FINAL REPORT

Development of post- harvest handling technologies for the under-utilised cross-jurisdictional Royal Red Prawn fishery

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In submitting this report, the researcher has agreed to FRDC publishing this material in its edited form.

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Executive Summary

The Queensland Department of Agriculture and Fisheries led this research project on improving the post-harvest quality of prawns landed from the multi-jurisdictional Royal Red Prawn fishery.

The research team have studied the supply chain of Royal Red Prawns including the fishing operations, prawn handling and processing, and current market supply chains. The research team has also undertaken extensive sensory investigation to understand the specific sensory qualities of the Royal Red Prawn to better understand the potential of the species more broadly.

The research team determined that the Royal Red Prawn has a clear point of difference to the majority of current commercial species of prawns in Australia, and this point of difference is not being adequately exploited by the current supply chain for the prawn. The research team determined that these unique and distinctive qualities would be worth investigating further towards directing this prawn to the fine dining and food service sector specifically.

The decision to target fine dining and food service applications was based on three key parameters:

1. The Royal Red Prawn has very unique sensory properties, specifically with regard to texture and flavour that are not commonly found in other Australian prawn species.
2. The prawn can also being utilised in a wide variety of dishes and cooking styles, and can even be easily eaten with the shell on.
3. The Royal Red Prawn is not very well known within the broader community. The element of novelty and exclusivity is also a concept that is attractive to fine dining.
4. The fishery is only very small and highly local to the Sydney areas. It makes sense to match the supply to the market. The fishery is not large enough to supply the wet seafood market more broadly. Also the product needs to be kept frozen for best storage conditions.
5. Current pricing of the Royal Red Prawn is a significant competitive advantage over other Australian prawn species. Having the Royal Red Prawn sold into food service ensures that all partners of the supply chain are maximising their exposure to premium pricing.

The research team developed some preliminary cooking protocols and methods. The research team also engaged an executive chef to refine these protocols, as well as develop a range of food service applications.

These recipes were presented to a select group of Sydney based chefs in a focus group session held at the Sydney Fish Market in December of 2018. These recipes and concepts were very warmly received by the chefs attending the focus group.

The most significant finding was that if chefs could receive this prawn product in the form that they require, then the price premium they would be prepared to pay would be four to five times the current market price for Royal Red Prawns. An increase in returns to fishery stakeholders of this magnitude would be a highly desirable outcome.

Some of the other key feedback from the chefs included the product formats and product specifications required to suit their respective menus.

These are the key learnings to be reported back to the fishery stakeholders to permit them to evaluate any necessary changes in their fishing and processing environments that would be needed to supply the customers.

Keywords

Royal Red Prawns (*Haliporoides sibogae*), quality, melanosis, frozen, pack size, product format, shell-on, food service, fine dining.

Introduction

Background

Royal Red Prawns (*Haliporoides sibogae*) exist in both eastern and western offshore waters of Australia, however the commercial fishery is limited to the deep water trawl fishery off the NSW coast. The fishery is managed under shared jurisdiction between the New South Wales (NSW) Ocean Trawl Fishery (OTF) and the Southern and Eastern Scalefish and Shark Fishery (SESSF). Royal Red Prawns are classified as lightly fished in NSW and not overfished and not subject to overfishing in the Commonwealth SESSF (Rowling et al. 2010; Fishery Status Report 2012). The Royal Red Prawn Fisheries in the OTF and SESSF are both reported as "sustainable" in the Status of Australian Fish Stock Report of 2018 (www.fish.gov.au). Recently (2015), Fisheries Queensland has issued a Developmental Permit for harvest and trade of Royal Red Prawns within the Coral Sea to support the development of a Royal Red Prawn fishery in Queensland waters.

Annual landings by NSW ocean prawn trawl vessels from waters north of Sydney were approximately .200 t between 1997 and 2003 but have since dropped to very low levels as demand has lessened (Rowling et al. 2010). In NSW, there are over 60 fishing businesses holding endorsements for deep water trawling within the OTF, however only 3 fishers currently target Royal Red Prawns, landing less than 10 t over the last 2-3 years. There is a total allowable catch of 374 t of Royal Red Prawns within the SESSF (2007) but catches since 2000 have been <250 t.

Poor market demand for Royal Red Prawns is likely attributable to lack of product recognition in the market place and variable quality of that product which is available. Royal Red Prawns are reputed to have an excellent sweet flavour and acceptable texture. However, being a deep-water species most abundant in waters of depths between 450-550 m, deterioration in prawn quality will be inherently rapid when the prawns are brought to the surface. Hence, customary post-harvest handling practices for prawns could be insufficient to retain quality of Royal Reds Prawns. With knowledge of those factors affecting deterioration, alternative handling practices can be developed to maximise eating quality of Royal Red Prawns and thereby establish higher positioning in the market place. As well, broadening the range of product formats presented and targeting market needs and convenience will also contribute to wider market acceptance.

This project was developed in direct response to a high-priority research need identification by the NSW Research Advisory Committee (RAC) and has been developed in conjunction with participant Royal Red fishers. Successful achievements will benefit OTF and SESSF deep water trawl fishers, seafood businesses processing Royal Red product and seafood consumers.

Need

The Royal Red Prawn fishery is effort-driven with frequent lack of demand and low wholesale prices resulting in a relatively lightly fished stock. Several endorsed fishers have indicated in recent conversations, that it has not been worthwhile to target Royal reds since 2000. The current low market demand and hence value of Royal Red Prawns can be attributed to variable quality of product and poor market recognition. Royal Red Prawns are reputed to have an excellent sweet flavour and acceptable texture however, being a deep-water species, quality degradation is rapid when the prawns are brought to the surface. Hence, customary post-harvest handling practices for prawns could be insufficient to retain quality of Royal reds.

The Royal Red resource is clearly under-utilised currently and has potential for value-addition. To gain further benefit and revenue from harvest of this prawn species, effective on-board handling practices need to be determined that limit the rate of quality deterioration and therefore retain maximum quality of product.

This project is designed to develop handling and post-harvest practices, identify preferred product format and establish domestic and international market opportunities to benefit the NSW deep-water prawn fishery, holders of Royal Red Prawn quota in the SESSF, and the developmental fishery in Queensland.

Objectives

Objectives of the project – as agreed in the contract

1. Establish the quality attributes of harvested deep water prawns

2. Determine post-harvest handling protocols that maximise product quality

3. Develop product formats that address the demands of local and international consumers

4. Identify new markets to increase economic return within the fishery

5. Encourage adoption of best practice handling and potential market opportunities to industry members (NSW, Commonwealth, QLD)

Method

Research focus is on retaining prime quality of harvested Royal Red Prawns in order to maximise price at point of sale. Project research approach is therefore designed to address three key aspects within the value chain;

- On-board post-harvest handling and processing
- Product formats targeted to consumer needs
- Identification of local and international market opportunities

1. Post-harvest quality and handling practices

Current post-harvest handling practice of the Royal Red Prawn fishers (based out of Wollongong and Sydney) is harvest, sort, chill and return product to port for processing. While logistically practical, this handling method may not ensure premium quality retention as Royal Red Prawns are reputed to spoil rapidly once taken from the water. Therefore a key element of this project proposal is to verify effectiveness of on-board handling techniques and establish a best practice protocol that maximises prawn quality. Scientific experience of prawn spoilage indicates a critical factor is rapid temperature reduction of the prawns as soon as taken on-board. Low temperature is also critical throughout the on-board handling process.

A specific focus will be on melanosis occurrence in these prawns, as anecdotal report is "they turn black before your eyes" when taken from the water. A series of trials is proposed on development of blackspot; location of first appearance on prawn shell, rate of development and period when the pigment affects the tail flesh.

Evaluation of prawn sensory acceptability and quality, as well as product storage life, from different handling procedures will be conducted at DAF by the Sensory and Consumer Unit.

2. Format of product targeted to market

Product formats (whole shell-on, head-off, tail meat, chilled, frozen, pack-size) need to be targeted to meet end-user requirements, convenience and demand. Different formats of product specify handling requirements for each product style.

Product quality and acceptability will be evaluated through structured sensory assessment at the DAF Sensory and Consumer Unit. Different sensory assessment methodologies will be used appropriate to specific product format and target market. It is likely these will centre on:

- Consumer Acceptability – to establish end-user preference for different products
- Focus Group – to determine specific attributes and descriptors of products

As Royal Red Prawns are relatively unfamiliar to end-users, it is proposed to carry out a comparative positioning evaluation with respect to other well-known and accepted prawn species. The information gained within this work will also include specific flavour and texture descriptors specific to Royal Red Prawns and this can provide benefit for targeted marketing. Where required, it is possible to recruit specific sensory panels based on ethnicity or other relevant factors that may apply for niche high-end market product targeting.

3. Identification of local and international market opportunities

The industry collaborators have existing supply chain pathways to enter the domestic market but the opportunity exists to widen market penetration and include export markets. A proposed concept for prawns from this fishery is exploration of export into a niche for high-end quality product through identification of specific networks and supply pathways.

Results and Discussion

Preliminary Sensory and Quality Assessments

Selection of prawns for assessment

A preliminary sensory assessment was conducted on Royal Red Prawns by an in-house trained panel of regular seafood consumers. Panellists were provided with Royal Red Prawns from two sources (retail and wholesale) as well as a comparative species being Banana Prawns (*Fenneropenaeus indicus*).

Retail prawns (head off and peeled) were sourced from Woolworths, Sunnybank (Brisbane) and kept frozen until the day before the assessment (Better Choice Fisheries, batch code 1614 best before 05/04/2018). One of the packs used for texture assessment can be seen in Figure 1.

Figure 1 Processed raw Royal Red Prawn meat purchased in Woolworths Sunnybank, QLD (Better Choice Fisheries)

Wholesale prawns (head and shell on) were sourced direct from a vessel operator and kept frozen (Gary Pinzone, frozen at sea). Prawns received can been seen still frozen in Figure 2.

Figure 2 Thawed Royal Red Prawns ready for sensory assessment (received from commercial fisher Gary Pinzone)

A comparative retail species (wild caught Banana Prawns head and shell on) were purchased the day before the assessment at Woolworths Sunnybank, 10/05/2017. An image of Banana Prawns used for the sensory assessment can be seen in Figure 3.

Figure 3 Retail wild caught Australian Banana Prawns (thawed at date of purchase)

Cooking method development

To ensure the retention of as much of the prawn flavour as possible, the preferred cooking method was determined to be steaming within a foil tart tray covered with foil. However, the first few attempts to conduct this method proved to be problematic. .

As has been reported to us from several industry stakeholders, Royal Red Prawns are very sensitive to overcooking. From the work we conducted in developing this method, a minute either way in the temperature range of 95-100°C can be the difference between under cooked and over cooked.

Our experience here suggests that much like premium fish dishes, being slightly under cooked is greatly preferred to be slightly overcooked. Once the Royal Red Prawn is over cooked, the texture becomes firmer, and the meat also has a quality that can be best described as a hard gel like material. A good comparison would be stale or old confectionary products like jelly babies.

However, for sensory sample preparation, under cooking is as bad as over cooking. This is because all meat consumers have different ideas on exactly how "cooked" a meat product should be. So the goal with sensory sample cooking is find a cooking point just on the cooked side of perfect. Quite a challenge, and one that will never please every panellist. In this work we found that 10 minutes at 100°C was too much, and 9 minutes was near enough to perfect, with 8 minutes being under cooked.

Also, to compensate for the larger size of the Banana Prawns, and to keep the cooking methodology consistent across the two species, two Royal Red Prawns were placed in each tray. For the Banana Prawns only one prawn was used per tray.

Sample preparation and cooking

On the afternoon before the assessment, frozen prawns were transferred to refrigerated storage (4°C) to allow thawing overnight. Wholesale prawns were peeled and deveined prior to cooking.

Peeled prawns were placed in a small foil tart tray (Cast Away # CA-RFC122) and covered with foil (see Figure 4 and Figure 5). Prawn samples trays were marked with a 3-digit blinding code for each sample to mask the identity of each sample to the panellists.

Table 1 Blinding codes for sensory panel samples

Sensory sample	Blinding code
Wild caught Banana Prawn	312
Commercially caught Royal Red Prawn	645
Retail Royal Red Prawn meat (head off and peeled)	978

Figure 4 Royal Red Prawns prior to cooking for sensory panel

Figure 5 Royal Red Prawns covered with foil and given 3 digit blinding codes prior to cooking

Prawns were cooked immediately prior to each assessment. Prawns were cooked in a Unox LineMiss™ steamer oven (Model XF135 Padova, Italy). Cooking parameters were 100°C (±3°C) for 9 minutes at 60% humidity. The oven was warmed up for approximately 1 hour under these conditions prior to cooking. At the end of the cooking cycle, the prawns were removed straight away and placed on a nylon cutting board to relax for a further minute. Prawns were then served immediately to the panellists.

Results of preliminary sensory assessment

Panellists were asked to describe aroma, appearance, flavour, texture. Panellists were also asked to provide an overall summary of the eating experience. Results for each of the prawns were as follows;

SAMPLE 312 (Wild caught Banana Prawn)

AROMA

strong, crabby, fresh seafood, slightly earthy, slight sweetcorn
meaty, bromophenol, crab, sweet, metallic
prawny like a farmed? prawn, strong, green weedy
prawny, sea shell, metabisulphite odour
normal prawn, sulfur
high prawn sweetness, cooked heat smell rather than ocean,
fresh, cooked seafood
low level, slight sulfur, crabby, roast meat, cooked veg

APPEARANCE

dull not shiny, white flesh/with dark pink red, green areas near centre, lots of juice in tray
stain around legs, cream colour flesh, bright orange outer
a bit yellowish around the legs, great looking prawn, large in size, good colour, denseness muscle fibres, looks firm and dense
pink orange colour, white flesh,
ok, pale, red not deepened
white, firm , dry, brown in the middle
cooked, clean white around the outside, inside legs a bit dirty yellow
dull orange, creamy

FLAVOUR

not fresh, slight metallic, sweet.
cooked cabbage, iodine, metallic
mellow flavour, good prawn flavour, slight metallic, low salt, green weedy, not as sweet as tiger prawns
slight meta bisulphate flavour, green weedy, some sweetness, very slight fruity
first bite and head end mushy and awful flavour, other parts tasted sweet
sweetness good, just right.
sweet, dry, steamed prawn, bland, earthy
weedy, steamed veg, earthy, low umami

TEXTURE

firm without being pleasant
firm flesh, soft crunch
dense, meaty, a bit of spring/bounce/slightly rubbery,
powdery, chalky, some resistance to bite
moist, firm, bit of grit
chewy overcooked, a bit gritty and tough
firm bite, soft chewing
firm, crunchy, fibrous, chewy

OVERALL

Didn't enjoy, flavour not fresh and texture not good. Smell a little overpowering, metallic aftertaste
firm texture, easy to chew, not tough
average - not horrible but not good enough to go back for seconds

SAMPLE 645 (Commercial catch of Royal Red Prawn direct from vessel)

AROMA

strong (but less than 312), fresh seafood, sweetcorn, crabby, oceanic
chemical, sweet, meaty
smells like prawn, not as strong as 312
hint of iodine, slightly metallic
normal, less sulfur
High level of aroma, a bit stale
sweet cooked prawn, fresh
crabby, oceanic, higher intensity than 312, slight chemical

APPEARANCE

slight glossy, white flesh with pale pink, slight yellowing in the centre
white flesh, pink, red outer
looks a bit dryer
pink - very distinctive, white flesh
good, white flesh
a bit dry and white
white and pink, vibrant
Pinky red in colour, very white muscle fibres

FLAVOUR

very sweet, very salty, umami, savoury balance
very sweet prawn flavour, crab-like without cabbage, umami, lingering aftertaste, - sweet
good salt flavour, great savoury, flavoursome, very nice, sweet
sweet, salty but not too much, almost a meaty flavour, red seaweed, lots of flavour
sweet, salty ,
very salty, very sweet
juicy, salty, sweet
sweet, salty, high umami, lots of length

TEXTURE

plump and firm, not mushy
soft texture, not quite mushy
softer than 312 but still holds structure and shape, very moist
soft, but kind of nicely chewy
firm and meaty
melt in the mouth, about right, not too soft and not too tough
delicate and soft
Soft without being mushy, excellent txt

OVERALL

very pleasant, enjoyable texture and flavour
best prawn, great flavour
OK, very sweet and salty/meaty, acceptable flavour
too salty
preferred sample, great saltiness, delicious

SAMPLE 978 (Retail Royal Red Prawn product)

AROMA

Milder than other 2 samples, fresh seafood, crabby, not much sweetcorn
sweet, crab, mild, low aroma
Prawn aroma, slight chemical taint (maybe ammonia?)
prawny and a little salty
general steamed seafood aroma, no sulfur
medium intensity, clean
slightly old bitter seafood smell
slightly less aroma, seawater, sulfur,

APPEARANCE

matt/dull, creamy flesh with orange, slight brown at one end
Off white flesh, pink/orange outer, slight staining at the head end
looks a bit mushy
orange
ok, exterior looks a bit rough, white flesh
moist
white and pink, slight browning around the legs
slightly orange colour

FLAVOUR

mild , slight crabby, slightly salty, slightly sweetness, balanced, mild umami/savoury
watery, light crab, bland after taste, slight umami
very bland , slight prawn flavour, no salt, no sweetness, no umami
bland is the major impression, some sweetness and meatiness (still with a touch of iodine)
sweetness good, just right
low level of sweetness and saltiness
slightly dry cardboard flavour, insipid.
low flavour, a little bland, low umami, low salt

TEXTURE

beautiful texture, firm but not rubbery. Best of the 3
soft, mushy, not crisp at all
very soft, fall apart easily, chalky, grainy
soft - but not mushy, disappears at first bite
under cooked, breaks up nicely in mouth
slightly soft and a bit mushy.
very soft texture, dissolves in mouth, too mushy
a little soft and mushy, variable, not entirely palatable

OVERALL

very enjoyable flavour and texture, mild overall
underwhelming, disappointing
very soft, not resilient at all, flavour too little

After the assessment there was a discussion about the three samples provided for the panel. Of the three samples presented here the clear favourite was sample 645 (Royal Red direct from vessel), followed by 978 (Retail Royal Red) and lastly sample 312 (Banana Prawn).

The qualities of flavour and texture were the primary reason identified by the panel as to why those two samples (645, 978) were deemed to be preferred. And of these two samples 645 was preferred over 978 in a group discussion.

Sample 645 was considered to have a more intense flavour than 978. Particularly in the qualities of sweetness, saltiness and umami. The combinations of these attributes resulted in the flavour of this sample

sustaining through to a pleasant aftertaste that lingered for many minutes after eating. All panellists described this experience. Sample 978 was considered to display these properties, but just not at the levels experienced when eating sample 645.

Sample 978 was also identified as having inconsistent flavour and texture. Several panellists commented on the lack of flavour in some of these samples. Some panellists also commented on the softness of sample 978 being an unpleasant characteristic. Mushy was a term generated several times.

However, all panellists found the sample 312 to be the least enjoyed of all the samples. Sample 312 had the most references to terms chemical, metallic and metabisulphite. The texture of this sample was also highly inconsistent between the samples provided to the panellists. An image of all three samples provided can be seen in Figure 6.

Figure 6 Cooked Banana Prawn (#312), cooked wholesale Royal Red Prawn (#465) and cooked retail Royal Red Prawn (#978)

The use of Banana Prawns as a reference sample against Royal Red Prawns is not necessarily ideal due to the fundamental differences in size and cooked texture. Most Australian prawn species of large size have a very firm and meaty cooked texture. The Royal Red Prawn has a much softer cooked texture, and a softer raw texture (refer Instron texture assessment).

However, the Banana Prawn is a widely consumed product in a competitive market and indicative of many species of prawn in Australia. As such the Banana Prawn provides a very good reference point for consumers as a comparison product to Royal Red Prawns.

Another characteristic not identified by the panellists, but clearly visible in Figure 6, is the colour difference between wholesale (#645) and retail (#978) products. The difference in colour between these products was not seen in the raw products, but very noticeable in the cooked products. The exact reason for this colour difference is difficult to identify without further analysis. Specifically the determination of the form of the astaxanthin, as well as the qualification of the primary astaxanthin form present in the Royal Red Prawn.

Summary of sensory panel assessment

The Royal Red Prawn was the clearly preferred to the Banana Prawn by these panellists in this assessment. The main characteristics identified by the panellists that influenced their decision was flavour and texture. The assessment also identified these characteristics as being less prominent in the processed Royal Red Prawn compared to the wholesale product sourced directly from the fishing vessel.

Factors affecting Royal Red Prawn flavour

Royal Red Prawns present a somewhat unique flavour when compared to other prawn species available in Australia. One of the key components in this unique flavour profile is the group of bromophenol compounds present in the prawn muscle.

The bromophenols (BP) are a group of flavour compounds in crustaceans, fish and mollusc (Boyle 1993). These compounds can act independently or in combination to enhance the flavour of seafood. An investigation into the BP content of Australian prawns was conducted by Whitfield et al (1997) quantified the five most common BP compounds. A summary of some of those key findings is presented in Table 2.

Table 2 Bromophenol content of selected whole uncooked prawns as determined by Whitfield et al. 1997

Species	Bromophenol content ng/g (whole uncooked)				
	2-BP	4-BP	2,4-BP	2,6-BP	2,4,6-TBP
Paneus plebejus (max value*)	19.0	240.0	360.0	4.4	84.0
Paneus monodon (max value*)	0.01	1.3	2.2	2.3	170
Paneus esculentus (max value*)	0.30	31.0	130.0	1.5	140
Metapaneus macleayi	0.06	0.10	5.6	0.56	12.0
Haliporoides sibogae	**1.5**	**0.83**	**23.0**	**34.0**	**31.0**

* *These species had multiple determinations. The highest values reported by Whitfield et al. are those reported here.*

Each of these bromophenols have specific flavour characteristic. 2-bromophenol (2-BP) and 2,4,6 tribromophenol (2,4,6-TBP) produced full and intense "shrimp-like" flavours. These compounds alone or in combination are reported to enhance the flavour of seafood (Boyle 1993). 4-bromophenol (4-BP) and 2,4-dibromophenol are reported to possess weak phenolic flavours. However their presence is reported have weak effects on the perception of certain seafood flavours (Boyle 1993).

Of the bromophenols identified in this work, the most potent is 2,6 dibromophenol (2,6-BP). This compound can impart an iodine or iodoform-like flavour to prawn meat. Whitfield (1997) also reports that at low levels 2,6-BP can impart an "*oceanic sea breeze*" flavour. As can be seen in Table 2, the quantity of 2,6-BP in Royal Red Prawns (*Haliporoides sibogae*) is almost eight times that of the found in the nearest species (*Paneus. plebejus*). When found in such quantities, and in the presence of other BP compounds, the effect on perceived prawn flavour is likely to be significant.

Determination of spoilage parameters

Chilled storage trials were considered important to undertake to gain pertinent information on spoilage deterioration patterns of Royal Red Prawns and to confirm that experimental methodologies determined were appropriate for this prawn species. Critical quality parameters to understand were melanosis development and flesh textural changes, along with bacterial growth rate.

Frozen prawns (held at -30°C) were obtained from Gary Pinzone, San Antone Fisheries and transported in frozen state (with temperature monitoring) to DAF laboratories. Prawns were in bulk-packaged free-flow format and were allowed to thaw on stainless steel trays covered with foil at room temperature for five hours. Once prawns reached 2°C they were randomly divided into 1.4 kg lots of different size grades and stored in sealed containers at 2°C. On each defined sampling day (0, 2, 4, 7 and 9 days) one container was taken for both microbiology and texture testing. Five prawns were used as a composite sample for total bacteria enumeration and 12 prawns were used for texture analysis.

Melanosis development

Part of the spoilage assessment was to develop an understanding of the rate of development as well as the intensity of melanosis in fresh chilled Royal Red Prawns. At day 0 of the assessment, equating to just thawed, there are no visible signs of melanosis present as can be seen in Figure 7.

Figure 7 Royal Red Prawns at day 0 of the spoilage trial

Figure 8 Royal Red Prawns prior to peeling at day 0

Figure 9 Peeled Royal Red Prawns at day 0

After two days in cold storage (2°C) melanosis had begun to be observed on the prawns. Melanosis is well advanced and clearly visible in some prawns (Figure 10).

Figure 10 melanosis in Royal Red Prawns at day 2 of the trial

By this stage some of the melanosis has also penetrated the muscle or edible portion of the prawn meat. These stained areas are almost exclusively adjacent to the prawn pleopods as illustrated in Figure 11.
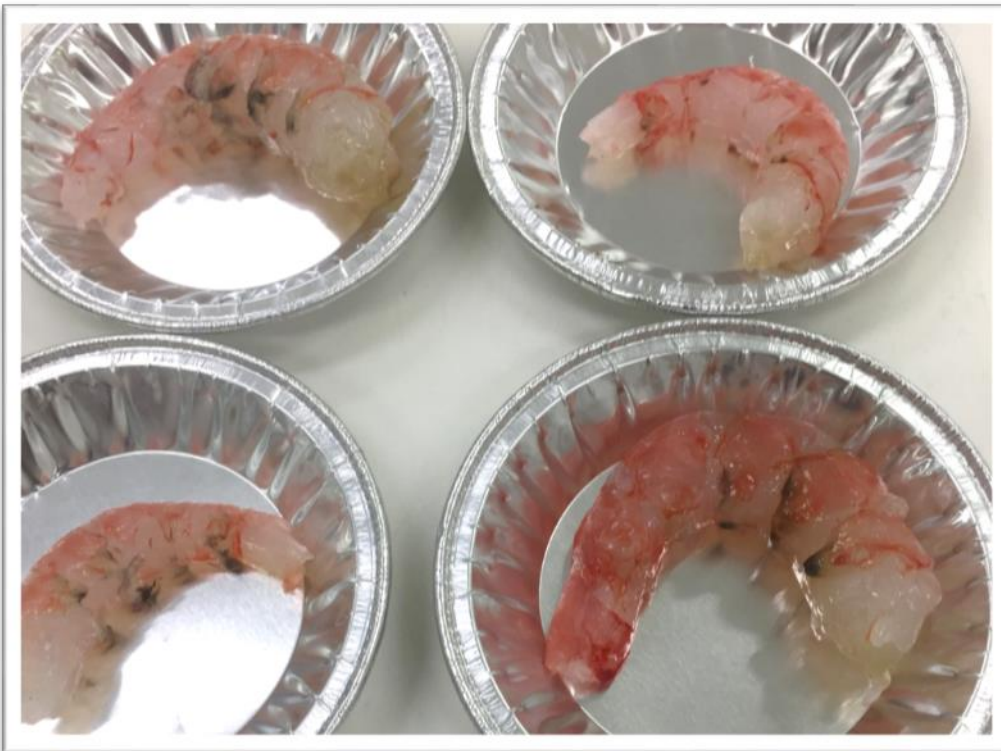
Figure 11 Peeled Royal Red Prawns at day 2 of the trial

By day 4 of the assessment, the majority of prawns had started to display melanosis. However, this trend was not consistent across all prawns. An image of prawns at this assessment point can be seen in Figure 12.

Figure 12 Royal Red Prawns at day 4 of the trial

By day 4 almost all prawns presented melanosis in the prawn meat. Peeled prawns from day 4 can been seen in Figure 13.

Figure 13 Peeled prawn meat from day 4 of the trial

By day 7 of the assessment all prawns were showing signs of melanosis to varying degrees. This can be seen in Figure 14

Figure 14 Royal Red Prawns at day 7 of the trial

The last day of this assessment was 9 days post-thaw. By day 9 almost all of every prawn was black in colour. The degree of melanosis is apparent in Figure 15 and Figure 16.

Figure 15 Royal Red Prawns at day 9 of the trial

Figure 16 Selected Royal Red Prawns from day 9 post thaw.

Within the prawn meat itself melanosis had extended throughout the edible portion. In several of these prawns almost the entire muscle portion had blackened considerably. This effect can be seen in Figure 17.

Figure 17 Peeled Royal Red Prawn meat at day 9 of the trial

Melanosis summary

The lack of visible melanosis at day 0 suggest that the fishing vessel that supplied this batch of Royal Red Prawns is well equipped to harvest, process and freeze prawns on-board the vessel in question. However with 48 hours of chilled storage extensive melanosis had commenced across a large number of the prawns observed in this trial.

The lack of consistent progression of melanosis across all the prawns during this trial suggests other factors are involved in the determination of the rate at which melanosis progresses in any individual prawn. This observation suggests time spent in the trawler net prior to landing may be an influence here; with the longer time experienced by prawns increasing the rate and intensity of the melanosis that develops post mortem.

Textural changes during chilled storage

Texture assessments were conducted on Royal Red Prawns at the same days of the microbiological testing. Testing was conducted on raw prawn meat. Analysis was conducted on an Instron 5543 texture analyser (Instron Corporation, 825 University Avenue, Norwood MA, USA.). Determinations were made using a 500 N load cell and a standard Instron Kramer-Shear cell. An image of the Instron is presented in Figure 18.

Figure 18 Instron 5543 with Kramer Shear cell installed

Prawns (N=12 per sampling point) were weighed prior to the assessment, and cut in half to allow all of the prawn meat to be placed with the cell and be in contact with the blades during the testing. An image of this process can be seen in Figure 19.
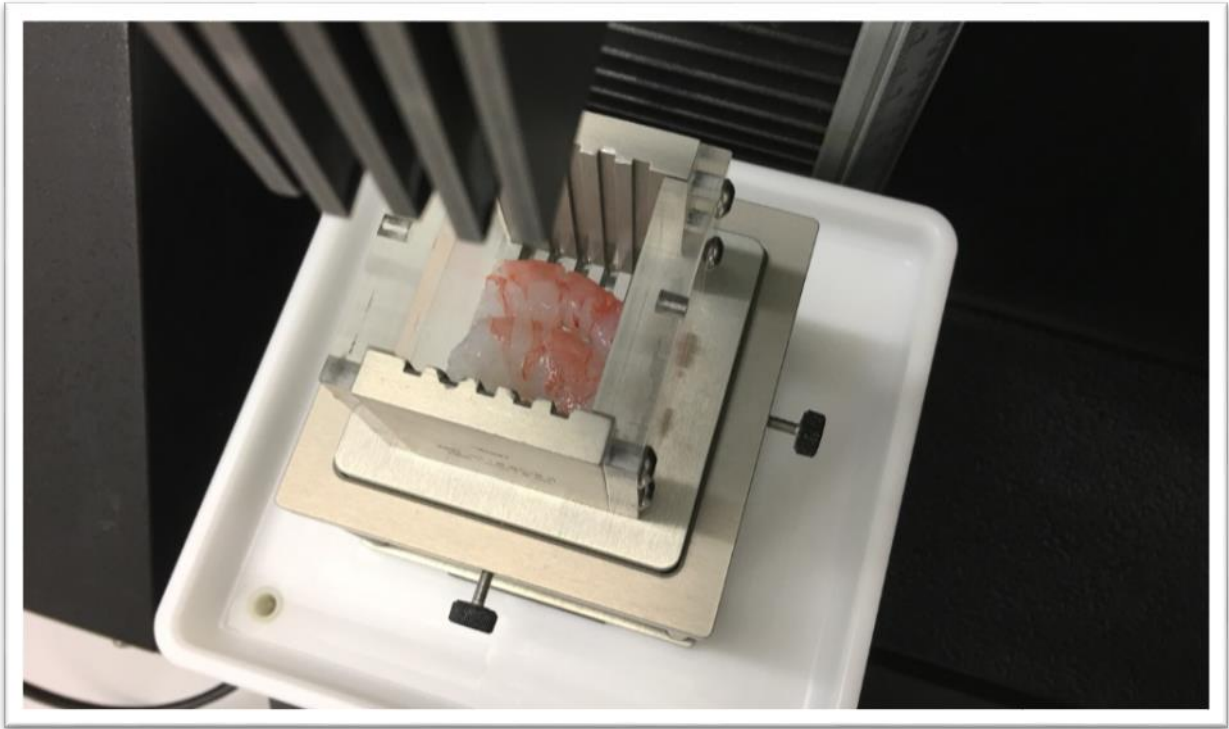
Figure 19 Royal Red Prawn meat ready for texture assessment

Two forms of data were collected during this analysis. The first is peak force (PF) of shearing and is expressed in newtons (N). This is the maximum force required to shear the raw muscle. The second is total energy (TE) required to shear the raw muscle and is expressed in millijoules (mJ). The values obtained for PF and TE and then divided by the weight of the sample assessed. These results are presented in Figure 20 and Figure 21.
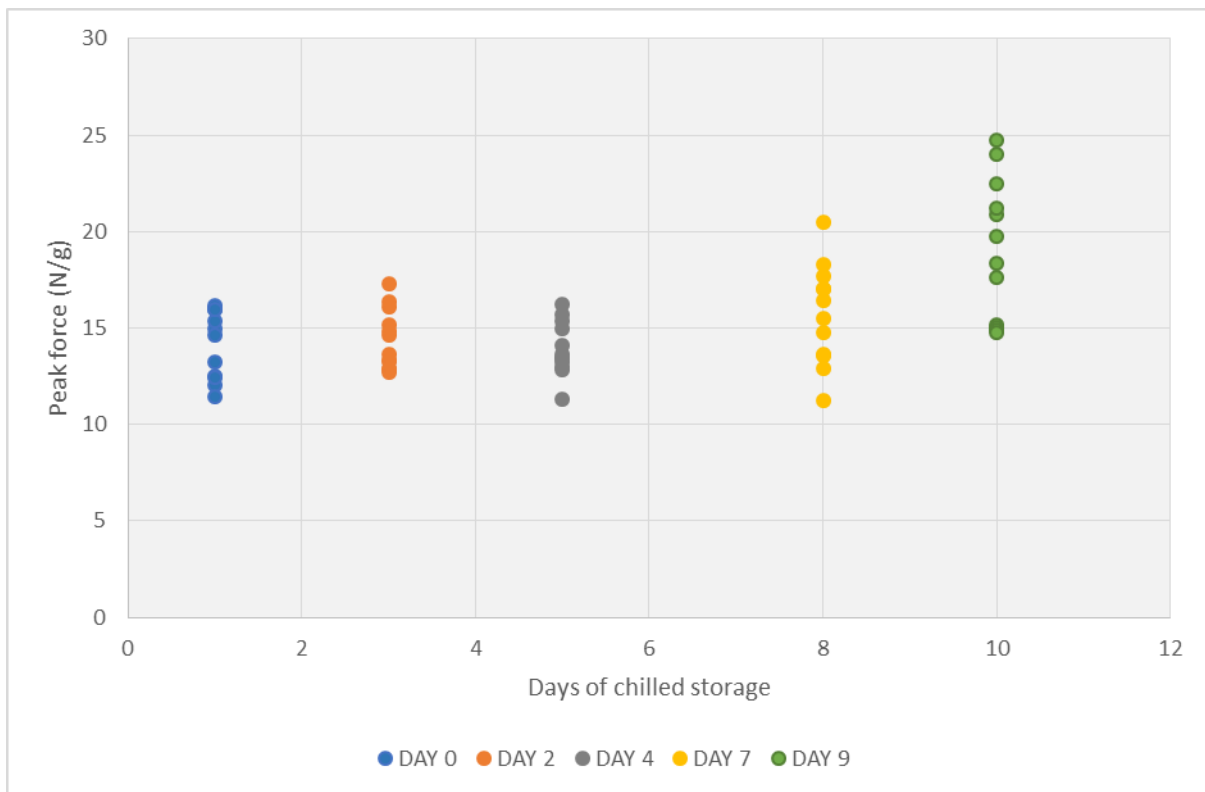
Figure 20 Peak force (PF) of Royal Red Prawns at sampling days through the spoilage trial
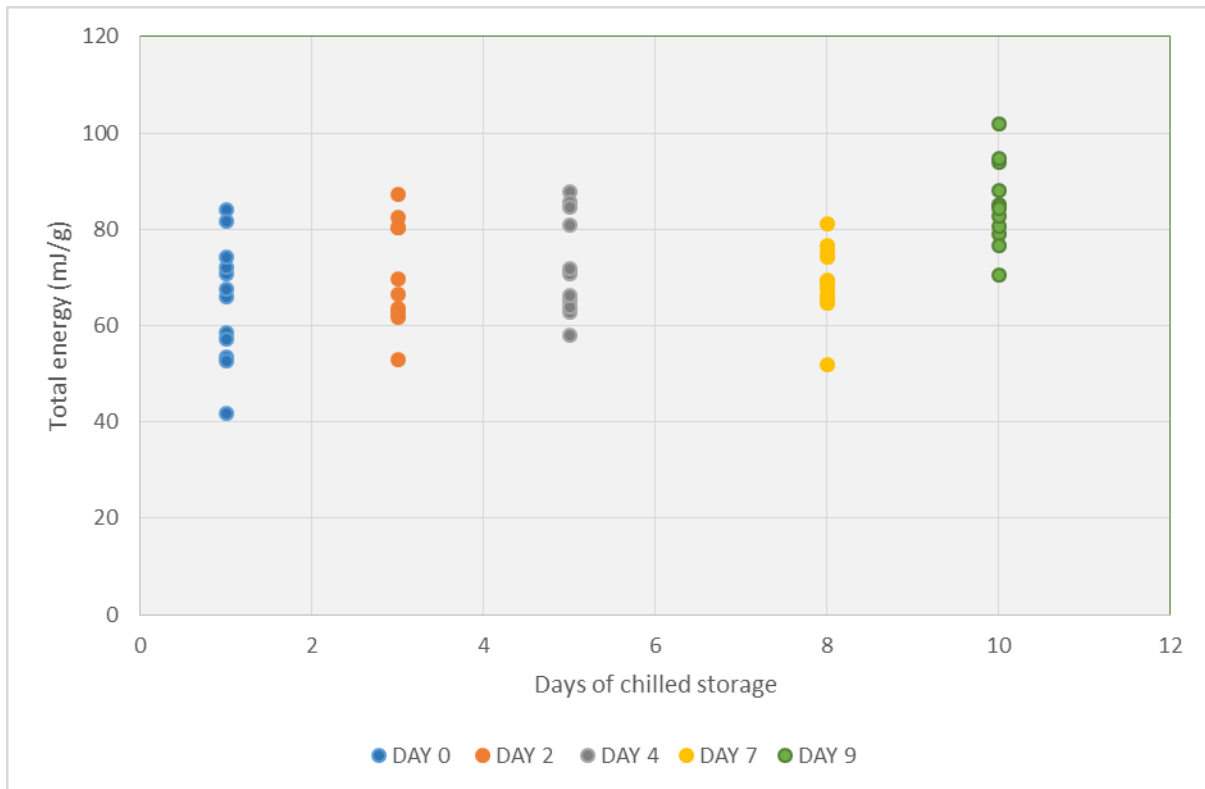
Figure 21 Total energy (TE) of Royal Red Prawns at sampling days through the spoilage trial

As can be seen in the graphs of the two methods of texture analysis, there was very little change over the first 4 days of storage in both PF and TE. The values obtained at these times are also very consistent within each sample point. However on day 7 and day 9 variability with the PF values is noticeable. Also, the trend across both parameters during days 7 and 9 is that of increasing firmness of the meat. This effect is against what would normally be expected by a trial such as this. However, with the prawns being exposed to air in a chilled environment it is highly likely that these prawns were simply drying out during the storage period.

Texture assessments were also conducted on the three samples assessed by the sensory panel (Banana Prawn, wholesale RR, retail RR). All assessments were carried out on raw meat as described above. Results are presented in Figure 22.

Figure 22 Peak force results of raw meat of Banana Prawns (n=11), wholesale Royal Red Prawns (n=12) and retail Royal Red Prawn meat (n=31).
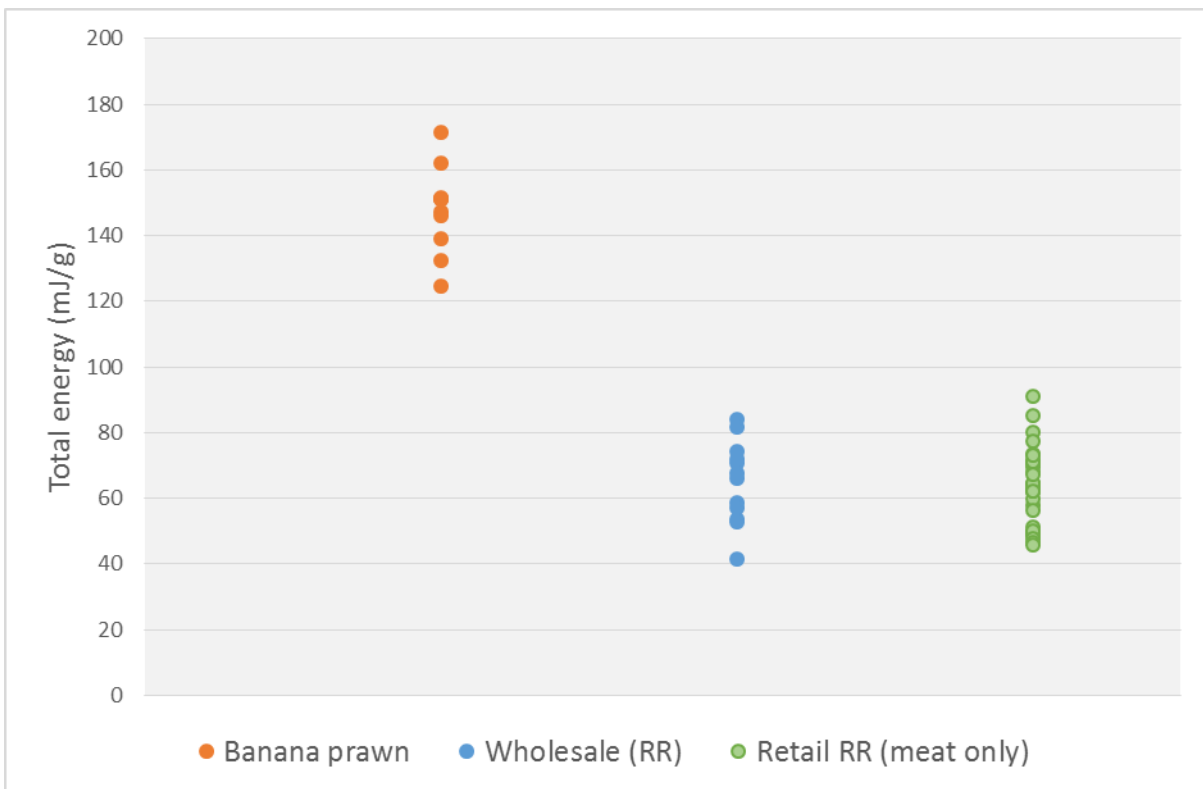
Figure 23 Total energy results for raw meat of Banana Prawns (n=11), wholesale Royal Red Prawns (n=12) and retail Royal Red Prawn meat (n=31).

Values obtained from Banana Prawns were more than double those obtained for both samples sets of Royal Red Prawns. This is an important result that validates the responses from the sensory panel that found large differences in textural experience in the cooked product.

The value of this textural assessment of the raw product, lies in the fact that there are clearly significant differences in the meat firmness between the species at a fundamental muscle structure level.

This factor should be considered as a real point of difference when developing a marketing plan and when educating buyers and consumers of Royal Red Prawns. A softer texture within a raw or cooked dish provides the Royal Red Prawn with a unique opportunity to position Royal Red Prawns in a space to which almost all other species of Australian prawn cannot genuinely occupy.

Subtle textural qualities such as those identified here, when combined with a sweet umami flavour that lingers, can form the centre piece of boutique dishes in the fine dining market; where subtlety is often a prized attribute.

Spoilage organism enumeration

On each sampling day, five individual whole prawns were subsampled from chilled storage and heads aseptically removed. Heads were discarded to negate bacterial enumeration results being overstated by the inclusion of bacteria present in the portion of prawns that is typically not eaten. A 10 g subsample of the 5 prawn portions, shell-on and including the digestive tract remaining in the tail meat, was homogenised with 90 ml of sterile peptone (0.1% w/v) in a Colworth Stomacher (UK) for 1 min. Appropriate serial dilutions of the homogenate were prepared in sterile peptone (0.1% v/v) and plated with seawater agar, comprising Standard Plate Count Agar (Oxoid) prepared with fresh seawater obtained from an offshore source (Bribie Island Aquaculture Centre seawater intake, DAF, Queensland). All plates were incubated at 30°C for 3 days to allow colony development. Subsequently, colonies were counted and bacterial numbers expressed as colony forming units per gram (cfu/g).

Bacterial colony increase during chilled storage is depicted in Figure 24. Immediately subsequent to thawing of product, prawns carried a bacterial load typical of prawns directly out of the ocean.
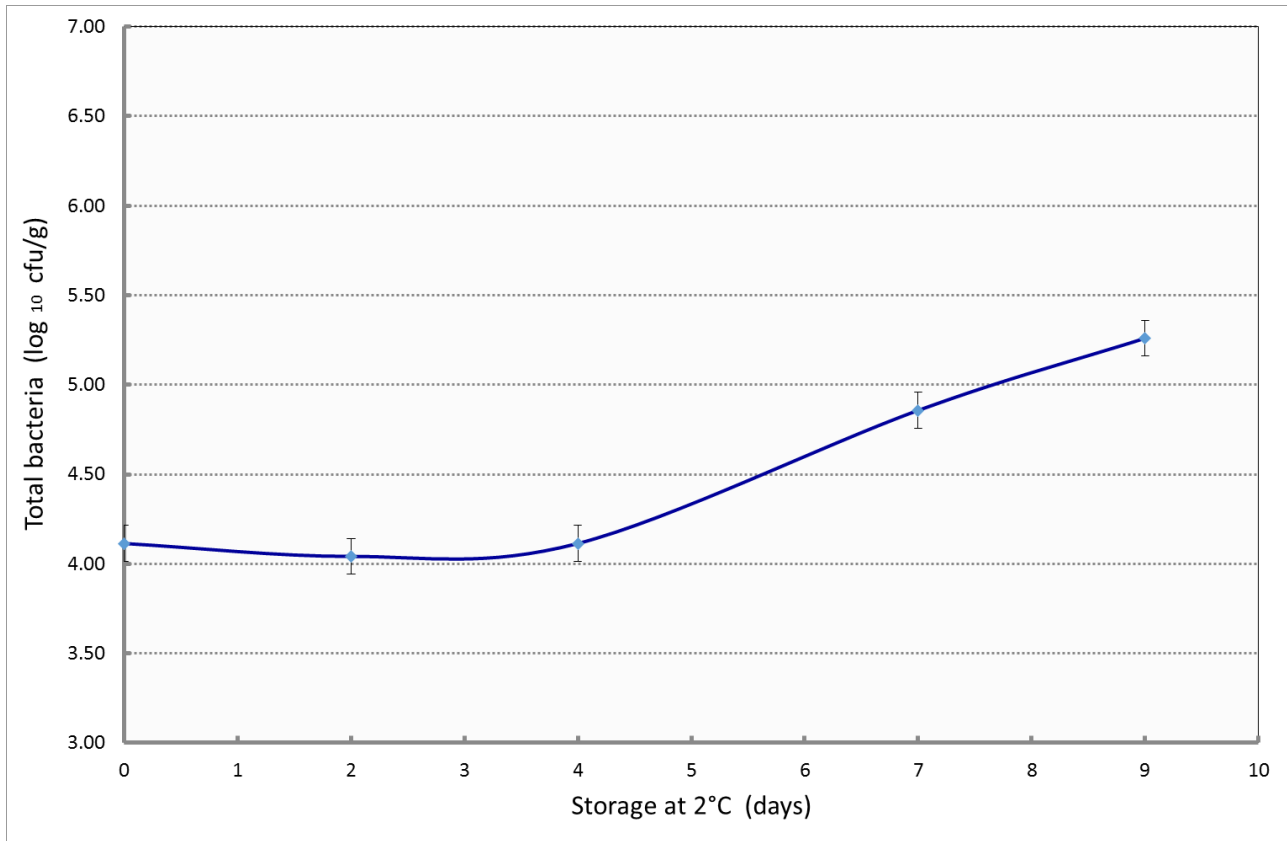
Figure 24 spoilage organism enumeration of Royal Red Prawns during chilled storage (standard error bars are shown)

Bacterial numbers did not increase until after 4 days storage had occurred. The extended lag period of 5-7 days before bacterial numbers increase is a well-established phenomenon with post-thawed storage of previously frozen prawns (Nip and Moy 1981, López-Caballero et al. 2007). This occurs while the bacterial population is recovering from freeze-process stress. The bacterial load does not show any increase in load until 7 days. Through the chilled storage period, bacterial numbers remain well below the maximum permissible threshold for acceptable food product as described by the FSANZ food standards code.

Review of project objectives and methods

The low number of licensees in this fishery created some very particular issues with regard to the successful achievement off the defined objectives. There is currently one processor of Royal Red Prawns being supplied from three licences operating in New South Wales (NSW) waters, one of which operates under the processing company business. There is also one exploratory permit to fish Queensland waters from north of Fraser Island to the NSW border. This specific fishery structure adds complexity to participant interaction, as well as the commercial dynamics between operators.

During development of the Royal Red (RR) proposal, the need described by Industry was focused on product quality handling and processing, with a second phase centred on identifying markets for this product. Both these aspects were driving towards gaining greater return for Royal Red Prawns than currently achieved. Early project work was directed towards engaging with each of the four industry members involved, of which one is currently the sole processor. One of the key fishers decided to withdraw from participation prior to project commencement, however, gentle persuasion during regular interaction over the last 12 month period has created a willing input from this fisher.

When confirming objectives and outcomes during early discussions with fishery participants, a clear mind set was depicted on Royal Red handling operation, processing system and specific market target – that market being China. The market choice was a little interesting for RR, as while Royal Red Prawns can tick a lot of the boxes of desirable attributes for the Chinese consumer, the current total allowable catch (TAC) for the fishery is small (approximately 375 T).

Successfully promotion of Royal Red Prawns into the Chinese market would likely result in demand far beyond supply capability. This, and the fact that Royal Red Prawns are not yet listed on the Chinese 'Approved product for import' list, raised concern whether this specific export market was the best option to target as first choice with Royal Red Prawns. Neither of the limitations noted are likely to have rapid resolution.

Since commencement of this project, there has been a slow but substantial shift of perceptions and focus by the participants of the Royal Red Prawn fishery. This has been engendered by several factors throughout the period, with the major shifts being:

1. *Reduction of drive towards export markets only and appreciation of economic benefits of domestic market supply*

Significant changes have occurred within the domestic market for prawns in Australia. The detection of white spot syndrome virus (WSSV) on eight prawn farms on the Gold Coast, Queensland November 2016, has had widespread implications on the trade of all species of prawns in Australia; both domestically produced and those imported. WSSV caused the removal of >1M kg of black tiger prawns destined for local supply, mostly into the two large supermarket operators in Australia. Coupled with this loss of production was the immediate cessation of imported green prawns, all of which are traded as frozen product. The overall effect has been a significant reduction in the supply of prawns into the Australian seafood market, both in the food service sector, and retail.

The net economic effect has been to drive up wholesale prices of Australian prawns sourced from both farmed production and wild harvest. Import restriction on prawns were eased in July of 2017, however prawn prices have remained strong. Wholesale prices for wild caught prawns have been reported up to $30/kg back-of-deck value well past the usual harvest season in June (personal communication, September 2017).

Another direct result of this issue has been the increased publicity around prawns and the heightened awareness of domestic prawns, farmed as well as wild production. All sectors of the Australian prawn Industry have experienced increased demand and market penetration, including RR prawns. Stakeholders in the Royal Red Prawn fishery are now in a strong position to shift their focus away from seeking export market opportunities and target the development of niche and premium supply opportunities within Australia. There is sound logic behind this strategy for the Royal Red fishery. The total production volume of this fishery is very small hence providing export markets with constant and likely large, volumes of product would be

extremely challenging for a fishery with currently four active stakeholders and a total catch of approximately 175 T annually.

The impact of substantial price increases, as well as issues of supply brought about by the WSSV outbreak, has led to the creation of perfect market conditions to establish the RR prawn within the domestic market and drive positioning towards high-end food service.

2.   Recognition that freezing on-board soon after capture is critical for prawn quality

There is now universal recognition among fishery participants that the practice of holding Royal Red Prawns in brine for transport to shore may not be ideal.

Inconsistencies in product quality have been the primary issue across operators in the Royal Red fishery. Each of the three NSW licensees engaged on this project utilise slightly different on board processing techniques.

The main challenges with Royal Red Prawns are damage to prawns during capture, separation of prawn species within the deep water trawl catch, managing the rapid development of melanosis and variability of flesh texture in retail product. Trial work with Royal Red Prawns reported within Milestone 2 (23 May 2017) clearly showed that this prawn species is unsuitable as a green chilled commodity product for retail level.

To date, Royal Red Prawns are frozen soon after landing, transported overseas for processing into peeled, deveined product, refrozen and returned to Australia for retail sale. This, therefore, subjects the prawns to a double freeze-thaw cycle which is likely to be detrimental to the flesh eating qualities of deep water prawns.

Melanosis development presents a significant quality issue when presenting Royal Red Prawns for peeling. If melanosis has been permitted to develop then staining can occur in the edible portion. This staining is quite visible even after the shell is removed. An example of this staining can be seen in Figure 25.
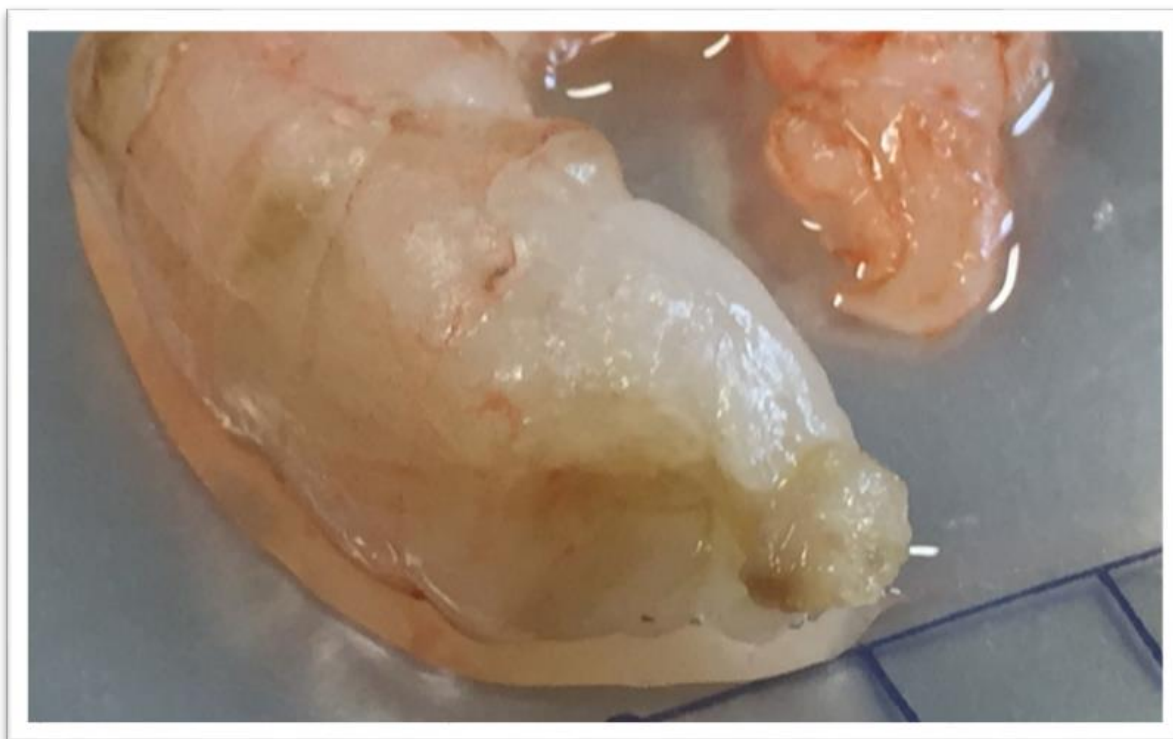
Figure 25 Royal Red Prawn (shell off) displaying staining from melanosis

A recent entrant into the fishery chose to handle the catch by freezing on-board and the vessel is fitted with significant freezing capability. Prawns are chilled immediately after release from the cod-end, rapidly boxed and frozen within a very short time. The speed at which prawns are frozen after capture on this vessel results in very high quality prawns with little or no melanosis whatsoever. A sample of these prawns was used for

the sensory assessments reported for Progress Report 2 and an image of these prawns is presented in Figure 26. These prawns were rated very highly by the tasting panel during that assessment. This information has encouraged the other fishers to adopt similar on-board handling methods, resulting in all participants having effective on-board freezing capacity early in 2018.

Figure 26 Sample of Royal Red Prawns frozen at sea

With this shift in on-board practices already taking place, and being conducted by the fishers themselves without intervention, the science plan for this project has been modified from that which was originally outlined in the application for FRDC project 2016-207.

Science Plan

Handling practices

The practice change to on-board freezing of Royal Red Prawns by all participants, shifts research focus to quantifying the benefits of on-board freezing. The key parameters pertaining to product quality then shift towards thawing practices and the risk of melanosis. The research team undertook thawing trials to determine the optimum thawing conditions for Royal Red Prawns.

Development of Royal Red Prawns sensory descriptors

A key change that has taken place in the strategy for this project is this shift away from identifying export market opportunities for Royal Red Prawns and focussing on the development of niche domestic markets. This shift will require repositioning the prawn from a relatively unknown commodity style product to a high value low volume product suitable for high end food service applications.

DAF Queensland project team have been in discussions with John Susman of Fishtales (Seafood Marketers) on developing a program involving high end seafood chefs to develop a set of eating quality descriptors that best describe the sensory attributes of the Royal Red Prawn. This will take the form of a half-day focus group where chefs not only get to taste the Royal Red Prawns, but also have the opportunity to cook with them in the same session to learn more about how the prawn performs in the kitchen. These terms will assist

stakeholders to target their marketing of the prawn, and provide a unique opportunity to specifically target the high-end food service sector.

After discussing these option with John Susman, the research team engaged Dianna Thomson to assist with recipe development and also to liaise with food service contacts in the Sydney area. Diana is a food technologists as well as being a chef, and more recently provided comprehensive menu building services to many Sydney venues. Diana is well experienced in both the quality requirements of food service as well as the financial metrics required to sell food for profit.

Such feedback from high-end chefs will be invaluable not only in obtaining a useful lexicon of sensory terms, but also provides an opportunity to expose the product to chefs who may not have experienced the Royal Red Prawn before. High-end chefs are always on the lookout for new, interesting food experiences and the provision of a provenance story with product description will be highly attractive. The Royal Red Prawn is not well known, however has very sweet flavour with good umami experience and hence has eating qualities to fulfil the niche market needs. Their flavour, combined with a softer texture than most prawns, also makes this product very well-suited to sashimi format.

The other key feature for this prawn is that it is not widely available in the retail environment, and as such food service application will have a high level of exclusivity. The volume of prawns available also means that there is enough product to supply the high end food service trade without issues of supply shortages.

Royal Red Prawn positioning

Sensory evaluation between Royal Red Prawns and other commercial prawn species more commonly known will be carried out. It is proposed to include comparative evaluation between Royal Red, King Prawns, and School Prawns. The latter species because of their purported eating characteristics that appear closest to those of Royal reds.

Review of thawing protocol for Royal Red Prawns

Several of the current licensees in the fishery are using freezing capability at sea. The two primary methods are individual quick frozen (IQF) or block frozen. Prawns processed using IQF present very few issues with regard to further processing and end user knowledge and understanding of the extent to which Royal Red Prawns can blacken. However the block frozen packaging method requires significant understanding of such issues and presents very real problems for end users.

Early project work completed by DAF was done using IQF prawns. These prawns were very simple to work with. The amount required for use on specific work was simply removed from the carton as prawns were loose in the box. Later work was conducted using block frozen prawns. Carton sizes ranged between 10 and 12 kg.

Coldroom thaw method

Our first attempt to thaw these prawns was attempted by transferring a carton from a seafood specific freezer room (being held at -29°C) to a cold-room and allow to relax at 4°C for approximately 24 hours prior to use. On the next day when the carton was opened, it became immediately obvious that prawns had begun to blacken significantly even though prawns were still clearly frozen. Figure 27 and Figure 28 show prawns displaying the effects of melanosis while frozen.

Figure 27 Royal Red Prawns showing melanosis while frozen

Figure 28 Close up of frozen Royal Red Prawns displaying melanosis

Cleary this method of thawing leaves the prawns being highly susceptible to melanosis activity. This was quite a surprise to the research team. The activity of the polyphenol oxidase (PPO) enzyme in this species is far more active than anticipated - even at subzero temperatures.

After consultation with the fisher and supplier of the prawns, we decided to repeat the thawing trial under conditions recommended by the fishers. This requires the block to remain submerged under water for the period of time required to thaw.

Brine immersion thawing

For this trial Royal Red Prawns were thawed under immersion a seawater strength brine (approximately 3.5% at 24°C). A full carton of prawns was transferred to a foam box and immersed in the brine. The box was then transferred to a cold room (4°C). 1 kg of ice was added to the prawns/brine to chill the brine from ambient temperature. An image of the prawns under brine is presented in Figure 29.

Figure 29 Day 0 of brine immersion thaw method

Prawns were monitored over the next four days to document the progress of thawing under these conditions. An image of these prawns at day 1 of storage is presented in Figure 30.

Figure 30 Day 1 of brine immersion thaw method

As can be seen in Figure 30 there is very little change in the prawns even after 24 hours in cold room. Much of this can be explained by the prawns coming out of a seafood specific freezer where product is stored at -29°C. This would represent a significant volume of latent heat capacity from prawns. However some darkening of the water can also be seen in Figure 30. This trend continues throughout the trial. An image of prawns at Day 2 of storage is presented in Figure 31.

Figure 31 Day 2 of brine immersion thaw method

By day 2 of the trial the bock had thawed a little around the edges, but was still frozen solid at the core. Melt water had also darkened a little more since day 1. An image of the prawns at day 3 is presented in Figure 32.

Figure 32 Day 3 of brine immersion thaw method

BY day 3 the bock was soft enough to break up. Melt water has continued to darken even though much broken ice remained in the brine. The trial was continued into day 4 to determine if the darkening would continue. An image of the brine immersion at day 4 is presented in Figure 33.

Figure 33 Day 4 brine immersion thaw method

Extensive blackening of the brine is immediately obvious in Figure 33. However the prawns themselves did not exhibit melanosis to the extent displayed in the brine. Some of the prawns from day 4 of the trial are represented in Figure 34 and Figure 35.

Figure 34 Royal reds prawns after 4 days of thaw under brine immersion

Figure 35 Close up of Royal Red Prawns after 4 days of thaw under brine immersion

The majority of prawns thawed during this trial displayed very little in the way of melanosis after four days. What little melanosis is visible is clearly restricted to the head of some prawns. However, no extension blackening has occurred as did happen during the shelf life assessment (see *Determination of spoilage parameters* on page 17). During the shelf life assessment prawns exhibited extensive blackening along the body of the prawns, and also stained the muscle beneath the shell in the affected areas (see Figure 16 and Figure 17).

The other dark colour that is visible in the prawns is due to the roe in several prawns. The colour is a very deep blue and is clearly visible though the shell of some individuals. When the roe is cooked it changes colour to more commonly observed bright red/orange of as per the shell colour of cooked prawns.

Summary of thawing methods

The brine immersion method is clearly affective at minimising the opportunity for melanosis to develop within the prawns while thawing. This method is clearly favourable to simply using cold storage conditions alone to thaw Royal Red Prawns. Thawing under refrigerated conditions alone is clearly not an acceptable method.

However the quantity of prawns being thawed in this experiment (approximately 15 kilograms) meant the process of thawing was very longwinded and not without its challenges. This is not the type of process that can be easily conducted in a domestic environment, let alone a commercial kitchen. And the quantity of prawns here would be a challenging amount to utilise within a reasonable amount of time in all but the busiest of commercial food service environments.

Another issue with this packaging method was the portion of the product that was unusable due to damage to the prawns. From this carton an amount of damaged prawns consisted of 4.48 kg of material. This represents approximately 30% of the prawns packaged. Any user of these prawns would need to take into account the amount of loss after thawing when considering using this prawn. In view of the many alternative options available in the market, this issue alone would be a significant barrier to purchase for many commercial buyers of frozen prawns.

Assessment of cooking methods for Royal Red Prawns

To better understand the options available for end users of Royal Red Prawns, the research team embarked upon an assessment of the various cooking methods deemed to be most suitable for the prawn in the food service environment, while retaining the key characteristics unique to the Royal Red Prawn. The cooking methods utilised in this assessment were *sous vide*, tempura, deep fry, and boil. The following is a summary of the key findings. A full description of the assessments can be found in Appendix 2.

Sous vide

Sous vide is cooking style in which the product is placed in a plastic pouch or bag, and cooked by use of a water using relatively low temperatures. The process is designed to cook the meat properly without overcooking and thereby retaining the inherent moisture in the meat. *Sous vide* is a popular method utilised in high end restaurants, and is increasingly being utilised in seafood applications.

Sous vide cooking was conducted on prawns from temperatures ranging between 55 and 60°C, and times of 15 minutes up to 45 minutes duration. On all but the highest temperature and cooking times, the prawns displayed varying degrees of melanosis. This can be seen in Figure 36 and Figure 37.
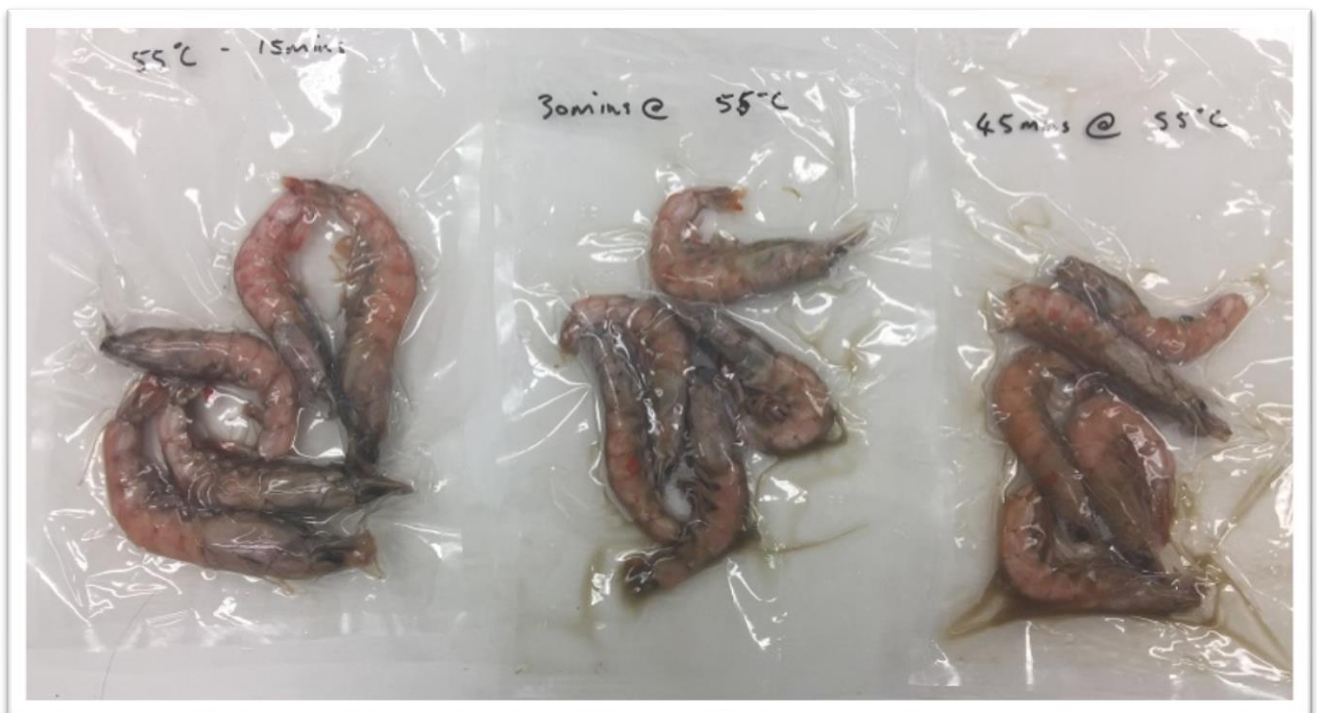
Figure 36 Royal Red Prawns cooked *sous vide* cooked at 55 degrees C

Figure 37 Royal Red Prawns cooked *sous vide* cooked at 60 degrees C

Low temperature *sous vide* was clearly not applicable for Royal Red Prawns. The PPO enzyme was simply too active to permit low temperature cooking. Cooking at 60°C was more promising with regard to appurtenance. However, the texture was soft and inconsistent. Further work would be attempted with Diana Thomson and cooking temperature would be further increased.

Tempura

Tempura is a Japanese deep frying technique adopted from Portuguese merchants residing in Nagasaki during the 16th century. The most common food items cooked in this method are vegetables and seafood. Tempura shrimp is probably the most common method utilised in Japanese cooking. For a full description of the batter recipe used in this work please refer to Appendix 2.

For this trial prawns were thawed and peeled prior to cooking, and cooking was conducted at 170°C and 180°C. An image from this cooking trial is presented in Figure 38.

Figure 38 Tempura cooking of Royal Red Prawns

It was of no real surprise that the tempura product was a very pleasant eating experience. Apart from the long tradition of cooking shrimp in this manner, the Royal Red Prawn has a relatively strong shrimp/prawn flavour. As such, it does not get lost in the strong savoury flavours of the batter, and is an excellent platform for experiencing the Royal Red Prawn flavour, with a highly refined texture.

Deep Frying

The key feature of this trial was to assess the possibility of cooking prawn with the bare minimum of preparation. Prawns were to be cooked from frozen, and with the shell on, with a simple dusting in cornflour. The concept to be evaluated here was one of developing a method that was so simple it could be very easily applied in the simplest of kitchens. And being able to keep prawns frozen right up until the point of cooking provides the product reduces the opportunity for product losses due to shelf life, and also provides a simplicity the issue of stock control. An image of some of the prawns cooked during this work is presented in Figure 39.

Figure 39 Royal Red Prawns deep fried from frozen

This method of cooking proved to be quite acceptable at both 170°C and 180°C. Both temperatures are used in commercial kitchens for various frying applications. The shell of Royal Red Prawns is very thin, and crisps up very nicely under frying conditions. Cooking from frozen also keeps the meat at a much lower temperature that the outside during cooking. Best cooking times were identified as 1:30 minutes at 170°C and 1:00 minute for 180°C. This concept is definitely worth progressing to further research.

Boiling

This method was utilised to understand the cooking times required for boiling Royal Red Prawns. Boiling is the most common method of cooking prawns in Australia for both wild fisheries and aquaculture operations. A full description of the boiling process and results can be found in Appendix 2. An image of prawns cooked during this work is presented in Figure 40.
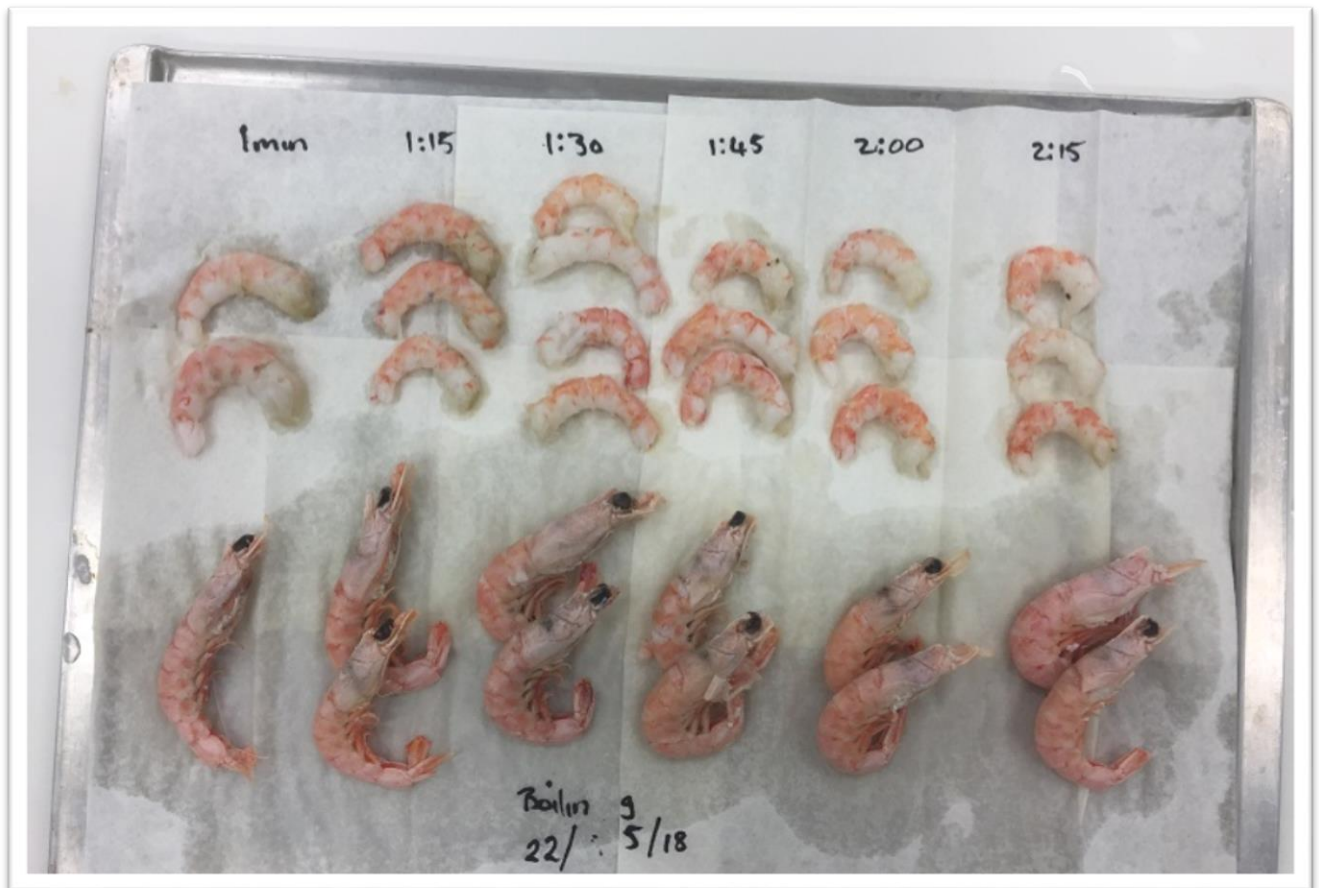
Figure 40 Assessment of Royal Red Prawns after boiling at various time duration

Optimum boiling time for Royal Red Prawns was determined to be 1:15 minutes up to 1:30 minutes depending on prawn size. Flavour and texture were both found to be at their best at these cooking times. However, as can be seen in Figure 40, the visual appearance of the whole prawn after boiling is not very appealing. Once the shell is removed, the prawn has an appearance not dissimilar to any other prawn meat.

Summary of cooking method development

The cooking methods investigated in this work proved to be favourable to the sensory characteristics available to users of Royal Red Prawns in cooking applications. Using tempura or deep frying in the shell provided a highly acceptable product with very little preparative input. The unique flavour and texture characteristics of Royal Red Prawns were definitely not lost in these methods. The next step of development was to further refine these processes into high end restaurant applications that could be presented to experienced seafood chefs.

High end food service concepts for Royal Red Prawns

The unique sensory properties of the Royal Red Prawn were previously identified by the research team as being a real point of difference in the range of prawn products currently available in Australia. Preliminary cooking method development has also achieved acceptable results that warrant further development towards providing a high end seafood product for restaurateurs.

To assist in this work the research team engaged Diana Thomson to assist with this recipe formulation. Diana's brief was to provide assistance on the following goals;

- Provide information on current trends for prawns in food service in Sydney, and examples of prawns on menus in restaurants and cafes in Sydney
- Conduct initial cooking trials to identify potential applications and product quality
- Conduct further recipe development on site at DAF in Cooper Plains
- To assist with presenting recipe concepts to key Sydney chefs in a focus group setting in Sydney

Complete information provided by Diana Thomson relating to current industry trends, initial product sensory assessment, and recipe formulations can be found in Appendix 3.

Current Industry Trends

Prawns of all species are a very popular restaurant item across a wide range of cooking styles and price points. The most popular of cooking techniques is sautéed prawns shell off, or the simple addition of prawns to soup, salad or curry. Increasingly, prawns are also being offered as a shell on option being either deep fried or cooked on cast on griddle. However, some restaurateurs are becoming increasingly adventurous and challenging their diners with more complicated offerings. Several restaurants were offering ravioli, wontons, prawn toast and even a *san choi bow*.

Several chefs also reported their interest in using as much of the prawn material as possible. Prawn heads being used to make prawn stock and prawn butter for use in other dishes. There was also a report of prawn shells being fried off and used for a favoured garnish. Use of these materials is a shrewd way of minimising waste material as well as maximising the potential outputs from ingredient that may represent a significant cost input.

Initial Cooking Trials

Diana conducted a range of assessments of the raw product and during use in several cooking techniques. The full list of assessments and results can be found in Appendix . The following is a brief summary of those assessments.

Flat grill/plancha (shell on/head off)

Good texture, shell browned nicely and crisped. Fine shell can be eaten when cooked at very high heat.

Deep fry – dusted/crumbed/tempura/wonton (shell on/head off)

Excellent clean sweet flavour. Thinner shell than school prawn of similar size.

Poach - simple tomato sauce (peeled – tail fan on)

Flavour good. Slightly overwhelmed by the tomato sauce. Texture was medium to soft.

Pan fry – sautee, stir fry (peeled – tail fan on)

Good browning achieved with the addition of fat. Tail fans crisped up nicely. Great presentation.

Mousseline – boudin, ravioli, timbale (peeled, puree)

Soft, light texture. Mild sweet flavour

Mince – wonton, ravioli, prawn cake, croquette (peeled, shell off)

Excellent result. Great texture and flavour

Prawn butter (shells, heads)

Flavour: Creamy sweet pronounced prawn flavour, nutty tones.

Colour: rich orange crustacean colour

Applications: use to enrich bisque, pasta sauce or glaze top of a fish portion

Further recipe development towards chef presentation

This initial list of concepts was then taken refined further over two days on site at the Health Food Sciences Precinct, Coopers Plains. The outputs from this work was to have a list of products to demonstrate to some key industry chefs in Sydney. The final formulations and cooking process parameters can be found in Appendix . The following is a summary of the key findings from work completed.

Deep fry coatings

One of the key areas of work was to identify the most appropriate deep frying coating for the Royal Red Prawns. Materials used included corn flour, rice flour, tapioca, semolina and combinations of the same. An image of some of these is presented in Figure 41.
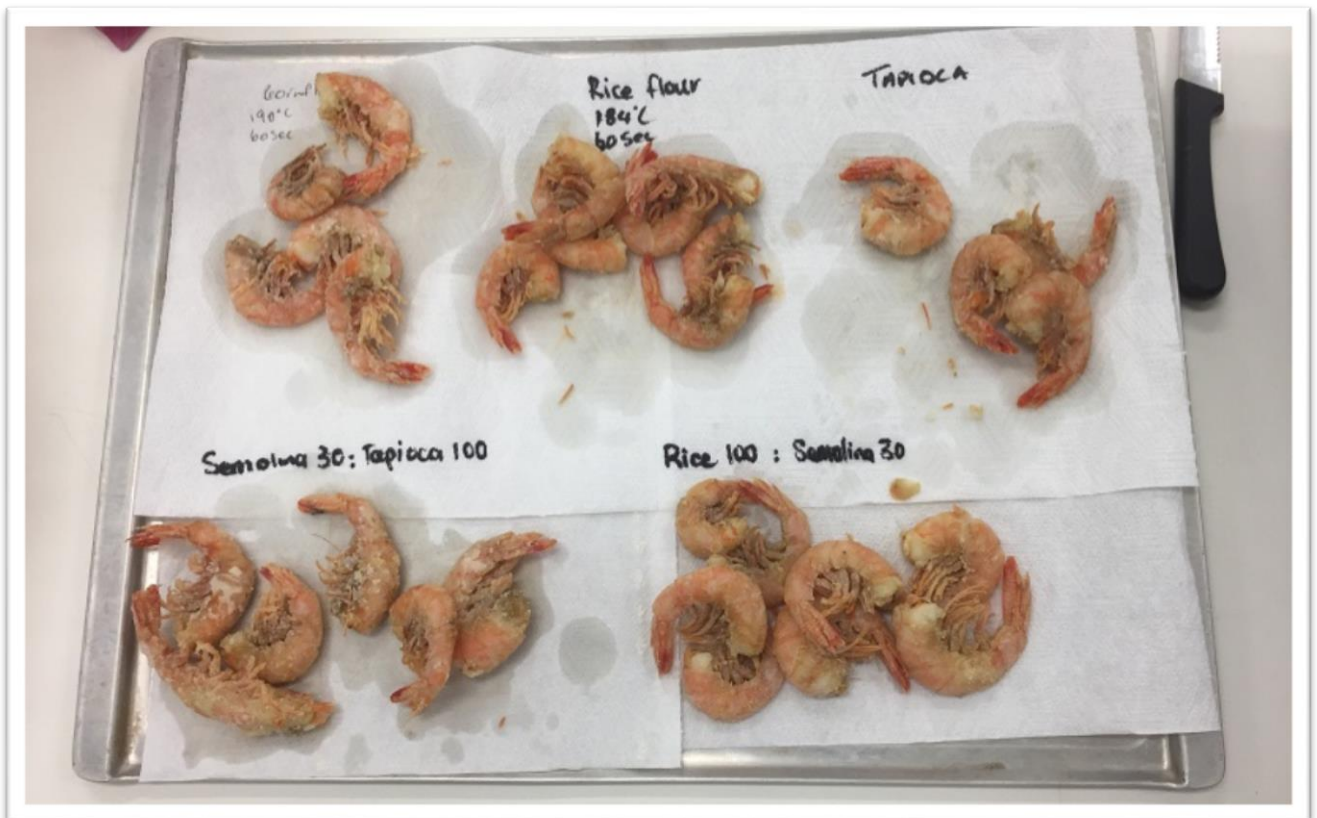
Figure 41 Royal Red Prawns under a range of coating options

Of the coatings tested in this work, the best results were obtained with a mix of rice flour and semolina. All the coatings were acceptable. However, the rice/semolina coating had some extra crunch that really added to the eating experience.

Sous vide

The *sous vide* concept was revisited for this trial. This time a range of higher temperatures was utilised for the cooking. An image of some Royal Red Prawns cooked via this method is presented in Figure 42.

Figure 42 Royal Red Prawns cooked via *sous vide*

For this trial it was also decided to partially cure the prawns prior to cooking. The curing assists with firming the texture during a low temperature cook. However, for this work the preferred temperature identified was 90°C. This is well above the normal range for *sous vide*. However, the product demonstrated a texture very similar to that of other *sous vide* products. The combination of good flavour and desirable texture made for a high quality eating experience.

Boudin and Ravioli

Both the boudin and ravioli utilised a puree of raw Royal Red Prawn meat. The mix also contained cream, egg and some seasoning. An image of the boudin is presented in Figure 43.

Figure 43 Royal Red Prawn boudin

An image of the uncooked ravioli is presented in Figure 44 and an image of the cooked ravioli after tasting is presented in Figure 45.

Figure 44 Royal Red Prawn ravioli prior to cooking

Figure 45 Royal Red Prawn ravioli after tasting

Both the boudin and ravioli had an excellent flavour. The slightly stronger prawn flavour of the Royal Red Prawn lends itself very well to this style of dish.

Pan Fry (head off/shell on and shell off/tail fan on)

Pan frying was also conducted on both shell on and shell off prawns. Cooking of these prawns was conducted using clarified butter. An image of these prawns is presented in Figure 46.

Figure 46 Pan fried Royal Red Prawns (head off/shell off/tail fan on)

Pan frying in clarified yielded a highly acceptable product for both shell on and shell of product. As the shell of the Royal Red Prawn is very thin, it is becomes quite brittle from the frying process and is easily eaten with little trouble.

Another benefit of cooking with shell on is that the texture of the shell masks some of the grit or sand that can be present in the gut canal of these prawns. As such cooking with shell on not only removes an additional processing step, but can also remove the need to remove the gut canal after shelling the same prawn.

Chef focus group – Sydney Seafood School

The final step of the recipe development process was to expose these concept to a select group of Sydney based chefs who had indicated their interest in understanding more about this little known species.

The environment used for this focus group session was the Sydney Seafood School within the Sydney Fish Market. Prawns for the day were supplied by Richie Bagnato, and Richie also attended the focus group. The attending chefs were as follows;

- Colin Barker, Head Chef, The Boathouse on Blackwattle Bay
- Damien Naughton, Sous Chef, Lox Stock And Barrel
- Meena Throngkumpola, Executive Chef, Long Chim Sydney
- Keith Higginson, Group Executive Chef, The Fresh Collective

Chefs were provided with an information sheet describing the key qualities of the Royal Red Prawn as well as a summary of the cooking parameters developed during the research. Cooking of the products was done in front of the chefs by Diana in the Seafood School. An image of Diana preparing the prawns for frying is presented in Figure 47.

Figure 47 Diana Thomson coating the prawns prior to frying

A healthy discussion developed during the cooking of each of the methods. The chefs were very keen to learn as much as possible about the species. The presence of Richie Bagnato also provided some valuable insight to chefs with regard to the fishing method, and the environment from where the prawns are sourced.

At the end of the presentation the research team provided each of the chefs with a one page questionnaire. This questionnaire was simple designed to obtain some honest feedback on their experience of the prawns during the focus group, without attribution of that feedback by name.

The following is the feedback obtained from each of the chefs. However, there are no names attributed to those comments.

Responses by chefs to the questionnaire from the recipe presentation

1. **What did you like most about the Royal Red Prawn dishes you tasted today?**

Chef 1: Great flavour profile

Chef 2: Sweetness in flavour, thin shell – still edible, good versatility

Chef 3: The prawns have a lovely robust sweet flavour, they look great and are very user friendly.

Chef 4: Depth of flavour, texture is great due to high oil content.

2. **Was there anything about the Royal Red Prawns that you disliked?**

Chef 1: Was really the blackening of the shell. Will require some staff training.

Chef 2: I didn't like the sausage (boudin) or wonton. Too much chopping makes the prawn smelly. Better as a whole product.

Chef 3: The *sous vide* prawns I found a little mooshy.

Chef 4: Not a fan of *sous vide* or low temp cooking.

3. **What cooking methods do you prefer when cooking prawns?**

Chef 1: Grilled, fried or raw.

Chef 2: Butter and deep fried, wok charred, sushi, seared with sesame oil and soy sauce. Grilled.

Chef 3: Deep frying or BBQ

Chef 4: Mousseline, not too high oil. Best flavour and texture from frying and BBQ.

4. In your opinion, what dish or cooking format would be best suited to Royal Red Prawns?

Chef 1: Ceviche, Prawn pasta.

Chef 2: Deep fried –salt and pepper style (Chinese), lightly poached (oil or blanched).

Chef 3: BBQ head off, shell on and deep frying. Same way coated in a spiced flour mix

Chef 4: Would love to try ceviche, but frying most user friendly

5. What would be your limitation(s) for using Royal Red Prawns on your menu?

Chef 1: Peeling if using for ceviche.

Chef 2: No limitations

Chef 3: Packaging. Needs to be in 1 KG blocks. Head off would be better. Heads used for sauce or stock etc??

Chef 4: Would love to access some fresh product. Freeze below -18°C would be difficult in kitchen freezer

6. What are your key parameters when you evaluate the quality of prawns for you menu?

Chef 1: Smell, taste, and appearance.

Chef 2: Texture – springy bit, flavour - sweetness, brininess, storage ease.

Chef 3: Flavour, texture, shelf life.

Chef 4: For us fresh is key

7. If you could purchase this prawn as a frozen product, what wold you preferred pack size and product format?

Chef 1: 1 KG headless, 1 KG peeled

Chef 2: 500 g – in brine or seawater

Chef 3: 1 KG frozen, head off.

Chef 4: 2-3 KG block.

8. **What would you expect to pay for this prawn in the product format you described in the previous question?**

Chef 1: $20/KG.

Chef 2: Current price for school prawns - frozen = $13/KG. Fresh = $18/KG. Anywhere around those marks.

Chef 3: $20/KG

Chef 4: $18-24/KG

9. **Any final thoughts on the Royal Red Prawn?**

Chef 1: Great product

Chef 2: Nice flavourful product, colour is very nice, retains attractiveness when cooked.

Chef 3: great potential with the right marketing, packaging.

Chef 4: Great flavour, underutilised.

In summary, the chefs who attended this focus group provided very positive feedback on the Royal Red Prawn. They were impressed by the unique flavour and texture offered by the prawns and provided a range of dish and recipe options that would suit the prawn. The chefs were also highly engaged during the session and were very keen to learn as much as they could about this species. There is clearly a desire for chefs such as these to source new and novel seafood products, and especially when the product can be sourced from local fishers and suppliers.

From the responses provided from question 8 of the questionnaire, these chefs would be comfortable with paying up to $20 per kilogram for this product. This figure is approximately three times the current wholesale price for Royal Red Prawns.

The response to question 7 provide the expectations from the chefs with regard to product format and pack size. Preferred pack size no greater than 3 kilograms, with 1 kilogram pack size being the most common response. All chefs were interested in ways to utilised prawn heads for stock and other products. However providing a head off prawn is also a highly desired product format. A head off/shell on product would provide end users with no pressing at their end if need be to produce similar dishes to what were present during the focus group.

There is clearly a great opportunity for fishers to supply local restauranteurs with a product that ensures all participants in the supply chain extract a premium. However, the format of the product needs to provide the end users with minimal additional processing and waste product.

Conclusion

The Royal Red Prawn fishery contains a good deal of diversity: both in fishing and on-board handling practices as well as the businesses of the licensees themselves. Some of these businesses are considerably more vertically integrated than others. For the smaller and less vertically integrated businesses, the ability to identify markets and buyers for their product is becoming increasingly difficult. Then net result of this trend is that the smaller businesses have become "price takers" rather than "price makers" in the wholesale market for Royal Red Prawns.

Many of these fishery stakeholders are also licensees in other fisheries in both NSW and Queensland, as well as Commonwealth fisheries. The net result of this fact means that licensees tend to move between fisheries depending upon access and market pricing for the commodity being fished. This means the Royal Red fishery tends to be operated only when other fisheries are not viable on the basis of availability of product, or low market pricing.

The overall trend for operation in the Royal Red fishery is thus one of opportunism rather than planned and structured operation. These conditions have created a vicious circle resulting in catch rates for Royal Red Prawns reducing from just over 600 t in 1983-84 to approximately 170 t in 2016 (Patterson 2017).

Royal Red Prawns have very little presence in the retail space, and are not even marketed as such when they are sold in the retail space. The only product that is currently available is also sent off shore for peeling and packaging prior to sale in Australia. The Royal Red Prawns has become somewhat of a forgotten product in the mind of the seafood consumer.

The original focus of this project was directed towards improving on-board practices of the operators within this fishery, for the purpose of providing higher quality product for both domestic and export markets. However, it soon became apparent to the research team that there were two major hurdles to proceeding the research plan along these lines.

The first issue was that previous variety of chilling and handling practices was being eroded by the transition, or wish to transition, from chilled storage at sea, to freezing product directly at sea. These methods are either by block freezing in cartons or by individual quick frozen (IQF) then packaged at sea. Freezing the product at harvest is clearly the best method of processing this species due to the very high activity of the PPO enzyme and its ability to induce melanosis even at subzero temperatures.

These second issue was the scale of production for this product is simply not of a volume to supply an export market. In fact, the volume of prawns currently being landed would barely supply a genuine domestic market, and certainly not in demand value added retail product. The only retail product currently available is competing against imported product in supermarket freezer space. The market conditions in this retail category would be incredibly difficult indeed and unlikely to represent an opportunity to extract a premium for fishery stakeholders.

With all these factors in mind, the research team decided to shift the focus of the research towards providing product into the high end food service sector. There are three strong arguments to support this shift.

The first was the opportunity to extract a premium. Restaurants and food service more generally are the strongest opportunities for any commodity to extract a price premium from the consumer. Chefs and restauranteurs achieve this outcome based on their own reputations as producers of a fine dining experience. Customers enter this space often without any prior knowledge of what is on the menu or the product on offer within a recipe. It is the job of the restauranteur to "sell the story" of the dish, and the origins of the star ingredient. For the fishers, this is great pathway to educate more broadly the seafood consuming public about their product via the restaurant or café menu.

Secondly, supplying product to restaurants and cafes allows fishers to manage their supply of product more efficiently considering the relatively small catch rates and volumes of operators within the Royal Red fishery.

The current catch rates are nowhere near those of more commonly consumed species like Eastern king prawns or Banana Prawns. Fishers can also match the effort to the market conditions far better, and grow the food service product supply far more organically and without direct exposure in the retail space. This also means that any mistakes happen outside the direct sight of the general public.

Thirdly, the restaurant space is the most likely environment for both producers and restaurateurs to extract a genuine premium of their products. On current market pricing, Royal Red Prawns have a significant cost advantage on other commercial species, and therefore the opportunity for all stakeholders in the supply chain to be profitable is genuine. Even if wholesale pricing for Royal Red Prawns achieves $25 per kg, this price is highly competitive against other Australian produced species, either wild harvest or sourced from aquaculture.

The work conducted in this research has identified key sensory properties that provide a real point of difference for Royal Red Prawns when compared to other Australian species. Royal Red Prawns have a delicate texture unlike most Australian prawns that have a firm and meaty texture. Royal Red Prawns have a very distinctive flavour that is more intense that other Australian prawns, and is not easily overpowered in combination with other flavours and cooking styles. Royal Red Prawns are also a prawn that is easily used across a large range of cooking applications including cooking and consumption of the prawns with the shell on.

The range of cooking methodologies developed during this work have been presented to some of Sydney's senior chefs and food service personnel to validate the properties described above. The feedback from the focus group conducted at the Sydney Fish Market clearly demonstrates that the Royal Red Prawn does provide the seafood chef with a product that can be easily adapted across a wide range of dishes and cooking applications.

The chefs also offered indicative pricing that would enable them to purchase Royal Red Prawns for their restaurants. The prices offered here are significantly higher than those currently obtained from the product in wholesale markets around Australia. The same pricing should present fishery operators with an exciting opportunity to engage with local chefs and restaurateurs to provide these products to them.

The challenge for the fishery operators is to provide these customers with a product format that they need to suit their kitchen applications, and a pack size that ensure minimal waste product and simple stock control. The chefs in our focus group suggested a pack size between 1-2 kg would be ideal for their purposes. Some fishery operators are well placed to provide such products within their current fishing operations. Others will need further investment in new equipment to supply similar packaging options for food service users.

Other challenges will be product quality, product consistency and consistency of supply to ensure their customers receive the best quality product possible on-time and when requested. Quality and consistency of product are concepts that are well understood by the existing fishery operators.

The opportunity to access such high end food service establishments and the premiums that can be achieved by doing so, should also keep the focus on fishery operators on providing the highest of quality product to these customers.

Providing a frozen product format is also an excellent manner in which to maintain adequate stock control for fishery operators. The concept of stock control will be a very important ongoing issue for the fishery operators considering the exposure to bad weather and the potential loss of time at sea to harvest product.

However for those current fishery operators who accept these challenges and address the key product format priorities provided by the food service industry participants during our focus group research, the opportunity to improve profitability and sustainability of current fishing operations is clearly available to licensees.

Implications

The research conducted during this project has demonstrated that the current wholesale pricing for Royal Red Prawns is currently well under true market value. Where the true value lies is yet to be accurately determined, however, the potential pricing offer by participants in our focus group research provide an indicative value of $20 per kg.

This value is approximately three to four times the current whole price for Royal Red Prawns. This value also raises the market value of the total allowable catch (TAC) of Royal Red Prawns to approximately $6.9 million.

Successful penetration of the food service sector invariably creates more knowledge of the product within the broader seafood consuming community. This broader understanding of the product by consumers would also raise the prospect for further expansion of products into the seafood retail space.

A successful expansion of awareness and acceptability of Royal Red Prawns by seafood consumers would also pave the way for other little known and underutilised species from Australian water. During the course of the research, one of the key industry participants and research partners (Urangan Fisheries, Harvey Bay) provided the research team with prawns sourced during activity under their exploratory license in Queensland.

The prawns were initially thought to be Royal Red Prawns. However, after consultation with Queensland Fisheries staff and Bond University (Dr Daryl McPhee), the species were identified as belonging to the genus *Arsiteus spp* (data not shown). Opportunities for exploiting these other lesser known species are clearly available.

Recommendations

One of the key factors identified during the research was packaging. From the focus group research conducted, the chefs suggested that product be in a packaging format no larger than 2 kg. The ability of any individual fishing business to change their current packaging and freezing practices will vary greatly from business to business.

Some fishery operators are already well equipped to make such changes within their current fishing operation. However many others will require significant changes to their current practices. These changes will require financial as well as technical input and support to commission such changes of practice. The research team is well placed to provide any necessary technical support as part of the extension plan provided to the FRDC at the time of project approval. However financial assistance is beyond the scope of this project.

It is recommended that the FRDC to provide assistance to the fishery operators in identifying any available leverage funding for investment in plant and equipment for business expansion purpose. Specifically, we recommend investigation into the procurement of freezing equipment and packaging equipment suitable for on-vessel operation at sea.

Further development

There is currently a funding opportunity with the NSW jurisdiction supporting commercial fishing. More information can be found here:

https://www.dpi.nsw.gov.au/fishing/commercial/consultation/supporting-seafood-future/supporting-seafood-future-guidelines

The purpose of the campaign is to increase consumption of NSW seafood, drive the value of NSW seafood through increased awareness and consumption and build industry capabilities and cohesiveness. From the link above;

"*Strategic objectives of the campaign are to:*

- *•increase value, through consumption of farmed and wild caught NSW seafood*
- *•increase shopper options across a broader variety of NSW seafood*
- *•drive awareness and build social licence of the NSW fishing community.*

The Supporting Seafood Future grants program aligns with the NSW Marine Estate Strategy."

The research team would like to respectfully suggest that any un-used operational funds from this project be directed towards an industry based program as described in this funding opportunity, provided the fishery licensees can agree on a model to take forward.

This funding represents an opportunity to increase the public awareness of Royal Red Prawns, and a project of that nature would be highly likely of success both at a funding level and at the outcome level.

Extension and Adoption

Extension content

1.   Best practice handling protocols for premium quality Royal Red Prawns

2.   Successful prawn product formats for presentation to markets

3.   A Royal Red Prawn eating-quality profile for in raising market awareness of Royal Red Prawns

4.   Potential new markets for Royal Red Prawn and the requirements of specific domestic markets

Target Audiences

The main target audiences for best practice handling information are Royal Red Prawn harvesters and processors as these two sectors have greatest influence over the quality of the prawn product.

The food service sector participants that have been in contact with the research team have also displayed a keen interest in better understanding the Royal Red Prawn. Encouraging an ongoing relationship between fishers and chefs would greatly improve the likelihood of increasing the exposure of Royal Red Prawns to the seafood consuming public.

Knowledge of product formats, thawing protocols and eating-quality descriptors have direct applicability to wholesale and retail sectors, as well as the consumer. The audience for market opportunity information is broad and encompasses any fishing and seafood business willing to trade in Royal Red Prawns.

Methods of extension

The project work has been undertaken in direct collaboration with the Industry partners in the Royal Red Prawn fishery. The key messages for fishers and processors relate to the quality parameters, packaging format (including pack size) and product format that address the needs of seafood users in the food service sector, and the profitability on offer by addressing these issues.

This will occur through direct communication with the fishers for greatest effect. Broader dissemination of post-handling technology for operating in this fishery will occur through written information made available through relevant State peak bodies' websites, along with Project Investigator contact details for follow up information.

Sensory properties and cooking protocols have been developed for the benefit of chefs and seafood consumers alike. The information sheet, along with other relevant cooking information, will be freely available through relevant websites and actively promoted to all parties throughout the supply and value chains. Information gained about domestic food service opportunities for Royal Red Prawns will be freely available in summary report format and uploaded to relevant Industry websites.

2.

Project materials developed

A fact sheet was developed for the purpose of supply to chefs during the focus group session held at the Sydney Fish Market 3rd December 2018. This fact sheet can be found in Appendix 5Appendix .

The research team would recommend a review of this fact sheet prior to further distribution. More specifically, it would be prudent to obtain follow up feedback from the chefs who attended the focus group session, to ensure and further relevant information be included.

More specifically, the research team has developed a suite of established and popular cooking protocols optimised for use in food service applications. These recipes and cooking conditions can be found in Appendix 3.

Appendix 1

Project staff (Department of Agriculture and Fisheries, QLD)

Sue Poole, Andrew Forrest, Paul Exley, Philippa Tyler, Jimmy Baker.

Consulting Chef

Diana Thomson (Executive Chef, Diana Thomson Food Consulting) www.dtfoodconsulting.com.au

Participating Industry Research Partners

Richie Bagnato

Gary Pinzone (San Antone Fishing Company)

Paul Hodson (Urangan Fisheries)

Frank Musemici (Better Choice Fisheries)

Other Participating Research Partners

Erik Poole (Supply and Business Development Manager, Sydney Fish Market)

Daniel Johnson (Scientific Officer, Fisheries Research, NSW DPI and Fisheries)

Appendix 2

Preliminary cooking method development

Sous Vide

15/08/2018

Method

For all trials 5 frozen Royal Red Prawns were placed flat in a heavy vacuum bag and vacuumed (Some air still in bag due to insufficient vacuum from machine). Each sample was placed in the water bath for the desired length of time and cooled to less than 4ºC in less than 30 mins

Equipment Used

Vacuum Sealer - Turbovac BV   Water Bath
Setting Power 1
Vac Time - 6
Gas Time - 0
Seal Time - 3

Results

Cooking Method	Shell on	Batch Identification	Temp at Cooking	Cooking Time	Cooking Temp	Comments
Sous Vide	✓	NSW 01/11/16	Frozen	15 mins	55ºC	Melenosis was more pronounced in the prawns cooked at lower temperatures.
Sous Vide	✓	NSW 01/11/16	Frozen	30 mins	55ºC	Texture of the prawns were soft and became rubbery the longer the prawn had
Sous Vide	✓	NSW 01/11/16	Frozen	45mins	55ºC	been left in the water bath.
Sous Vide	✓	NSW 01/11/16	Frozen	15 mins	57ºC	Melenosis is not as bad as the samples cooked at 55ºC however still evident.
Sous Vide	✓	NSW 01/11/16	Frozen	30 mins	57ºC	Similar texture to the samples cooked at 55ºC, slightly firmer when cooked less
Sous Vide	✓	NSW 01/11/16	Frozen	45mins	57ºC	then turns more firm and rubbery the longer they are cooked.
Sous Vide	✓	NSW 01/11/16	Frozen	15 mins	60ºC	Melenosis still present but not to the extent as the lower temperatures. Prawns
Sous Vide	✓	NSW 01/11/16	Frozen	30 mins	60ºC	are more firm than the lower temperatures also and the longer the prawns are
Sous Vide	✓	NSW 01/11/16	Frozen	45mins	60ºC	cooked the more rubbery the texture as seen in the lower temperature samples

NOTE:

Age of Prawns may be a factor in the taste and texture. Sous Vide not an ideal method of cooking. Shell was also very soft, maybe due to the age of the prawn, may have also been contributed from cooking in the bag with the vacuum bag in it's own moisture.

Guide to Sous Vide prawn Cooking

Sous Vide Shrimp Cooking	
52°C	Translucent, semi-raw with a soft, buttery texture.
54°C	Nearly opaque, very tender with a hint of firmness.
57°C	Barely opaque, moist, juicy, and tender.
60°C	Traditional poached texture with good bounce and a crisp, juicy bite.

Ingredients	
700g	Large peeled shrimp
Pinch	Kosher salt
1/2 tsp	baking soda
1 tbsp	Extra virgin olive oil or butter (optional)
1 tbsp	Aromatics such as garlic, shallots, tarragon, or parsley (optional)

Directions	
1	Set your sous vide water bath to desired temperature according to the chart above.
2	In a large bowl, toss shrimp with 1/2 teaspoon kosher salt and the baking soda. Place shrimp in a heavy duty zipper-lock bag or a vacuum bag. If desired, add 1 to 2
3	Add bagged shrimp to preheated water bath and cook for at least 15 minutes and up to 1 hour (the texture should show very little variation within this time frame).

Tempura Recipe

16/05/2018

Hanaage technique

Ingredients Tempura batter	Method Batter	Method Prawns
1 cold egg 200ml Iced water 1/2 cup of CornFlour 1/2 cup of PlainFlour Oil 170 to 180 ºC Plain Flour for dusting	Cold egg and iced water mere mixed, equal quantities of flours were sifted into the iced water/egg to form a batter. Rice Bran oil was used for deep frying and heated to 170ºC and 180ºC.	Prawns were defrosted, shelled and tail left on. Prawns were then dusted with plain flour before dipping in the tempura batter

Royal Red Prawn Cooking	Shell off Tail on	Source - age and storage	Prawn Temp at Cooking	Cooking Temp	Cooking time	Comments
Tempura	✓	NSW 01/11/16	Defrosted	170ºC	1min	Batter not crisp, Prawn texture good a little softer than the new prawns, strong umami
Tempura	✓	NSW 01/11/16	Defrosted	170ºC	1min	Batter not crisp, Prawn texture more firm than the old prawns, flavour more subtle not as strong in umami flavour
Tempura	✓	NSW 01/11/16	Defrosted	180ºC	1min	Batter slightly more crispy at higher temperature, stronger Umami flavuor than the new prawn
Tempura	✓	NSW 01/11/16	Defrosted	180ºC	1min	Batter slightly more crisp at higher temp but still not crisp enough. Prawn texture more firm than the old prawns, flavour more subtle not as strong in umami flavour
Tempura	✓	NSW 01/11/16	Defrosted	180ºC	1min	The "Odd" prawn had a stronger flavour as seen in the old prawn, has a less firm texture than the other 2 samples tested against. This was a different variety of prawn than the other 2 as suspected.

Deep Fried

Method

Frozen prawn were used for the test. Prawns were lightly coated in corn flour then added directly to the hot oil with head and shell on.

16/05/2018

Royal Red Prawn Cooking	Shell on	Source - age and storage	Prawn Temp at Cooking	Cooking Temp	Cooking time	Comments
Deep Fried	✓	NSW 01/11/16	Frozen	180ºC	1min	Pale in colour meat cooked, shell still a little soft
Deep Fried	✓	NSW 01/11/16	Frozen	180ºC	2min	Shell more crisp, meat more firm flesh has pulled away from the shell inside, shell colour looks more red
Deep Fried	✓	NSW 01/11/16	Frozen	170ºC	1:30min	Smaller prawn used - good texture, colour is bright red, cooked through. Preferred texture for this test.
Deep Fried	✓	NSW 01/11/16	Frozen	170ºC	1:30min	Larger prawn used - 38ºC in thickest part of flesh once cooked. Shell was quite thick and a bit tough.
Deep Fried	✓	NSW 01/11/16	Frozen	170ºC	2min	Shell too tough to eat, flesh cooked nicely, good texture and colour

17/05/2018

Royal Red Prawn Cooking	Shell on	Source - age and storage	Prawn Temp at Cooking	Cooking Temp	Cooking time	Comments
Deep Fried	✓	NSW 01/11/16	Frozen	180ºC	1min	Meat cooked well strong umami flavours coming through. Differing in opinion regarding shell being too tough, not crisp enough and good crispness
Deep Fried	✓	NSW 01/11/16	Frozen	180ºC	1min pause + 20sec	Meat slightly overcooked (very slightly) has a little more of a rubbery texture. Strong umami flavours coming through. Shell more crisp when cooked longer. Not a true 1min 20sec cook due to pullin gout of the oil and putting back in.
Deep Fried - Cornflour	✓	NSW 01/11/16	Frozen	180ºC	1min	Texture of the meat as good, cooked nicely. Cornflour carried more of the oil flavours, still has a strong Umami flavour. Cornflour was more crisp but shell remarded a little tough/chewy
Deep Fried - Cornflour	✓	NSW 01/11/16	Frozen	180ºC	1:20min	Texture of the meat is slightly rubbery. Cornflour carried more of the oil flavours, still has a strong Umami flavour. Cornflour was more crisp shell was also slightly more crisp than the shorter time sample.

Boiling

Method

Prawns were defrosted on the bench to between 1 and 4ºC prior to cooking.

Boiling was done in the sensory gas stove top with a 5L saucepan.

Water was brought to a rolling boil prior to the prawns being added

The prawns were added to the boiling water and taken out at 15 sec intervals from 1 min to 2 mins 15 sec. Boiling water dropped to 84ºC when prawns were first added, lid was then put on top of the sacepan and was boiling again at the 1 min mark.

Between 4 and 5 prawns were removed from the boiling water at a time and place immediately into an icebath to chill as quickly as possible.

22/05/2018

Royal Red Prawn Cooking	Shell on	Source - age and storage	Prawn Temp at Cooking	Cooking Temp	Cooking time (min)	Comments
Boiling	✓	NSW 01/11/16	Defrosted	100ºC	1:00	Prawn meat was not quite cooked through, still has an opaque appearence and and texture was also a little undercooked. Melenosis was also more present in the 1 and 1:15 min samples compared to the longer cooked prawns. Flavour is strong Umami
Boiling	✓	NSW 01/11/16	Defrosted	100ºC	1:15	Very similar to the prawns cooked for 1 min, prawn meat was slightly more cooked than teh 1 min samples but only just. Prans looked more cooked and weren't quite as opaque in appearence. Melenosis was also present in the 1 and 1:15 min samples compared to the longer cooked prawns. Flavour is strong Umami.
Boiling	✓	NSW 01/11/16	Defrosted	100ºC	1:30	Very good texture and nice "bite" flavour is less strong than the lower cooked samples, colour also looks more bright.
Boiling	✓	NSW 01/11/16	Defrosted	100ºC	1:45	Very good texture nice "bite", flavour is slightly less strong. Very close to the sample from 1:30. The 1:30 and 1:45 samples are the preferred cooking time for taste testure and appearance.
Boiling	✓	NSW 01/11/16	Defrosted	100ºC	2:00	Has lost some of the texture from the previous 2 sample, has started to develop a slightly pastey texture. Flavour is still very similar to the 2 previous samples
Boiling	✓	NSW 01/11/16	Defrosted	100ºC	2:15	This sample is the same as the 2:00 sample.

NOTE: at all time intervals the shells were soft on peeling. Shell also had a dry white look to them.

Appendix 3

Diana Thomson Project Outputs

Current trend Sydney – snapshot of restaurant menu items featuring prawns (May 2nd 2018)

RESTAURANT	LOCATION	MENU	Menu pricing
Saint Peter	Oxford St, Paddington, NSW	Salt & Pepperberry Wallis Lakes School Prawns	$18
Sepia	201 Sussex Street Sydney, CBD	Tempura oba, smoked ama ebi, shell powder	(dego *$245*)
Rockpool Bar & Grill	66 Hunter St	Sauteed prawns in garlic w/ farro, green olives and pistachios	$34 (starter)
		Charcoal roast king prawns, split and marinated	$39 (starter)
		Seared King prawn w/ goat cheese tortellini, burnt butter, pine nuts & raisins	$39 (main)
Bentley Bar	27 O'Connell St, Sydney CBD	King Prawns + Guanciale + Koshihikari Rice + Sea Herbs	$34
Cirrus	Barrangaroo	Roasted King Prawns + Koji Butter + Sea Lettuce	$110 (tasting Menu
Est	George St, Sydney	ravioli of prawns, young leeks, lemongrass and shellfish vinaigrettes	
		raviolo of prawns, snow peas, young leeks, shellfish – lemongrass vinaigrette	
Pendolino	Strand Arcade, Sydney CBD	WILD WEED' SPAGHETTI Ground Barramundi, Spencer Gulf King Prawns, Chilli, Sicilian Capers, Garlic, Pinot Grigio, Tuscan Kale. 2017 New England Dolce EVOO, NSW	
		REGOLA AND SEAFOOD Spencer Gulf Prawn, Port Lincoln Sardine, Black Mussels, Baby Scallops, Southern Calamari, Pine Nuts, Currants, Crustacean Pangrattato, Prawn Oil	4 Course Set Menu $135 (Entree, Pasta, Main, Dessert)
Spice Temple		Stir fried prawns with salted duck egg and four chillies Brined, dried, fermented and pickled	$49
		Kung Pao prawns Sichuan peppercorns, heaven facing chillies and cashews	49
		Prawn and scallop spring roll	6 for $24
		Prawn toast with Spice Temple sweet and sour sauce	$16
		Prawn wontons with black vinegar and chilli	8 for $29
Long Chim	corner Pitt Street & Angel Place, Sydney CBD	DRIED PRAWNS GINGER TOASTED COCONUT betel leaves	$8/two pcs
		กุ้งฝอยแพทอดกับสมุนไพร CRUNCHY PRAWNS herbs shallots chillies	$22 Starter
		BAKED PRAWNS WITH GLASS NOODLES	$34

		PAD THAI prawns peanuts bean sprouts	$34
		MASHED PRAWN CURRY coconut turmeric	$38
		Plus 3 other prawn + pork or Prawn + fish dishes	
ACME			
Felix	2 Ash St, Sydney CBD	Prawns 200g	$25
		Sauteed garlic prawns Provencal	$23
Hubert	15 Bligh Street, Sydney	Le Petit Aioli Seasonal vegetables, Clarence River prawns & garlic aioli	$32 starter
North Bondi Fish		Prawn sanga | coastal rocket mayo, pickles	$16ea
Flying Fish	Pirramima Rd, Pyrmont	King prawns, nashi pear, radish, whipped cod roe	$35
		Tidal bisque of shellfish, prawn, mushroom & corn	$40
The boathouse on Blackwattle	123 Ferry Rd, Glebe,	Roast Clarence River King Prawns Tarragon & Cider Butter	$29
Ms G's	Potts Point	Royal Red Prawns with kimchi, buttermilk dressing	$22
		Prawn toast kiev	$7
The Fish Shop	Potts Point	School Prawns flash fried and served with a smoked garlic mayo	$19
Bondi's Best	Hall St, Bondi	Prawn San Choy Bow with fennel, tobiko, spicy mayo, sweet soy sauce	$14/2 pieces – add extra$7 per piece
		Prawn cocktail, iceberg salad, cocktail sauce, lemon	$20
		Plus types sushi rolls; tempura	

Restaurants without prawns on Menu

- Pilu
- Sixpenny
- 4Fourteen
- Automata
- Porteno

Initial product assessment of Royal Red Prawns (9th August 2018)

Product assessment	General	Positives	Negatives
Appearance			
General			Damage to the shell and body 30% have black heads (looks old)
Colour		Lovely pink/red colour	Discoloured heads make display whole unsuitable option
Size		Small size, great for deep frying	Small size not suited to buffet or whole product e.g. platter or bucket of prawns
Shell		Fine shell that crisps well at high temperatures. The tail can be eaten shell on. Best deep fried or high temp pan/grill	Fine shell makes peeling time consuming Dull / rough textured shell lacks the lustre of other species of green prawns for whole product display.
Handling			
Storage			Large block frozen Have to smash/damage or thaw whole box
Preparation			
Peeling			Peeling is time consuming due the small size
Flavour:			
Sweet		Very sweet similar to fresh school prawn or	
Salt		Good natural level	
Ammonia		None detected	
Iodine			Slight
Chemical		None detected	
Texture:		Softer than King prawn Tender	Meat is lacking crunch or bite

Product assessment	General	Positives	Negatives
Whole:	Appearance, black head and dull, loose shell detracts (potential for IQF product only)		
Tail (shell on):	Small dainty prawn suited to mixed seafood dishes e.g. paella, pasta, risotto, curry, bouillabaisse	Tail fans crisp nicely and are fine enough to be consumed	
Meat:	Good colour Lots of applications using minced meat		
Shells:	Clean sweet taste makes them a viable option to create prawn products/ ingredients	Make excellent stock, flavoured butter or oil	

Cookery Method Performance Testing	Method	Positive	Negative
WHOLE			
Boil	3L water + 20ml salt For 2 minutes Refresh in ice water	Flavour: sweet, pleasant, umami Texture: moist, med- soft Appearance: pleasant rosy pink colour	Low Yield; 250 = 91g meat = 36.4 % Appearance: damage broken, drop heads, loose shells Handling: time consuming to peel.
Steam	3 min	Flavour: sweet, pleasant, umami Appearance: pleasant rosy pink colour	Low Yield; 200g = 73g meat = 36.5% Appearance: damage broken, drop heads, loose shells Handling: time consuming to peel. Texture: drier & firmer than boiled, med- soft
PRAWN TAIL – SHELL ON/HEAD OFF			
Charcoal grill	N/A		
Flat grill - plancha	Preheat heavy (cast iron pan) until smoking hot. Coat shell on prawn tails in olive oil Add to hot pan – single layer only, spaced out well. Cook 30-45 seconds turn and cook second side Do not stir during cooking	Texture: shells browned nicely and crisped. Fine shells can be eaten when cooked at very high heat.	

Cookery Method Performance Testing	Method	Positive	Negative
Deep fry – dusted / crumbed / tempura / wonton	Remove heads Dust with seasoned tapioca flour mixed with semolina Deep fry 180c	Excellent clean sweet flavour. Thinner shells than school prawns of similar size.	
Sous vide	N/A		
PEELED – tail fan on			
Poach – Simple tomato sauce (pasta)	Add prawn tails to simmering sauce Cook for 1 min, stirring occasionally	Flavour: good, slightly overwhelmed by tomato Texture: medium - soft	
Pan Fry – sautee, stir fry	Preheat pan over medium heat Add clarified butter Cook 30 seconds each side	Good browning achieved The addition of fat Tail fans crisped up nicely Great presentation	
PEELED			
Puree	Minced in food processor		
Mousseline – boudin > poach, ravioli, timbale,	Made mousseline, formed into sausage and poached 80c 1:1 prawn mince : cream	Soft light texture Mild sweet flavour	
Mince – wonton, ravioli, prawn cake, croquette, potted prawns	Added small amount of cream and flavourings Filled wonton wrappers into ravioli Simmer for 3 min.	Excellent result Great texture and flavour	
Raw – tartare, escabeche	N/A will review once sashimi grade is available		
SHELLS/HEADS			
Stock	400g prawn shells & heads 1200g water Bring to boil > simmer 15 min Strain		
Prawn oil	Would expect the same/similar results		

Cookery Method Performance Testing	Method	Positive	Negative
Prawn butter (value added product)	75g prawn heads + 75g butter + ¼ teaspoon salt Simmer in a pot on low for approx. 5 min. Strain through fine sieve, mashing with a ladle to extract prawn	Flavour: Creamy sweet pronounced prawn flavour, nutty tones. Colour: rich orange crustacean colour Applications: use to enrich bisque, pasta sauce or glaze top of a fish portion	
Prawn dust	N/A		
BRINING	N/A		
SOUS VIDE	N/A		

Cooking trials, Brisbane – Royal Red Prawns (3rd September 2018)

Product assessment	General	Positives	Negatives
Appearance			
General	More than 30% had blackened heads Blackened prawn juices in the base of the box. A large number prawns were squashed and damaged		
Colour	More than 30% had blackened heads		
Size	More consistent than initial product assessment	Consistent size	
Shell	Loose		
Handling			
Storage	The centre of the box had most blackening		
Preparation			
Peeling			
Flavour:			
Sweet	Mild prawn flavour, low umami		
Salt	Good levels		
Ammonia	Very slight		
Iodine	Occasional		
Chemical	Soapy aftertaste on the front of the tongue		
Texture:			

Product assessment	General	Positives	Negatives
Whole:	Not suitable		
Tail (shell on):			
Meat:			
Shells:	Not suited to cooking, due to extensive blackening		

Cookery Method Performance Testing	Method	Details to explore	Results
WHOLE			
Boil	N/A		
Steam	N/A		
PRAWN TAIL – SHELL ON/HEAD OFF			
Charcoal grill	N/A		
Flat grill – plancha	- Preheat heavy (cast iron pan) until smoking hot. - Coat shell on prawn tails in olive oil - Add to hot pan – single layer only, spaced out well. - Cook 30-45 seconds turn and cook second side - Do not stir during cooking	Temperature; smoking hot pan Cooking time; 1 minute approx. per size of prawns	- Appearance; good, shells browned well - Taste; shells assist in boosting flavour - Texture; shell on is good, crisps up nicely and is pleasant to eat
Pan fry	- Preheat heavy based pan over medium - Add clarified butter - Add prawns in a single layer - Turn once	Can shells still be eaten	- Appearance- good caramelisation - Flavour -butter enhances the nutty sweetness of prawns - Texture- the shell is still edible and pleasant
Stir fry	- Preheat heavy (cast iron pan or wok) until smoking hot.	Can shells still be eaten	- Appearance- good caramelisation - Flavour- flavour is good

Cookery Method Performance Testing	Method	Details to explore	Results
	- Add rice ran oil - Add prawns and cook, stirring constantly		- Texture- the shell is still edible and pleasant
Deep fry – dusted / crumbed / tempura / wonton	- Dust with a range of flours - Stand 2 minutes then shake off excess flour - Deep fry 1 minute @ 185c NB: unable to explore higher temperature cooking due to small domestic size and inadequate heat in the fryer.	Temperature: 185c 1. Corn flour 2. Rice flour 3. Tapioca flour 4. Tapioca + semolina 100:30 5. Rice + semolina 100:30 6. Gary Penzone's product (No. 5 coating)	1. Crisp – dry white coating, starchy flour taste 2. Very crisp, clean crunchy result, good colour 3. Crisp – but starchy, slightly less than cornflour, improved 4. Crisp but still some starchy taste 5. Best result, crisp and holds texture well, no starchy taste, good colour 6. Outstanding presentation due to quality handling, but lacking flavour due to age.
PEELED – tail fan on			
Poach – Simple tomato sauce (pasta)	N/A		
Pan Fry – sautee, stir fry	N/ A		
PEELED (deveined)			
Sous vide	- Cure in 1:1 cooking salt and sugar for 5 min Rinse off cure, dry - Vac pack with, Olive oil, lemon zest Sous vide 2 ½ minutes @ 90c	Temperatures were gradually increased from 70c to 90c. (V1 > V5)	- Flavour- the cure added deepened prawn flavour, the olive oil and lemon notes came through as well. - Texture-the higher temperature achieved the most bite and desirable firmness. - Appearance-At higher temperatures (V5) the roe was cooked to a pink coral colour. - Low temperatures resulted in dark purple/grey roe.

Cookery Method Performance Testing	Method	Details to explore	Results
Puree	Minced in food processor		
Mousseline – boudin > poach, timbale, quenelle or possibly soufflé	- Made mousseline, formed into sausage and poached 80c - 300g prawn mince : 200ml cream + egg + seasoning - Formed into sausage in cling film - Poached @ 80 for 8-10 minutes (per size)	Demonstrate recipe Assess viability for mince	- Texture-Very light soft texture - Flavour- rich, clean prawn taste - Colour – pale pink coral
Mince – wonton, ravioli, prawn cake, croquette, potted prawns	- Added small amount if cream and flavourings - 400g Prawn: 75g cream + egg white + seasoning - Filled wonton wrappers into ravioli - simmer for 3 min.	Demonstrate recipe Assess viability for mince	- Texture- medium to firm texture - Flavour- rich, clean prawn taste - Colour – pale-medium pink coral
Raw – tartare, escabeche	N/A will review once sashimi grade is available		
SHELLS/HEADS			
Stock	- 500g prawn shells & heads : 1000g water - Bring to boil > simmer 15 min - Strain	Demonstrate recipe Assess viability for shells/heads	- Colour - Due to black heads and shells the colour brown grey - Flavour was dull and lacking
Prawn oil	- 500g prawn heads and shells + 250g Olive + 250g rice bran - Simmer in a pot on low for approx. 5 min. - Strain through fine sieve, mashing with a ladle to extract prawn		- Due to black heads and shells the colour brown grey - flavour was dull and lacking
Prawn butter (value added product)	- 500g prawn heads and shells + 500g butter - Simmer in a pot on low for approx. 5 min. - Strain through fine sieve, mashing with a ladle to extract prawn	Demonstrate recipe Assess viability for shells/heads	- Due to black heads and shells the colour brown grey - flavour was dull and lacking
Prawn dust	N/A		

Appendix 4

Focus group with chefs – questionnaire

Royal red pawns workshop 3rd Dec 2018

Feedback questions from the recipe presentation

What did you like most about the Royal red prawn dishes you tasted today?

Was there anything about the royal red prawns that you disliked?

What cooking methods do you prefer to use when cooking prawns?

In your opinion, what dish or cooking format would be best suited to Royal red prawns?

What would be the key limitation(s) for using Royal red prawns in your menu?

What are you key quality parameters you use to evaluate the quality of prawns for your menu?

If you could purchase this prawn as a frozen ingredient, what would be your preferred pack size and product format?

What would you expect to pay for this prawn in the product format you described in the previous question?

Any final thoughts on the Royal red prawn?

Thank you!

Appendix 5

Royal Red Prawn information sheet for chefs

Royal Red Prawn (*Haliporoides sibogae*)

Description

Available all year round, the Royal red prawn is caught in water all along the NSW coast. However the primary commercial catch is sourced between Port Stephens and Ulladulla.

Size and Weight

Commercial catches are usually mixed sizes. Average weight is 25g and size is 7-10cm. However Royal red prawns can grow to 20cm in length. This places them a little larger than school prawns, but not quite the size of a medium size king prawn.

Seasonality

Available all year round. Spawning peaks from February to April, and again in July and August. Mature females can carry large quantities of eggs which will appear dark blue, and is visible in the rear of the carapace (prawn head) and visible down the back of the prawn. The eggs are stored in the tissue sitting just above the gut line. Mature females carry eggs can often look slightly blackened. However, once cooked the eggs turn orange as per most prawn eggs.

Storage and handling

Although fresh supply can be possible, most supply is now frozen. Frozen storage temperature below -17°C is essential. Royal reds prawns will blacken when exposed to temperatures above -10°C.

Royal red prawns are best thawed under brine immersion (approx. 10% brine) and kept under water until use. This is very similar to instruction for using school prawns.

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Texture and flavour

Royal red prawns have very pleasant and gentle springy texture when cooked. The texture of the cooked prawn is significantly softer than that of more common used species. However they can be easily over cooked which results in a dry and rubbery texture. The shell of Royal red prawns is also very thin. This lends itself well to dishes that do not require peeling of the prawn meat.

Product concept – deep fried Royal red prawns (shell on).

Royal red prawns have a very thin shell. This means the shell can be left on for deep frying and can be easily eaten without overcooking the prawn meat. This fact also means the prawn can be deep fried direct from frozen. For best results use with a coating of rice flour and semolina. For a starting point try deep frying for 1 minute at 185°C.

The Royal red prawn shell is also thin enough tom simply pan fry in a little oil and consume shell on.

Product concept – Royal red prawn ravioli

Royal red prawns can make a great option as an ingredient in a pasta filling. The flavour of the prawn is such that a small amoun t of meat can add significant flavour to the dish.

Royal red parwn could also be added to more common prawn species meat to add length and roundness to the flavour profile.

Product concept – Sous vide

Royal red prawns make an excellent sous vide product. However due to the presence of the polyphenol oxidase enzyme, lower temperatures cooking can impart a dark colour in the meat. For best results, cure in a 1:1 mix of cooking salt and sugar for 5 minutes. Rinse off and pat dry, then place in a vacuum bag with olive oil and lemon zest. Sous vide for 2 ½ minutes at 90°C.

Contact

Any further questions please contact Andrew Forrest on the contact details below.

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