1:5 weight/volume) at 4°C in 1% weight/volume solutions of ascorbic acid, citric acid, sodium carbonate, sodium bicarbonate and sodium metabisulphite for 2, 4, 6, 24 and 120 hours. The prawns were visually assessed during the treatments and the pH of the homogenised prawn meat determined.

Concentration of additives in blending process

Prawns were homogenised in a food processor and concentrated solutions of ascorbic acid, citric acid, sodium bicarbonate and sodium metabisulphite were then blended with the homogenate so that the final concentrations of the additives were 0.01% weight/volume or 0.1% weight/volume.

RESULTS AND DISCUSSION

Concentrations of additives in dip process

The pH of the homogenised prawn meats after soaking in the additive solutions are shown in Figure 30. Most of the additives, when compared to the control (tap water) had an effect on the pH of the extracted prawn meat. The effects of these pH variations on enzymatic activities or product degradation were not determined. The concentration of the additives had a lesser impact. The prawns were not rinsed prior to homogenisation and it is unknown if the additives had penetrated the tissue of the prawns or if the observed pH changes were caused by a carry-over of the additive from the surface of the prawns to the homogenisation solution.

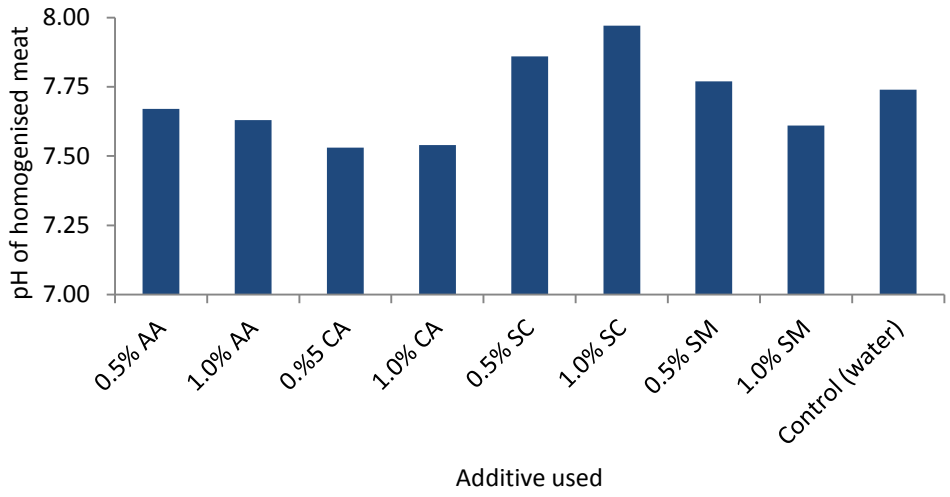


Figure 30 Effect of various additives on the pH of the prawn meat; where AA is ascorbic acid, CA is citric acid, SC is sodium carbonate and SM is sodium metabisulphite

Contact time of additives in dip process

The effect of the contact time of the additive solutions on the pH of the prawn meat is shown in Figure 31. With the exception of citric acid, the short-term contact time (contact time of up to 6 hours) did not have a major effect on the pH of the meat. Longer contact

times had a greater effect on the pH of the meat, although the changes were generally within 0.5 pH units. The effects of these pH variations on enzymatic activities or product degradation were not determined.

The visual appearances of the dipping solutions and the prawns after an extended (five day) soak are shown in Figure 32 and Figure 33, respectively. After 5 days all the dipping solutions were discoloured, with the exception of 1.0% sodium metabisulphite which remained colourless. Ascorbic acid (1.0%), sodium metabisulphite (1.0%) and citric acid (1.0%) treatments appeared to inhibit melanosis and the use of 1.0% sodium carbonate turned the prawns an orange colour.

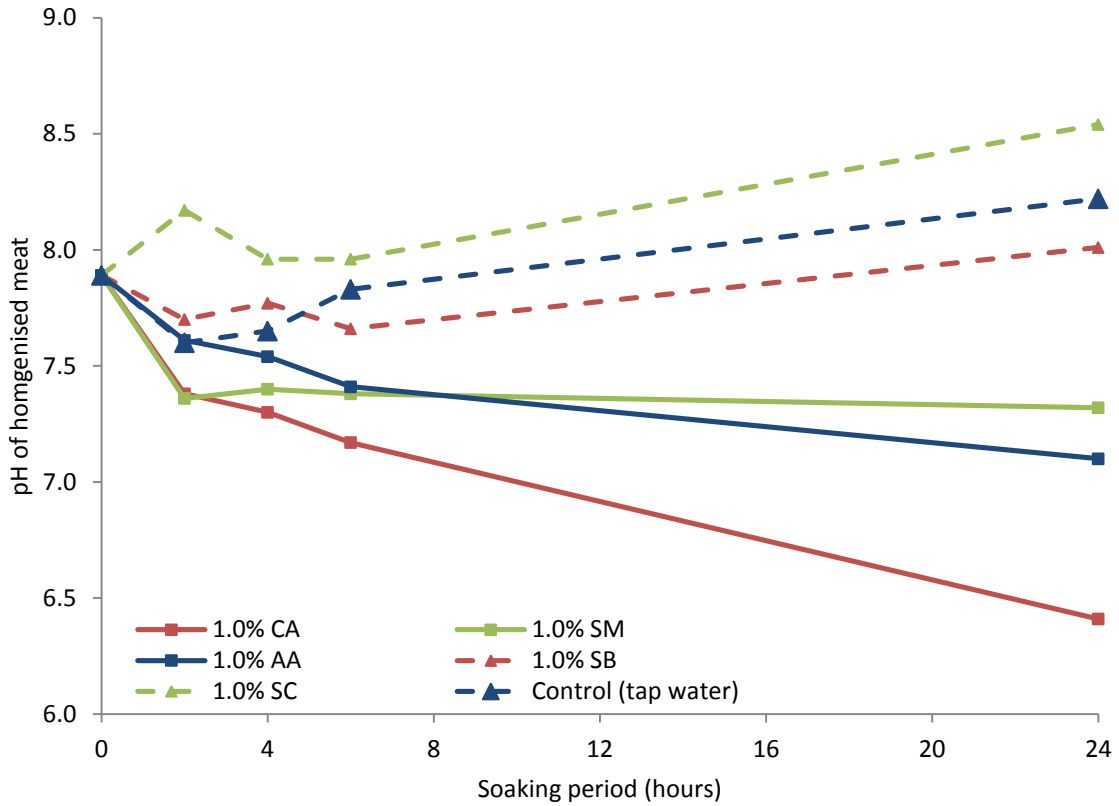


Figure 31 Effect of additive contact time on the pH of the prawn meat; where CA is citric acid, SM is sodium metabisulphite, AA is ascorbic acid, SB is sodium bicarbonate and SC is sodium carbonate

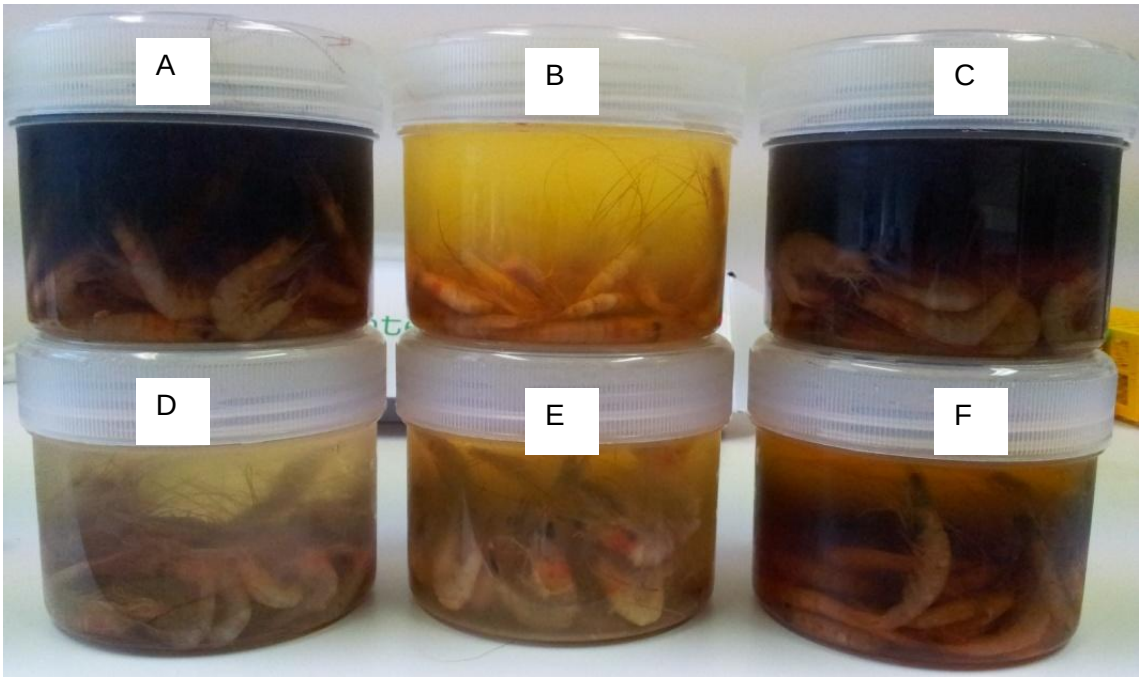


Figure 32 Appearance of additive solutions after 5 days; (A) control (tap water); (B) 1.0% ascorbic acid; (C) 1% sodium bicarbonate; (D) 1.0% sodium metabisulphite; (E) 1.0% citric acid; (F) 1.0% sodium carbonate

Figure 33 Appearance of prawns after extended (5 day) soak; (A) water; (B) 1.0% ascorbic acid; (C) 1.0% sodium bicarbonate; (D) 1.0% sodium metabisulphite; (E) 1.0% citric acid; (F) 1.0% sodium carbonate

Concentration of additives in blending process

Attempts were undertaken to blend concentrated additive solutions with samples of homogenised prawn meat. These attempts were regarded as unsuccessful due to

constraints caused by a limited batch size in the food processor. The prawn meat stuck to the side of the food processor. It was considered highly likely that the additives would have been unevenly mixed through the processed meat. A blending process could deliver a satisfactory result, but it would require the use of more complex equipment adding to the processing cost. In addition, blending the additives after extraction of the meat may be counter-productive as it would increase the time between extraction and freezing.

KEY FINDINGS

- The additives investigated had an influence on the pH and visual appearance of the prawns and will be trialled at the CRFC to determine their efficiency on inhibiting product degradation.
- The duration of additive exposure (at the concentrations used) did not have a significant impact on the pH of the homogenised prawn meat and a short dip time (approximately 10 minutes) is recommended. Longer dip times could be feasible and their suitability would depend on the processing logistics.
- Blending concentrated additives into extracted meat could deliver a suitable outcome but compared to dipping would involve a greater level of investment.

APPENDIX 7: TRIAL 4 (06 MARCH 2013)

BACKGROUND

Trials 1, 2 and 3 had extracted the prawn meat from green prawns and the product from Trials 2 and 3 were packaged in 1 kg bags and frozen. When assessed, the extracted product from Trial 3 had low to poor sensory attributes and product deterioration was attributed to autolytic enzymatic degradation. The activity of enzymes can be influenced by a number of factors, including temperature, pH and substrate concentration. A treatment process was required to reduce the rate of product degradation. The preliminary assessment of additives (Appendix 6) had shown that the additives were capable of changing the appearance and pH of the extracted meat; however their efficiency in inhibiting product degradation was not determined.

OBJECTIVE

The objectives of Trial 4 were to:

a) investigate a number of treatment options in an attempt to reduce the rate of deterioration of the extracted prawn meat.

b) produce products for frozen and chilled shelf-life assessments.

c) create samples of the extracted product and use these samples to commence the initial market assessment and feasibility.

METHODS

Raw Materials

The prawns used in Trial 4 were caught by commercial fishermen between 28 February and 01 March 2013 and had been frozen and held at -18°C in 1 kg bags. The prawns were thawed (overnight) prior to use. Although some extra handling is involved, the use of thawed prawns is a practical option for the CRFC as the prawns could be processed during a quieter period of the year. Approximately 200 kg of green prawns were used in the trial.

Equipment and Sanitisation

The Baader separator was disassembled, and the wetted surfaces cleaned and soaked overnight in a solution of Sanifoam (Tasman Chemicals Limited, Braeside, Victoria). The wetted surfaces were rinsed with potable water and the Baader separator reassembled. All prawn meat extract in Trial 4 was undertaken in the Baader separator with three people processing and packaging. In between treatments the Baader separator was rinsed with potable water.

Treatments

In an attempt to reduce the rate of product degradation nine treatments were investigated. These treatments and the assessment dates are reported in Table 20.

- Sodium metabisulphite was trialled as it is frequently used as a disinfectant, antioxidant or preservative. Sodium metabisulphite is used in the industry to control melanosis in prawns which is catalysed by polyphenol oxidase enzymes.
- Sodium ascorbate (sodium salt of vitamin C) was trialled as it is an antioxidant and could reduce oxidation in the extracted meat.
- Citric acid was trialled as it is often used as pH regulator to decrease pH.
- Sodium bicarbonate was trialled as it is often used as pH regulator to increase pH. Sodium bicarbonate has also been shown to improve the water holding capacity, colour and organoleptic properties of prawn meat (Lopkulkiaert et al., 2009).
- Cooked prawns and cooking the prawn meat after extraction were trialled as heat can deactivate enzymes.

Prawns were drained of any free water or additive solutions and manually loaded into the hopper. The extracted meat from each treatment was packaged into 500 g bags and vacuum packed for the shelf-life assessment program. The 500 g bags were either kept chilled at 4°C, or frozen in the CRFC blast freezer and then held at -18°C. In addition, samples of the extracted meat were also packaged into approximately 50 g bags, vacuum packed and rapidly frozen by submersion in a brine-ice slurry before being transferred into the CRFC blast freezer and then transported to Adelaide in Styrofoam boxes where they were kept at -80°C until analysed for nucleotide degradation and lipid oxidation. These 50 g samples were used to represent the extracted products at day 0.

The temperature of the factory, blast freezer, chiller and extracted prawn meat were measured and recorded with either a temperature probe or iButton data loggers (Maxim Integrated, San Jose, CA, USA).

Table 20 Treatments in Trial 4

Treatment ID	Description
1	**Cooked, chilled:** Green prawns cooked in boiling salt water for 3 minutes. Once cooked the prawns were submerged in iced water to cool, allowed to drain, and stored on ice for 20 hours in the chiller. Meat from cooked prawns extracted, product vacuum packed in 500 g bag and kept chilled at 4°C. Products assessed after 1, 3, 6 and 8 days of storage.
2	**Green, chilled:** Green prawns soaked for 15 minutes in potable water (control) and allowed to drain for 20 minutes (prawns to water ratio 1:2). Meat from green prawns extracted, product vacuum packed in 500 g bags and kept chilled. Products assessed after 1, 3, 6 and 8 days of storage.

3	**Cooked, frozen:** Green prawns cooked in boiling salt water for 3 minutes. Once cooked the prawns were submerged in iced water to cool, allowed to drain, and stored on ice for 20 hours in the chiller. Meat from cooked prawns extracted, product vacuum packed in 500 g bags and frozen. Products assessed after 1, 2, 4, 12 and 24 weeks of storage.
4	**Sous vide, frozen:** Green prawns soaked for 15 minutes in potable water (control) and allowed to drain for 20 minutes (prawns to water ratio 1:2). Meat from green prawns extracted, product vacuum packed in 500 g bags, cooked for 8 minutes, rapidly chilled in ice water and frozen. Products assessed after 1, 2, 4, and 12 weeks of storage.
5	**Green, frozen:** Green prawns soaked for 15 minutes in potable water (control) and allowed to drain for 20 minutes (prawns to water ratio 1:2). Meat from green prawns extracted, product vacuum packed in 500 g bags and frozen. Products assessed after 1, 2, 4 and 12 weeks of storage.
6	**Sodium metabisulphite, frozen:** Green prawns soaked for 15 minutes in 1% sodium metabisulphite solution (a preservative) and allowed to drain for 20 minutes (prawns to dip ratio 1:2). Meat from prawns extracted, product vacuum packed in 500 g bags and frozen. Products assessed after 1, 2, 4 and 12 weeks of storage.
7	**Sodium ascorbate, frozen:** Green prawns soaked for 15 minutes in 1% sodium ascorbate solution (an antioxidant) and allowed to drain for 20 minutes (prawns to dip ratio 1:2). Meat from prawns extracted, product vacuum packed in 500 g bags and frozen. Products assessed after 1, 2, 4 and 12 weeks of storage.
8	**Citric acid, frozen:** Green prawns soaked for 15 minutes in 1% citric acid solution (a pH regulator) and allowed to drain for 20 minutes (prawns to dip ratio 1:2). Meat from prawns extracted, product vacuum packed in 500 g bags and frozen. Products assessed after 1, 2, 4 and 12 weeks of storage.
9	**Sodium bicarbonate, frozen:** Green prawns soaked for 15 minutes in 1% sodium bicarbonate solution (a pH regulator) and allowed to drain for 20 minutes (prawns to dip ratio 1:2). Meat from prawns extracted, product vacuum packed in 500 g bags and frozen. Products assessed after 1, 2, 4 and 12 weeks of storage.

Assessment Criteria

Triplicate samples of the frozen product concepts (extracted meat from Treatments 3 – 9) were thawed (approximately 18 hours at 4°C) after 14 days storage and analysed for SPC (25°C for 96 hours). The moisture contents and pH of frozen product concepts (Treatments 3 – 9) were also assessed.

Sensory evaluation of the product concepts was assessed with an informal panel from the SARDI Food Safety and Innovation team. Chilled product concepts (Treatment 1 and Treatment 2) were assessed for colour, appearance, texture and aroma after 1, 3, 6, and 8 days of storage at 4°C. Frozen product concepts (Treatments 3 – 9) were thawed (approximately 18 hours at 4°C) and assessed for colour, appearance, texture and aroma after 1, 2, 4 and 12 weeks of storage at -18°C. The product concept from Treatment 3 was also assessed for colour, appearance, texture and aroma after approximately 24 weeks of storage. After 12 weeks the frozen product concepts (Treatments 3 – 9) were also assessed for flavour after being dry-fried in a non-stick pan.

Nucleotide degradation and lipid oxidation were assessed from samples of the product concepts (extracted meat) collected during the shelf-life assessment program. Samples were packed in zip-lock bags, air evacuated and stored at -80°C until analysis.

RESULTS AND DISCUSSION

The extraction and packaging of all treatments was undertaken on a single day (day 0). Some of the whole cooked and green prawns used in Trial 4 are shown in Figure 34.

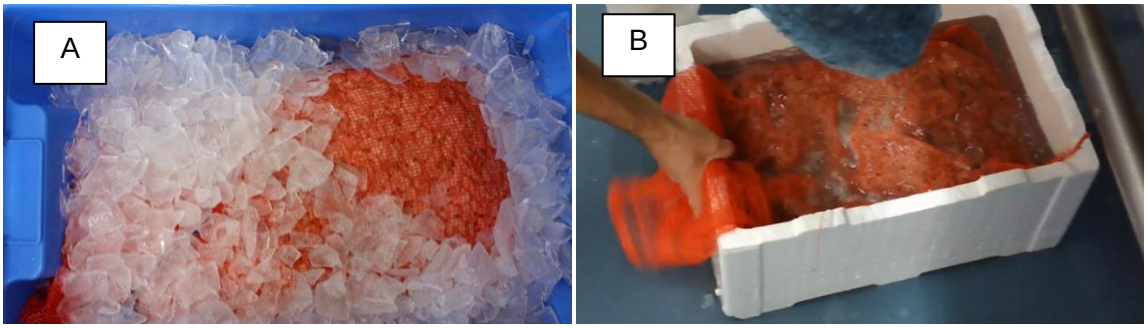


Figure 34 Prawns prior to extraction; (A) cooked prawns on ice, (B) green prawns during potable water (control) dip

Product Yield and Temperature Profiles

A summary of the weights and yields for the cooked product (Treatment 1 and Treatment 3) and green product (Treatment 2 and Treatment 5) are reported in Table 21. The estimated yield for the cooked prawns is significantly lower than that of the green product. This is because the logistical constraints during the trial meant that no attempt was made to recover all of the extracted product. This yield has not been included in further calculations; the yield of the cooked product would need to be more accurately determined as it will have a significant impact on the commercial viability.

Table 21 Summary of weights and yields from Trial 4

Item	Cooked Product	Green Product
Whole prawns (green)	30.0 kg	17.9 kg
Extracted meat (packaged)[A]	15.5 kg	11.5 kg
Yield	60.8%[B]	86.0%

[A] The weights of the extracted products were not recorded. Weights of extracted meat (packaged) were estimated based on the number of bags packaged to a minimum weight of 500 grams.

[B] Weight of cooked prawns not measured (a 15% weight loss has been assumed to have occurred when prawns were cooked).

The recorded temperature profiles of the factory, chiller and blast freezer during the trial are shown in Figure 35 and the average temperature of the factory, chiller and blast freezer were 15.6°C, 1.7°C and -20.0°C, respectively. The variations in the recorded temperature of the chiller and blast freezer are associated to the physical placement of temperature loggers in the chiller and freezer, which were impacted by opening and closing of doors, and would not represent the overall temperature within the chiller and freezer. The core temperature profiles during blast freezing process of two random bags of product (one bag from Treatment 3 and one bag from Treatment 5) are shown in Figure 36. For these bags the thermal arrest time (duration it takes the product temperature to reduce from -1°C to -5°C) was approximately 1 and 1½ hours, and it took between 2½ and 4 hours for the core temperature to reach -18°C. These thermal arrest times are significantly shorter than those calculated in Trials 2 and 3 and are attributed to the smaller bag sizes and better utilisation of the capacity of the blast freezer.

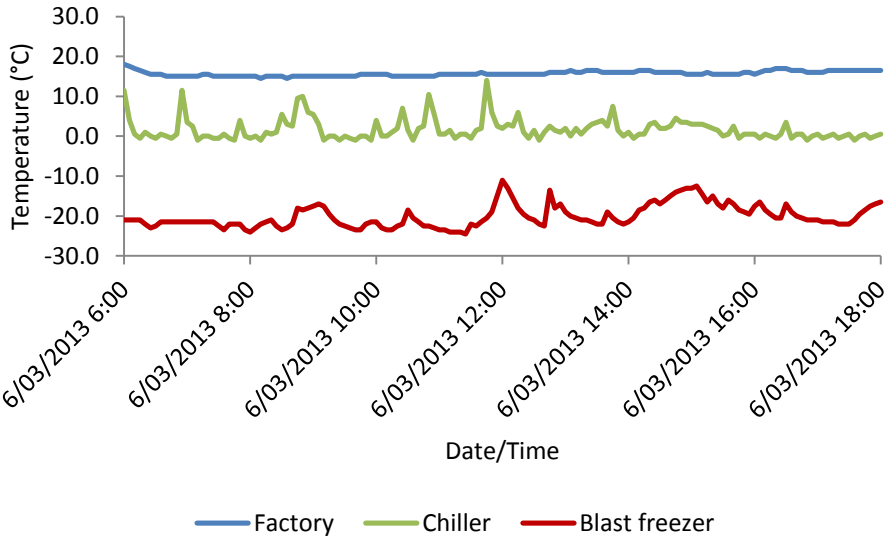


Figure 35 Temperature profile of the factory, chiller and blast freezer

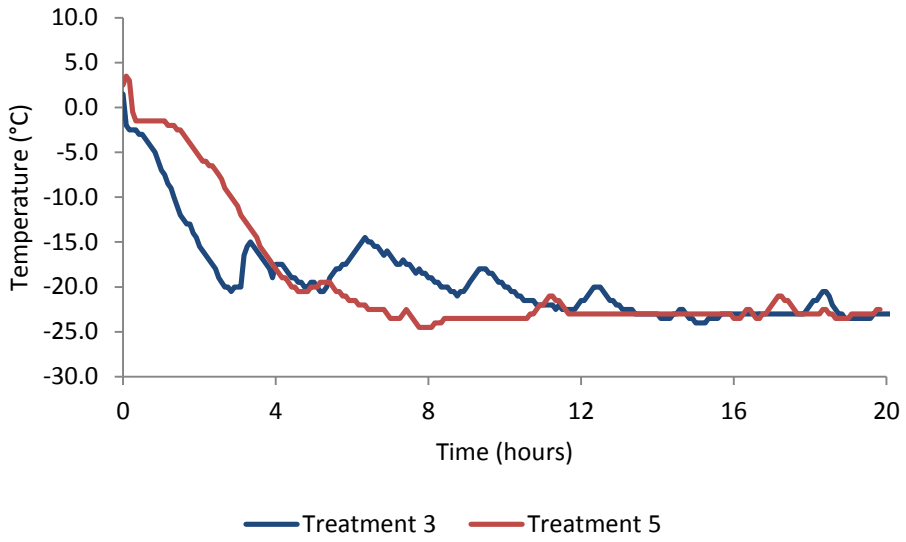


Figure 36 Core temperature profiles during blast freezing of two bags of product from Trial 4

Sensory Assessment

Several bags of the packaged product concepts are shown in Figure 37. There was no visual difference in appearance of Treatments 5 - 9. The extracted meat from the cooked prawns (Treatment 3) was firm in texture and pink/orange in colour (typical of a cooked prawn meat); however purple/black flecks where visible throughout the product. The meat recovered from the green prawns (Treatment 5) was dark purple/grey in colour and was quite mushy.

Figure 37 Packaged products; left to right: cooked (Treatment 3), sous vide (Treatment 4) and green (Treatment 5)

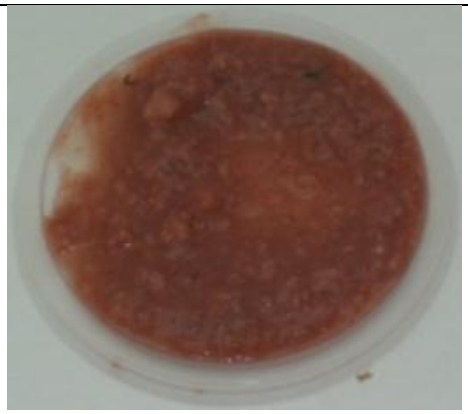
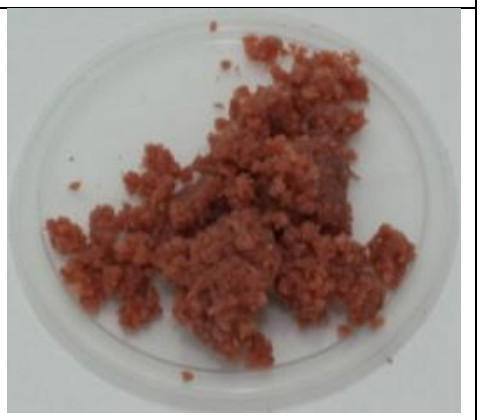
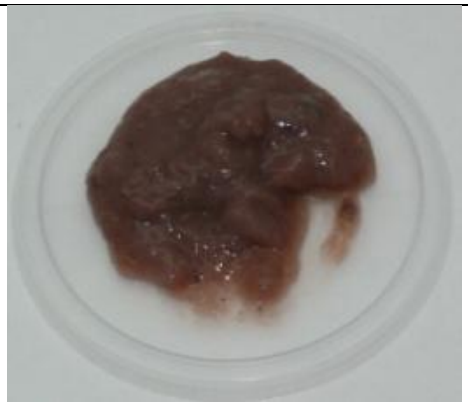
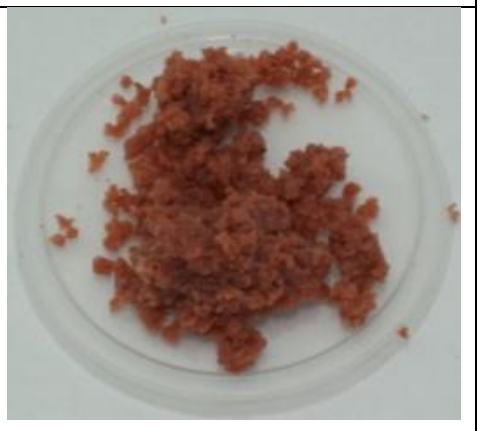
The cooked product concepts (Treatment 1 and Treatment 3) had an acceptable appearance whereas the remaining product concepts (Treatments 2, 4 – 9) were not visually attractive. Despite their appearance, an assessment undertaken by a consultant chef showed that the cooked (Treatment 1 and Treatment 3) and green (Treatment 5) product concepts had an opportunity to be used as an ingredient as they provided a strong prawn flavour and aroma. Treatments 6 – 9 were not assessed by the consultant chef as the main objective of the trial was to reduce the rate of product degradation. The product assessment results from the consultant chef are reported in Chapter 3.2 Market Feasibility.

The chilled product concepts from Treatment 1 and Treatment 2 (cooked and green, respectively) were maintained at 4°C and assessed for colour, appearance, texture and aroma after 1, 3, 6 and 8 days of storage. The sensory assessments by SARDI did not reveal any noticeable changes in the product during the chilled storage trial up to day 6. However, after 8 days of chilled storage the aroma of the cooked product was offensive, with a strong ammonia-like smell.

Treatments 3 – 9 were maintained at approximately -18°C during storage. These frozen product concepts were thawed overnight (approximately 18 hours at 4°C) and assessed for colour, appearance, texture and aroma after 1, 2, 4 and 12 weeks of frozen storage by SARDI staff. There were no noticeable change in the appearance, texture and aroma of the product concepts (Treatments 3 – 9) during the shelf-life assessment program. Samples of product concepts from Treatments 3 – 9 (after 12 weeks of frozen storage) are shown in Figure 38.

The product concepts from Treatments 3 – 9 were also dry fried after 12 weeks of frozen storage and were assessed for colour, appearance, texture, aroma and flavour. A summary of the sensory assessment findings from the ‘dry fried’ product concepts are reported in Table 22. No bitterness or off-flavours were detected after 12 weeks; however some of the products left an astringent mouthfeel.

	Thawed	Dry fried
Treatment 3		

	Thawed	Dry fried
Treatment 4		
Treatment 5		
Treatment 6		
Treatment 7		

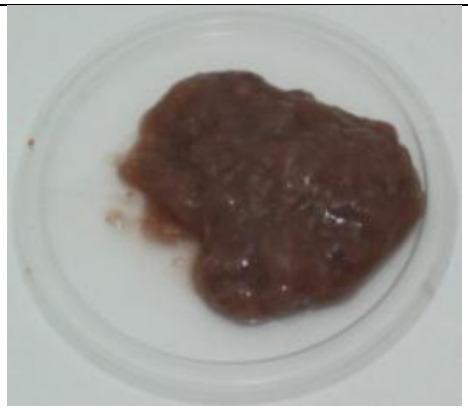
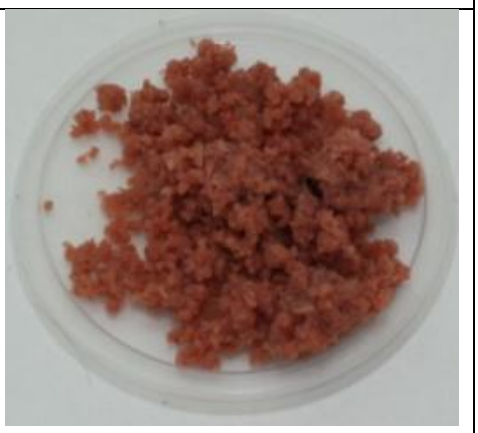
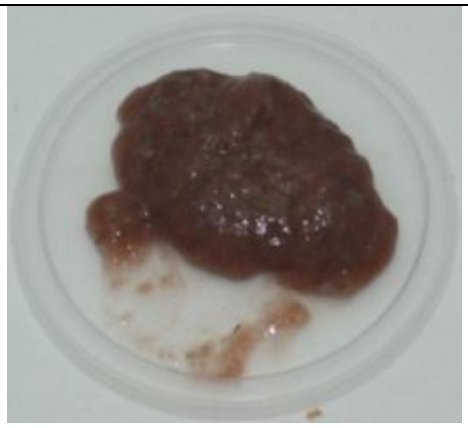
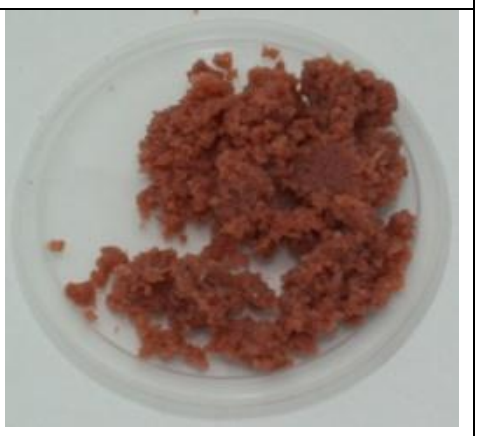
	Thawed	Dry fried
Treatment 8		
Treatment 9		

Figure 38 Images of product concepts (thawed and dry fried). Refer to Table 20 for treatment descriptions.

Table 22 Sensory assessment of product concepts (dry fried) after 12 weeks of frozen storage. Refer to Table 20 for treatment description.

Treatment ID	Appearance/colour	Aroma	Texture	Flavour
3	Peachy pink	Very strong fishy smell	Dry/crumbly texture, slightly gritty	Some sweetness, not bitter. No off flavours
4	Browny pink	Fishy/prawn	Slightly gritty	Initially sweet then astringent, no off flavours, no bitterness
5	Browny pink	Fishy/prawn	Slightly gritty	Slight prawn sweetness, then astringent. Not bitter, no off flavours
6	Browny pink	Strong meaty smell	Slightly gritty	Astringent. Not pleasant, no sweetness, but not bitter. No off flavours
7	Browny pink	Meaty	Slightly gritty	Astringent, but not bitter. No off flavours
8	Browny pink	Meaty	Gritty	Astringent, not pleasant, no sweetness, but no off flavours. Not bitter
9	Browny pink	Strong meaty smell	Gritty	Not sweet, but not bitter. No off flavours, possible metallic taste

Microbiological Assessment

The individual microbiological (SPC) results for Treatments 3 – 9 are reported in Table 23. Microbiological assessment was not undertaken on Treatment 1 and Treatment 2 as the concepts are anticipated to be frozen immediately after extraction and sold as a frozen product. The SPCs in all concepts are quite high; however, the samples were incubated at 25°C for 96 hours which is different to the methods stated in the Food Standards Code (30°C for 72 hours). The lower incubation temperature of 25°C was examined as this assay is more sensitive and can produce significantly higher numbers of bacteria in fish and fishery products (Nickelson and Finne, 1992). Minimising the holding period of the cooked prawns prior to extraction (Treatment 1 and Treatment 3) should reduce the microbiological contamination.

Table 23 SPCs (Log_{10} cfu/g) from frozen product concepts (Treatments 3 – 9). Assessed (25°C for 96 hours) after 2 weeks of storage[A, B]

Sample	Treatment						
	3	4	5	6	7	8	9
Replicate 1	5.46	4.45	5.41	4.96	5.08	5.08	5.00
Replicate 2	5.58	4.58	5.28	5.04	5.00	5.00	4.98
Replicate 3	5.62	3.82	5.11	4.97	5.08	4.93	4.97

[A] The Australia New Zealand Food Standards Code stipulates that a minimum of five sample units from a lot should be examined for microbiological criteria for regulatory purposes. Consequently the results presented in this table are indicative only when comparing to the limits prescribed in the Australia New Zealand Food Standards Code.

[B] Samples for SPC were incubated at 25°C for 96 hours which is different to the methods stated in the Food Standards Code (30°C for 72 hours). The lower incubation temperature of 25°C was examined as this assay is more sensitive and can produce significantly higher numbers of bacteria in fish and fishery products (Nickelson and Finne, 1992).

Biochemical Assessments

Nucleotide degradation

The k-value is an indication of the extent of the degradation of the nucleotide ATP. The lower the k-value the higher the quality, and a k-value less than 20% is frequently used to represent high quality seafood. The k-value from the chilled and frozen product samples collected during the shelf-life assessment program are shown in Figure 39 and Figure 40, respectively. In the chilled and frozen ranges, there were significant differences between treatments (p-value<0.001) and days (p-value<0.001).

The cooked chilled products (Treatment 1) were of high quality for at least 3 days (based on k-value results), whereas the green chilled product (Treatment 2) degraded rapidly. The cooked frozen product (Treatment 3) had a k-value of about 20% indicating high quality product and that remained stable during the first 24 weeks of the frozen shelf-life

assessment program. The k-values of the green extracted products (Treatments 4 – 9) were all initial approximately 40% and degraded during frozen storage. The k-values for Treatments 4 – 9 were not determined after 12 weeks.

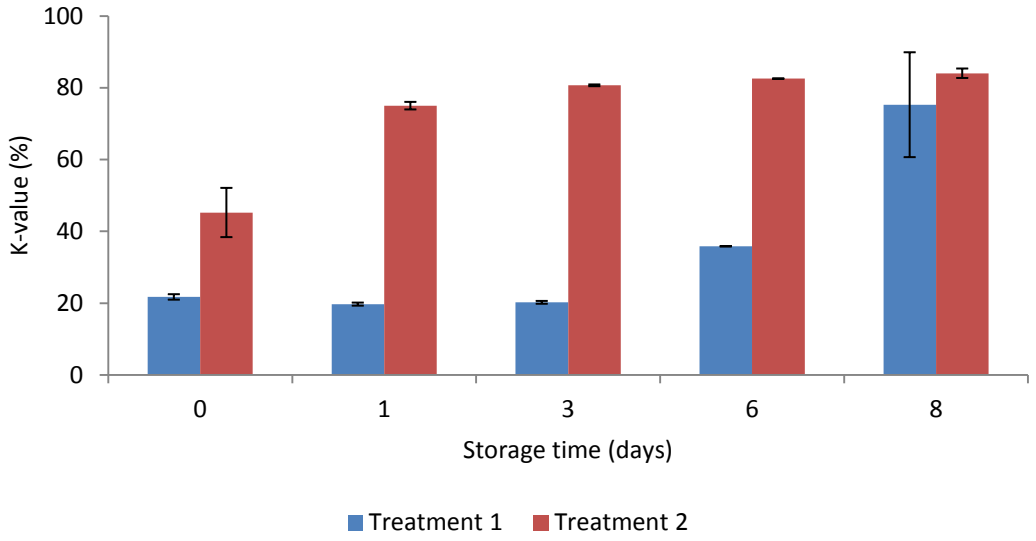


Figure 39 Effect of storage time on the k-value in chilled product samples. Refer to Table 20 for treatment description (data expressed as mean ± standard deviation; n = 3)

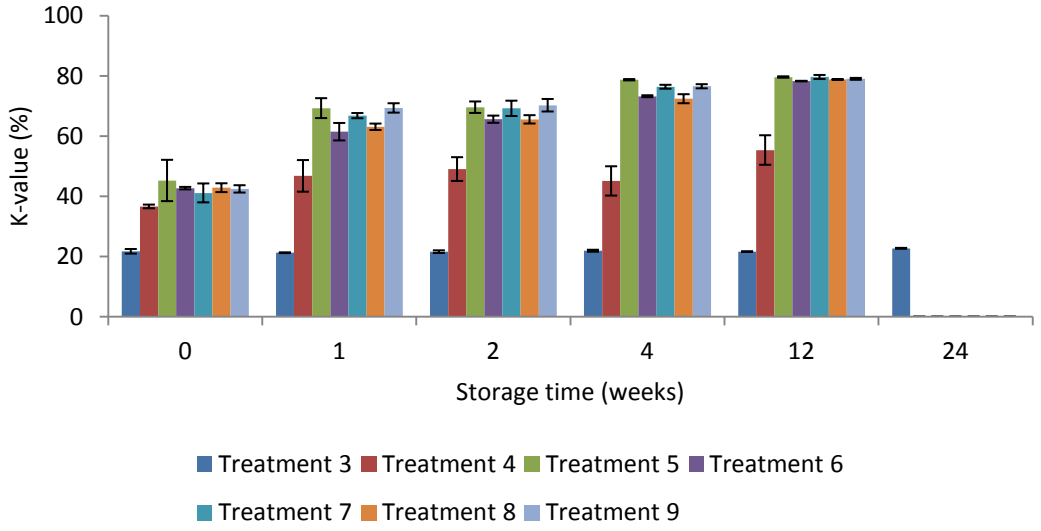


Figure 40 Effect of storage time on the k-value in frozen product samples. Refer to Table 20 for treatment description (data expressed as mean ± standard deviation; n = 3)

Lipid peroxidation

The concentrations of TBARs from the chilled and frozen product samples collected through the shelf-life assessment program are shown in Figure 41 and Figure 42, respectively. In the chilled range there was a significant difference (p-value<0.001) between treatments; with Treatment 2 significantly higher on all days, but no significant

differences (p-value>0.5) between days. In the frozen range there was a significant difference between treatments (p-value<0.001). In all cases the green and sous vide products had a higher concentration of TBARs, but did not exceed 0.075 mg malonaldehyde/kg over the shelf-life assessment program. While there is currently no other information available on the concentration of TBARs in school prawns, the concentration of TBARs in all of the treatments remained relatively stable through the shelf-life assessment program. The measured TBARs concentrations were very low and well below the 3 mg malonaldehyde/kg limit that has been suggested to indicate good quality seafood (Cadun et al., 2005). The TBARs in the frozen product concepts were not measured at 24 weeks of storage as there had been no prior increase.

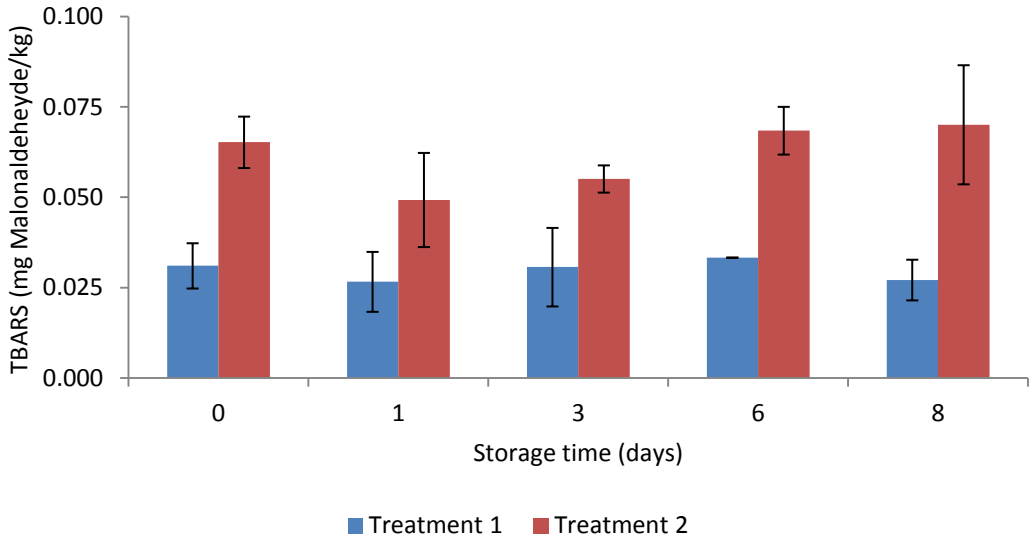


Figure 41 Effect of storage time on the concentration of TBARs in chilled product samples. Refer to Table 20 for treatment description (data expressed as mean ± standard deviation; n = 3)

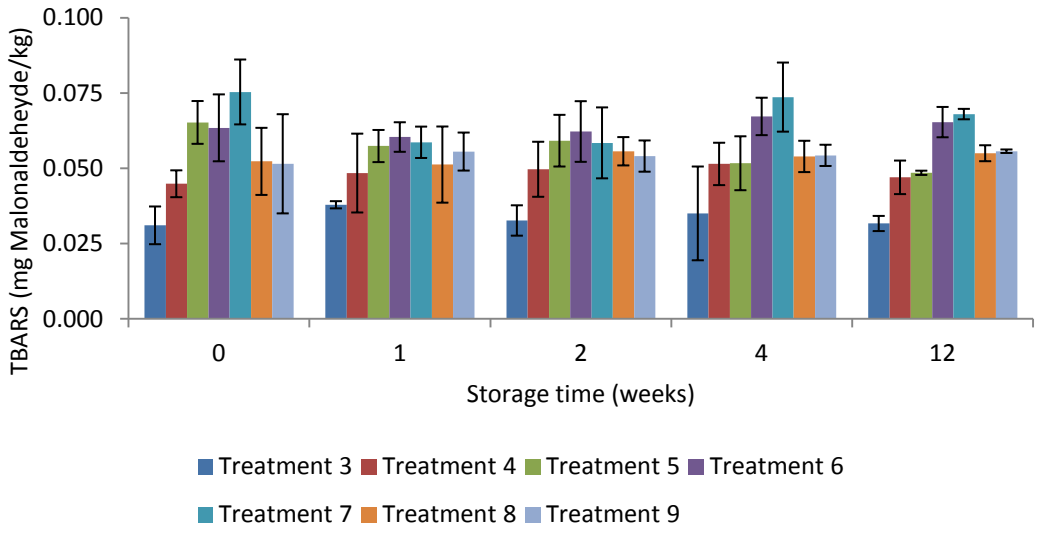


Figure 42 Effect of storage time on the concentration of TBARs in chilled product samples. Refer to Table 20 for treatment description (data expressed as mean ± standard deviation; n = 3)

pH

The pH values from the chilled and frozen product samples collected through the shelf-life assessment program are shown in Figure 43 and Figure 44, respectively. The pH values of Treatments 4 – 9 were not determined at 24 weeks as the product did not met commercial expectations. There were significant differences (p-value<0.001) in the pH readings between product concepts and in all cases the cooked product concept had higher pH readings. The pH of the cooked chilled product concepts remained relatively stable up to and including day 6, after which the pH began to decrease. The pH of the green chilled product slowly decreased throughout the shelf-life assessment program. The pH in the frozen products remained relatively stable throughout the shelf-life assessment program. The two pH regulators trialled with Treatment 8 (citric acid) and Treatment 9 (sodium bicarbonate) slightly altered the pH of the product concepts. The use of citric acid decreased the pH of the product by approximately 0.2 pH units, whereas sodium bicarbonate increased the pH of the products by approximately 0.1 pH units.

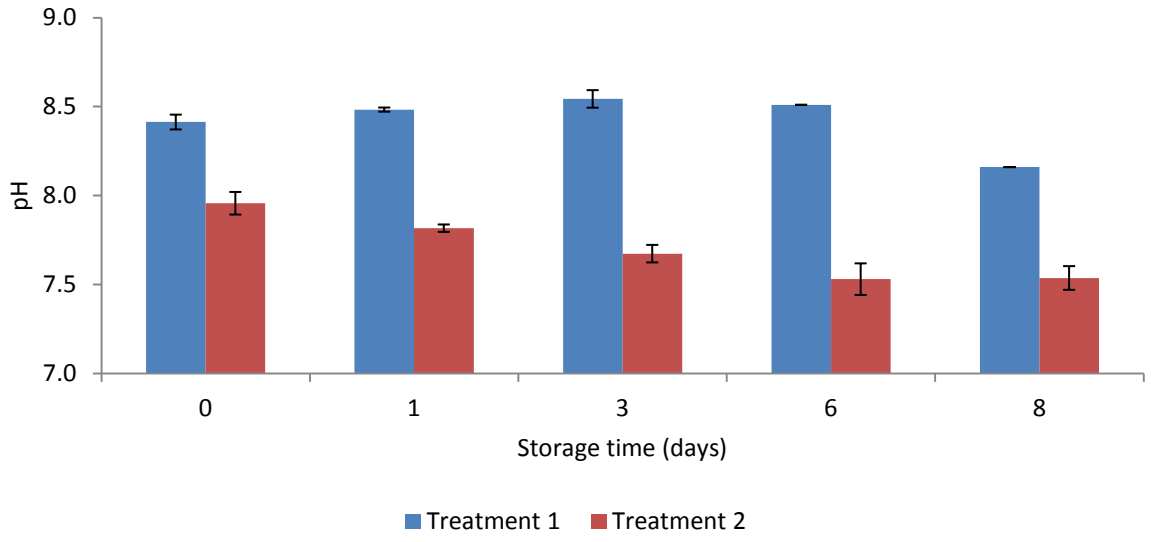


Figure 43 Effect of storage time on the pH in chilled product samples. Refer to Table 20 for treatment description (data expressed as mean ± standard deviation; n = 3)

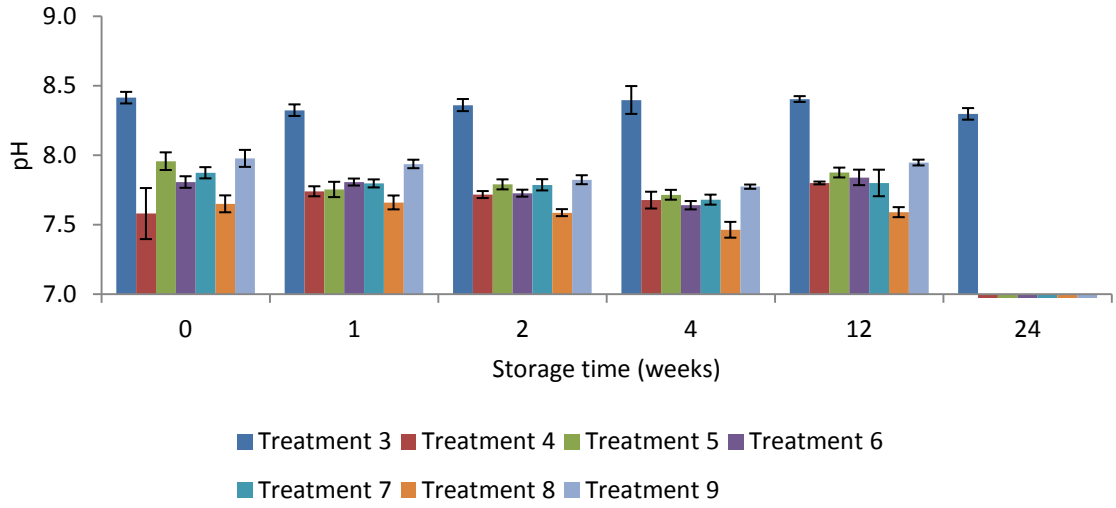


Figure 44 Effect of storage time on the pH in frozen product samples. Refer to Table 20 for treatment description (data expressed as mean ± standard deviation; n = 3)

Moisture content

The moisture contents for the product recovered from Treatments 3 – 9 are shown in Figure 45. Whilst the product concept recovered from the cooked prawns (Treatment 3) had a slightly lower moisture content than the other products (c.f. 80% compared to 83%), the differences were not significant. The moisture content for Treatment 1 and Treatment 2 were not determined as they would be identical to those of Treatment 3 and Treatment 5, respectively.

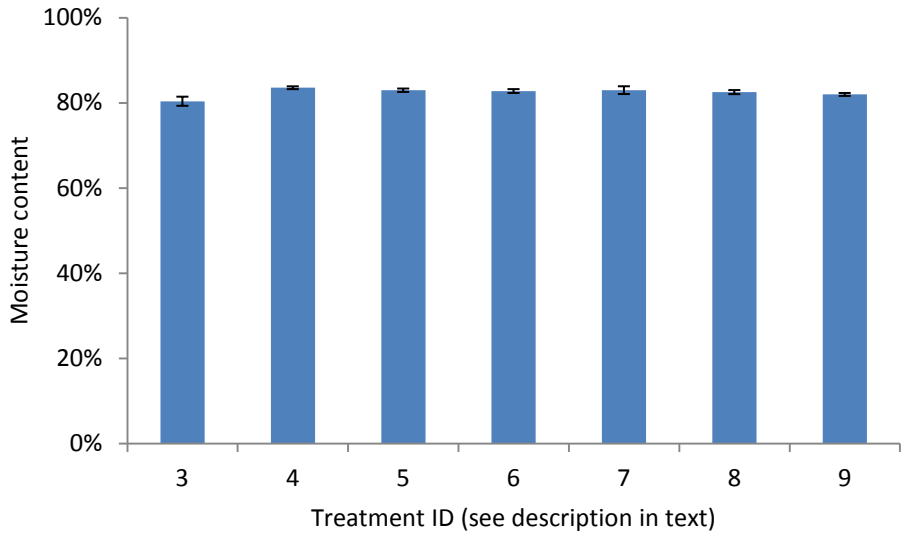


Figure 45 Moisture content for frozen product concepts (Treatments 3 – 9). Refer to Table 20 for treatment description (data expressed as mean ± standard deviation; n = 3)

KEY FINDINGS

- Initial microbiological results indicated all frozen products may be at risk of unacceptable high levels of SPCs.
- Cooked product concepts (Treatment 1 and Treatment 3) had an acceptable visual appearance whereas the remaining product concepts (Treatments 2, 4 – 9) were not visually attractive. Despite the visual appearances, the cooked (Treatment 1 and Treatment 3) and green (Treatment 5) product concepts had an opportunity to be used as an ingredient as they provided a strong prawn flavour and aroma. However, some grit was detected in the extracted products, which may be a barrier to the uptake of the product. The extent of this barrier was not determined as it would depend how the product is used.
- Cooking the whole prawns was the only treatment that sufficiently stabilised the extracted product and the chilled shelf-life (based on sensory and nucleotide degradation) was approximately 6 days. No product degradation was observed during the first 24 weeks of frozen storage for this product concept.

APPENDIX 8: TRIAL 5 (30 JULY 2013)

BACKGROUND

Cooking the whole prawns was the only treatment in Trial 4 that sufficiently stabilised the extracted product. The cooked product concepts from Trial 4 (Treatment 1 and Treatment 3) had an acceptable visual appearance, offered a strong prawn flavour and aroma, and provided an opportunity to be used as an ingredient. Some grit was detected in the extracted products and additional application ideas and market assessments are required to determine the extent of this barrier.

OBJECTIVE

The objectives of Trial 5 were to:

a) recover extracted meat from cooked prawns and record measurements for costing and product specifications including labour, throughput, product yield and packaging options

b) produce product for thawed shelf-life evaluation and nutritional composition

c) create samples of the extracted product and use these samples for the development of end user application ideas and market assessment.

METHODS

Raw Materials

The school prawns used in Trial 5 possessed a use by date of 04 April 2014. The prawns were U80 grade and had been caught by commercial fishers on 03 April 2013, cooked, packaged in 5 kg plastic lined cartons and frozen. Approximately 100 kg of prawns were thawed (overnight) prior to use.

Equipment and Sanitisation

The Baader separator was partially disassembled (drum and belt remained in place), and the wetted surfaces cleaned with a solution of Sanifoam (Tasman Chemicals Limited, Braeside, Victoria). The drum and belt were not removed as the separator could not be readily disassembled. The wetted surfaces were rinsed with potable water and the Baader separator reassembled. Trial 5 was undertaken with two people processing and packaging.

Treatments

No treatments (per se) were investigated in Trial 5. The cooked prawns were manually loaded into the hopper and processed. The separator was stopped after every 10-15 kg so that the extracted prawn meat could be transferred in the chiller for short-term storage (½ - 4 hours prior to packaging). The extracted meat was packaged into approximately 500 g bags and vacuum packed. Twelve bags were kept chilled and supplied to a consultant chef for the development of additional application concepts and market assessment. The additional application concepts and market assessment results from the

consultant chef are reported in Chapter 3.2 Market Feasibility. The remaining bags were flattened, placed into the holding freezer to freeze and stored at -18°C. The temperature of the extracted prawn meat was measured and recorded with iButton data loggers (Maxim Integrated, San Jose, CA, USA). The frozen product was transported to Adelaide on 16 August 2013 via commercial transport and held at -18°C.

Assessment Criteria

The frozen product concept was removed from the holding freezer and thawed (approximately 18 hours at 4°C). Thawed samples were kept at 4°C for the shelf-life assessment program. Sensory evaluation (colour, appearance, texture and aroma) and pH of the product was assessed on days 1 – 8 (post-thaw). The extracted prawn meat were analysed on days 1, 3, 4 and 5 (post thaw) for SPC. Samples for SPC were incubated at 25°C for approximately 96 hours and at 30 C for 72 hours. The two assay conditions were used to provide a comparison in the SPC results between the method specified in the Food Standards Code (30°C for 72 hours) and to the method that was used in Trials 2, 3 and 4.

The extent of nucleotide degradation was determined from samples of the extracted prawn meat collected during the thawed shelf-life assessment program. Samples were packed in zip-lock bags, air evacuated and stored at -80°C until analysis.

Compositional analysis of the extracted prawn meat was undertaken for nutritional information panel labelling.

RESULTS AND DISCUSSION

Product Yield and Temperature Profiles

The cooked whole prawns used in Trial 5 are shown in Figure 46. It took 20 minutes to process approximately 95 kg of prawns with intermittent operation. During operation, 10 kg of whole prawns could be processed in approximately 20 seconds.

Figure 46 Cooked whole prawns used in Trial 5 (photograph taken during initial thawing process)

A summary of the weights, product yield and throughput for the cooked prawns are reported in Table 21. The low yield, whilst a concern, is not a true representation as due to logistical constraints (inability to weight all inputs and outputs). Improvements in product handling by minimising material losses would increase the yield.

Table 24 Summary of product yield and throughput from Trial 5

Item	Cooked product
Whole cooked prawns (estimate)[A]	90.0 kg
Extracted meat (packaged)[B]	57.9 kg
Yield	64.4%
Throughput	285 – 1,800 kg/h

[A] Weight of cooked prawn not measured (assumed to be weight of prawns as packaged).

[B] Total weight of recovered product not recorded (weight of product estimated based on the mean weight of approximately 30% of packaged bags).

The core temperature profiles during freezing process of four random bags of product are shown in Figure 47. For these bags the thermal arrest time (duration it takes the product temperature to reduce from -1°C to -5°C) varied between ¾ and 1¾ hours, and it took between 5 and 5¼ hours for the core temperature to reach -18°C.

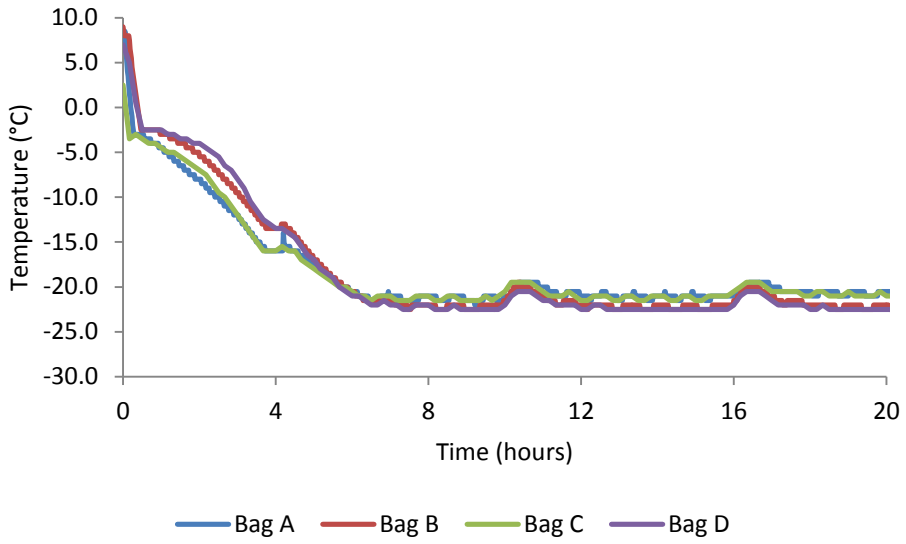


Figure 47 Core temperature profiles of four bags of product during freezing from Trial 5

Sensory Assessment

The extracted meat was similar in appearance to the cooked product recovered from Trial 4. The thawed product concepts were held at 4°C and assessed for colour, appearance, texture and aroma over 8 days of chilled storage. There was no noticeable change in colour, appearance and texture of the thawed product over this period. In all cases the cooked extracted meat was pink/orange in colour with purple/black flecks throughout. The texture was dry and crumbly. The aroma of the product changed during the thawed shelf-life. Slight sulphurous odours began to emerge after 4-5 days and the intensity gradually increases, but did not become offensive.

Microbiological Assessment

The microbiological (SPC) results for the thawed products during the shelf-life assessment are shown in Table 25. SPC assessments were undertaken at 25°C for 96 hours and 30°C for 72 hours for comparative purposes. The mean SPCs are reported in Figure 48 and the mean SPCs increased throughout the storage period for both incubation conditions. By day 3, three samples (assayed at 30°C for 72 hours) exceeded the SPCs level prescribed in the Food Standards Code for cooked crustacea.

Table 25 SPCs (Log_{10} cfu/g) results from Trial 5. Assessed after approximately 4 weeks of storage.

Sample	25°C for 96 hours				30°C for 72 hours			
	Day 1	Day 3	Day 4	Day 5	Day 1	Day 3	Day 4	Day 5
Replicate 1	4.38	4.72	5.61	5.85	4.26	4.65	5.74	5.83
Replicate 2	4.20	4.81	5.34	6.76	4.26	5.15	5.46	6.72
Replicate 3	4.32	5.54	5.41	5.83	4.48	5.36	5.20	5.82
Replicate 4	4.64	5.52	4.53	5.99	4.64	5.41	5.62	5.99
Replicate 5	4.34	4.91	5.86	5.78	4.08	4.77	5.76	5.58

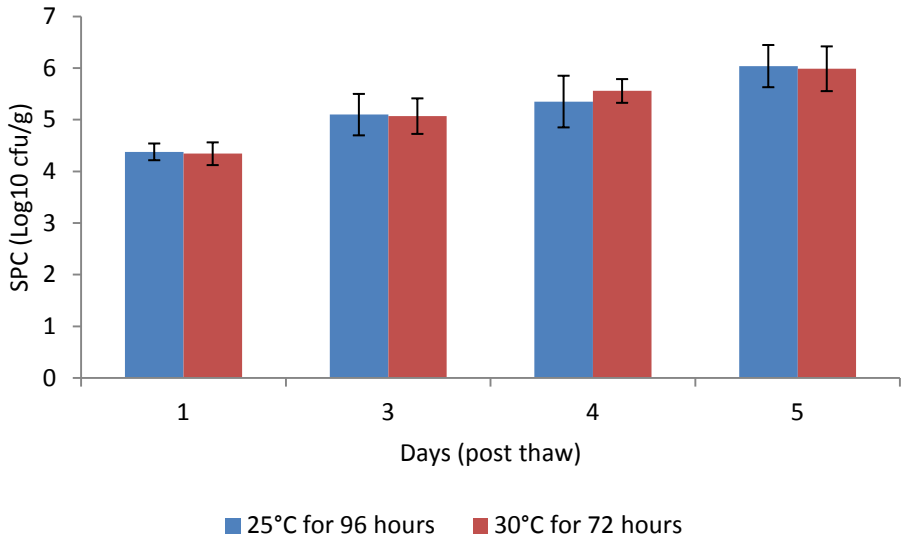


Figure 48 SPC (Log_{10} cfu/g) results from Trial 5. Assessed after approximately 4 weeks of storage (data expressed as mean ± standard deviation; n = 5).

Biochemical Assessment

Nucleotide degradation

The k-value is an indication of the extent of the degradation of the nucleotide ATP. The lower the k-value the higher the quality, and a k-value less than 20% is frequently used to represent high quality seafood. The k-value from the thawed product samples collected during the shelf-life assessment program are shown in Figure 49. The thawed product had a k-value of about 10% indicating high quality product and this remained stable during the first five days of chilled storage.

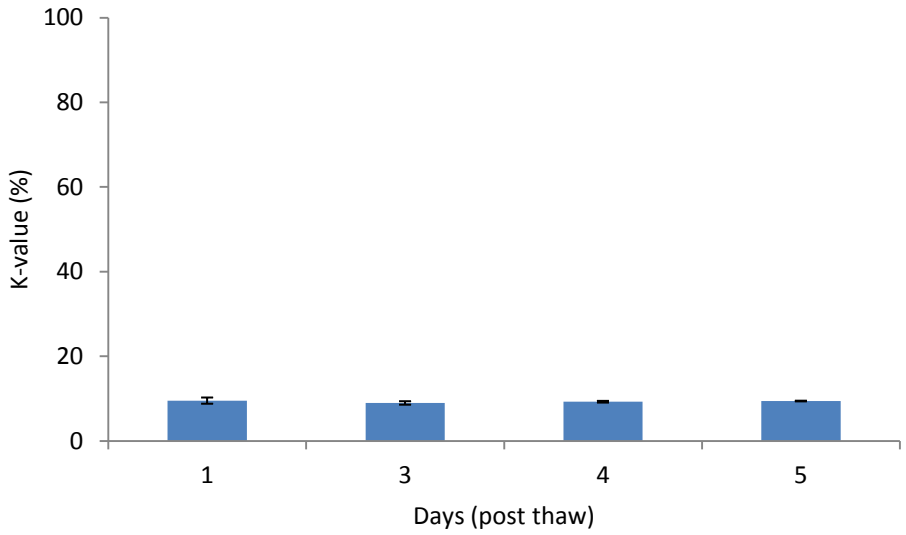


Figure 49 Effect of storage time on the k-value of thawed product samples.

pH

The pH of product samples during the thawed shelf-life assessment are shown in Figure 50. The pH readings were less than that observed in Trial 4 (c.f. pH 8.5).

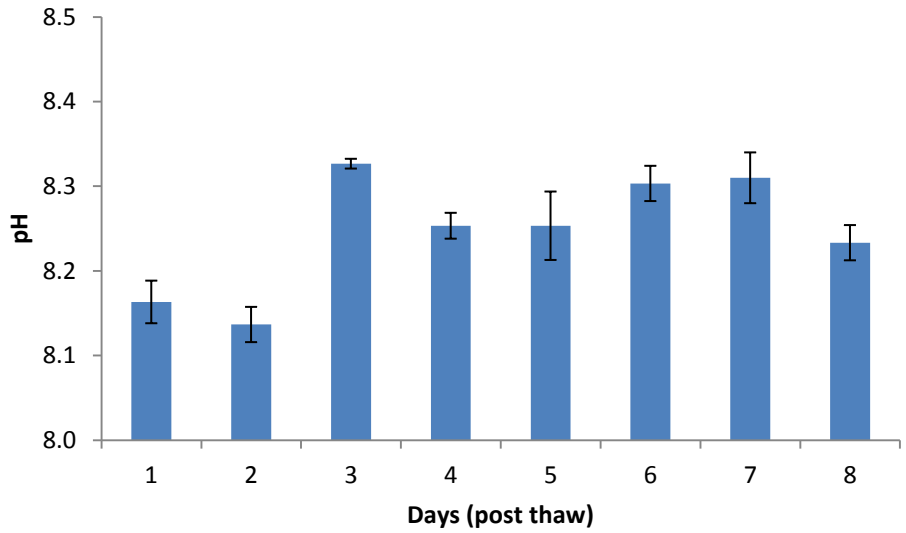


Figure 50 Effect of storage time on the pH in thawed product samples.

Nutritional Composition

The nutritional composition results for the cooked extracted prawn meat are reported in Table 26. The extracted meat would meet the Omega 3 fatty acid claim ‘a good source of Omega 3’ as highlighted in the Super Seafood Factsheet (provided that the serving size is >25g).

Table 26 Nutritional composition of cooked extracted prawn meat from Trial 5

Analyte	Values per 100 g
Moisture	81.0 g
Energy Value	318 kJ
Protein	15.9 g
Fat, Total	1.3 g
Saturated	0.6 g
Trans	<0.1 g
Polyunsaturated	0.4 g
Omega-3 Total	340 mg
alpha-linolenic acid	< 1 mg
eicosapentaenoic acid	170 mg
docosahexaenoic acid	140 mg
Monounsaturated	0.3 g
Carbohydrate	< 0.1 g
Sugars	< 0.1 g
Sodium	310 mg
Calcium	210 mg

KEY FINDINGS

- The Baader separator had a throughput of up to 1,800 kg/h.
- Product yield was 64.4%. However, the weight of recovered product was not recorded and the yield was estimated based on the mean weight from approximately 30% of packaged bags.
- The ATP-related nucleotides remained stable during the thawed shelf-life assessment program.
- The microbiological results (SPCs) were satisfactory at day 1 (post thaw). SPCs increased during the storage period and by day 3 three samples exceeded the SPC level prescribed in the Food Standards Code for cooked crustacean.

APPENDIX 9: WONTON RECIPE DEVELOPMENT

Extracted prawn meat and whole chopped prawns from Trial 3 (17 May 2012) were trialled as ingredients in several wonton recipes in July 2012. An initial trial considered three variants of wontons which were prepared with different proportions of chopped prawns and extracted prawn meat. Refer to Table 27 (recipe 1, 2 and 3) for list of fillings ingredients. The wontons were prepared by combining all ingredients and 1 teaspoon of each mixture (see Figure 51) was used to fill wonton wrappers. The wontons were cooked in boiling water for 2 minutes and assessed for flavour, texture and appearance by an informal SARDI panel (n = 4). A summary of the sensory evaluation results are reported in Table 28.

Table 27 Wonton fillings

Ingredients	Recipe 1	Recipe 2	Recipe 3
Peeled prawn tails (chopped)	454g	227g	-
Extracted meat (Trial 3)	-	227g	454g
Egg white (whisked)	1 (34g)	1 (34g)	1 (34g)
Coriander leaves (chopped)	2 Tbs (6g)	2 Tbs (6g)	2 Tbs (6g)
Fresh ginger (grated)	1/2 tsp (3g)	1/2 tsp (3g)	1/2 tsp (3g)
Sesame oil	1/2 tsp	1/2 tsp	1/2 tsp

Ingredients	Recipe 4	Recipe 5	Recipe 6
Peeled prawn tails (chopped)	Combined 80g of Recipe 1 and 20g of Recipe 3	Combined 60g of Recipe 1 and 40g of Recipe 3	Recipe 5. Filling cooked in frying pan before adding to wrappers
Extracted meat (Trial 3)			
Egg white (whisked)			
Coriander leaves (chopped)			
Fresh ginger (grated)			
Sesame oil			

Table 28 Summary of the sensory evaluation findings with wontons prepared from recipe 1, 2 and 3.

Recipe	Key sensory evaluation findings
1	The wontons held their shape well and the filling, seen through the wrapper, was paler than the other samples. The flavours of the coriander and ginger were much more prominent than in the wontons from recipe 2 and recipe 3.
2	The wontons did not hold their shape as well as the wontons from recipe 1. The filling seen though the wonton wrapper was a medium pink colour. These wontons had a strong prawn flavour. It was agreed that the flavour of the prawn mince overpowered the other flavours. It was described as “metallic”. There was some grittiness detected.
3	The wontons did not hold their shape as well as the wontons from recipe 1 and recipe 2. The filling seen though the wonton wrapper was a medium pink colour. These wontons had a strong prawn flavour. It was agreed that the flavour of the prawn mince overpowered the other flavours. It was described as “metallic”. There was some grittiness detected.

The wontons that used the extracted meat (recipe 2 and 3) did not hold their shape and the flavour of the extracted prawn meat overpowered the other ingredients. These findings led to the preparation and assessment of three additional types of wonton fillings with a lower percent of extracted meat. Recipes 4-5 used different proportions of the filling prepared from recipes 1 and 3, recipe 6 was identical to recipe 5 except that the filling was cooked in a frying plan before being placed in the wonton wrappers. One teaspoon of each mixture (see Figure 51) was used to fill wonton wrappers. The wontons were cooked by placed into boiling water for 2 minutes and the cooked wontons that used recipes 4-6 are shown in Figure 52. A summary of the sensory evaluation results for these wontons are reported in Table 29. Reducing the percent of extracted meat assisted the wontons in holding their shape and cooking the mixture prior to filling the wrappers overcome the pasty texture.

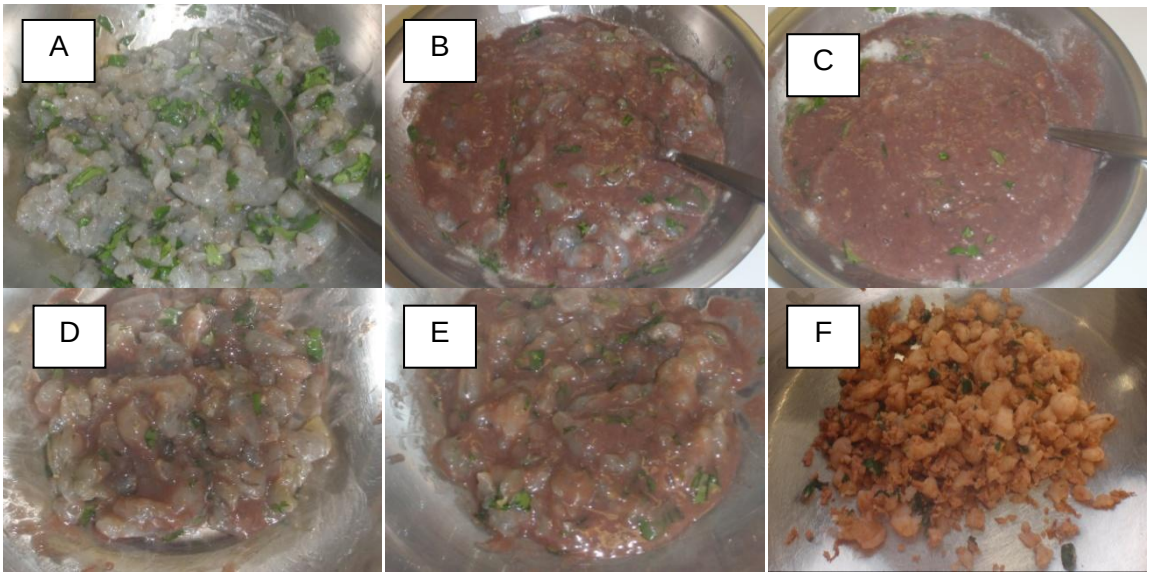


Figure 51 Fillings used in the wonton wrappers; (A) recipe 1; (B) recipe 2; (C) recipe 3; (D) recipe 4; (E) recipe 5; (F) recipe 6

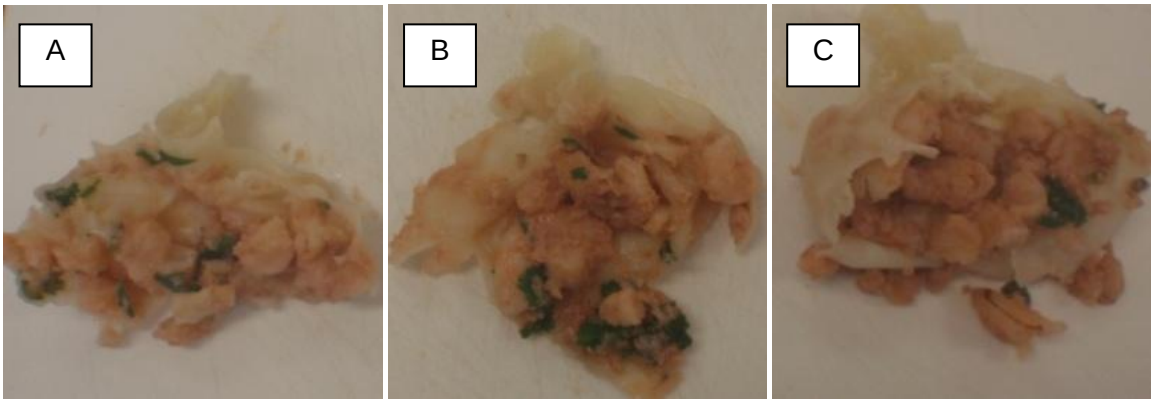


Figure 52: Fillings from cooked wontons; (A) recipe 4; (B) recipe 5; (C) recipe 6

Table 29 Summary of the sensory evaluation findings with wontons prepared from recipe 4, 5 and 6.

Recipe	Key sensory evaluation findings
4	The wontons held their shape well. The flavour was described as bitter, metallic and very strong prawn flavour. Some grittiness was detected. The texture was described as “pasty”.
5	The wontons from recipe 5 held their shape reasonably well but were slightly flatter than recipe 4. The flavour was described as metallic, very strong prawn flavour with a lingering aftertaste. Some grittiness was detected. The texture was described as “pasty”.
6	The wontons held their shape well. The flavour was described as having a slight metallic note and a strong prawn note. Some grittiness was evident. This sample was not pasty.

KEY FINDINGS

- The extracted prawn meat was very strong in flavour and had metallic and bitter aftertastes.
- Grittiness was detected in most, but not all wontons.
- The cooking method affected the texture. Cooking the meat prior to filling the wontons improved the appearance and texture of the wontons.