NATIONAL SEAFOOD CENTRE

Evaluation of the Cooking Process on Aquacultured Giant Tiger Prawns (Penaeus Monodon)

CRAIG WINKEL

NSC 97/485

Commissioned by: A Raptis and Sons Pty Ltd
90 Colmslie Road
Colmslie Qld 4170

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

CENTRE FOR FOOD TECHNOLOGY

QUEENSLAND GOVERNMENT

DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

CONTENTS

ACKNOWLEDGEMENTS

D Leighton, Technical and Processing Assistant.
N Herbst, Gold Coast Marine Hatcheries.
D Herbst, Gold Coast Marine Hatcheries.
P MacNamara, Ayr Prawn Farm.

EXECUTIVE SUMMARY

This report outlines an operational procedure for the cooking of *P.monodon*. It discusses critical control points within the process and gives an indication of best practices. The work conducted should be considered as a snap shot of the process and used as a starting point for further investigation. Appendix 6 is a flow chart of the process from cooking to brining outlining critical controls and recommended procedures. Many areas that may assist in increasing recoveries or quality of the cooked product require further investigation.

The highest quality prawns were produced when the product was heated to an 85°C core temperature. The prawn basket should be agitated to prevent uneven heating, thus reducing the potential for under and/or over cooking of individual prawns. Appendix 1 represents a summary of the results from the cooking process.

When prawns were cooked to a core temperature of 85°C and stored at 4°C, a shelf life of 10 days was achieved. A reduction in quality was apparent between day 7 and 10. At 14 days, the prawn flesh was greater than the microbial limits set by the Food Standards Code. At an abuse temperature of 10°C, the shelf life was reduced to a maximum of 5 days. The shelf life results are tabulated in Appendix 5.

An initial wash (cooling stage 1) in ambient water (25°C ±5°C) for 3 to 4 minutes is sufficient to reduce the temperature to within 5°C of the water temperature. The length of time needed in the chilled water (cooling stage 2) was directly dependant upon the size of the prawns with 7 minutes being the time required for the 16/20 product to reduce to a core temperature of 10°C. No significant time reductions were achieved by agitating the prawns in the chilled water.

Only small changes occurred in the drain weights between prawns soaked in fresh water and those soaked in a 3% ice brine. Taste differences were detected between prawns soaked in 0% and 1.5% or 3% salt. Customer preference would likely play a more important role in the salt concentration of the brine over the potential gains in recovery.

Further work on the handling of prawns pre-processing and the investigation into alternative cooking methods may yield some interesting results that could be of significant benefit to the industry.

INTRODUCTION

A Raptis and Sons Pty Ltd acquired assistance through the National Seafood Centre to evaluate and produce a cooking procedure for aquacultured giant tiger prawns (*P.monodon*). A Raptis and Sons Pty Ltd commissioned the Centre for Food Technology to conduct this work. Cooking was achieved by boiling the prawns in a standard 120-litre prawn cooker using gas flame heating.

Aquaculturally harvested giant tiger prawns are graded into 3 sizes - small (30/40 per lb), medium (20/30 per lb) and large 16/20 per lb). Larger prawns are grown but generally sold raw.

AIMS

1. To conduct cooking trials.
2. To produce a report outlining a standardised cooking procedure.
3. Document changes in yields at varying cook times and brine levels using the above procedure.
4. Outline critical control points within the procedure.
5. Compare the quality of cooked prawns at varying cook times/core temperatures.
6. Assess cooked prawns for shelf life.

METHODOLOGY

A literature search and an investigation of 2 Aquaculture farms producing cooked prawns on a commercial scale was used to determine the time and temperature parameters for this trial. An initial cooking trial was conducted to establish the core temperature required for prawn flesh to be cooked to prevent blackspot. Prawns were heated to core temperatures between 70°C and 80°C at 2-degree increments. The prawns were stored for 5 days at 4°C to determine if blackspot occurred. Blackspot was seen to occur at 70, 72 and 74°C with minor darkening of the carapace at 76°C. A 75°C core temperature was chosen as the starting point with increases to 80°C and 85°C for subsequent cooks.

The procedure used in the cooking trials was as follows:

1. Pre-graded prawns were drained for 10 minutes and weighed out into 16kg batches (±0.05kg).
2. Thermocouples were inserted into the centre of the flesh in the second abdominal segment of 8 prawns and into the centre of the head of 3 prawns. The thermocouples were inserted through the belly and held in place with rubber bands. Prawns were weighed to ± 1g of the maximum weight in each grade. Initial core temperatures were equilibrated to 20°C (± 3°C) with one exception where the core temperature was 14°C. Probed prawns were placed in different positions throughout the cook basket. Thermocouples were checked for accuracy in ice and boiling water. All were within ±1°C.
3. The cooker was filled with 80 litres of fresh water giving a 5 water:1 prawn ratio. The water was vigorously boiling when the prawns were placed into the cooker. Two thermocouples were used to record the water temperature: one at the surface the other in the middle of the prawns.

4. Prawns from each grade were cooked to core temperatures of 75°C, 80°C and 85°C. Prawns were removed when the last thermocouple reached the desired temperature. Temperatures were recorded using a temperature analogue every 5 seconds. Duplicates of each cook were made. The water in the initial cook was agitated, the duplicate cooks were not. Gas pressure (kpa) was monitored with a minimum pressure of 120 kpa permitted. Gas pressure below 120 kpa would possible increase the time for the water to return to the boil.
5. When the final cook temperatures were reached the product was removed from the cooker and placed into a water bath. The water temperature was 26°C ±4°C. The basket was agitated to simulate washing and core temperatures were recorded every 5 seconds for 5 minutes.
6. Product was removed from the water bath into another of chilled water. The water temperature was 2°C ±2°C. Temperature was monitored until the last probe recorded 10°C. The initial trials were in fresh water and the basket was agitated, duplicates were in a 3% salt solution and basket was not agitated.
7. Once the core temperature reached 10°C the prawns were removed and a 10-minute drain weight was recorded.
8. From each of the initial cook trials 3 samples of approximately 5 kilograms were weighed. One sample was held in fresh water, another in 1.5% brine and the final in a 3% brine. After 20 hours, 10 minute drain weights were recorded. Solutions were made of 50% water 50% ice and stored in a chiller at 4°C.
9. Samples from these trials were collected and stored in a chiller to assess weight loss over time. Ten-minute drain weights were recorded after 1, 4 and 10 days.

SHELF LIFE EVALUATIONS

Prawns from the initial trials of each grade were evaluated for shelf life and tested for coliforms and coagulase positive staphlococci. Sensory assessments and microbial analysis were conducted over 14 days on prawns that were stored at 4°C and 10°C. Additional product was held in chilled water and stored at 4°C to compare against the shelf life product.

The 20/30 prawns that were cooked to a core temperature of 85°C and soaked for 20 hours in 0, 1.5 and 3% salt solutions were subjected to a triangle test to determine if a significant taste difference was detectable between these samples. The panel consisted of 12 untrained staff. These prawns were also analysed for salt content of the flesh (%NaCl).

RESULTS

Appendix 1 contains a summary of each trial. The figures relate to the limiting factor at each stage i.e., the last probe to reach the required cook temperature or the last probe to record 10°C during cooling stage 2. All weights were recorded after a 10-minute drain. Appendix 2 shows the graphed temperature changes of the prawns through the cooking and subsequent cooling stages.

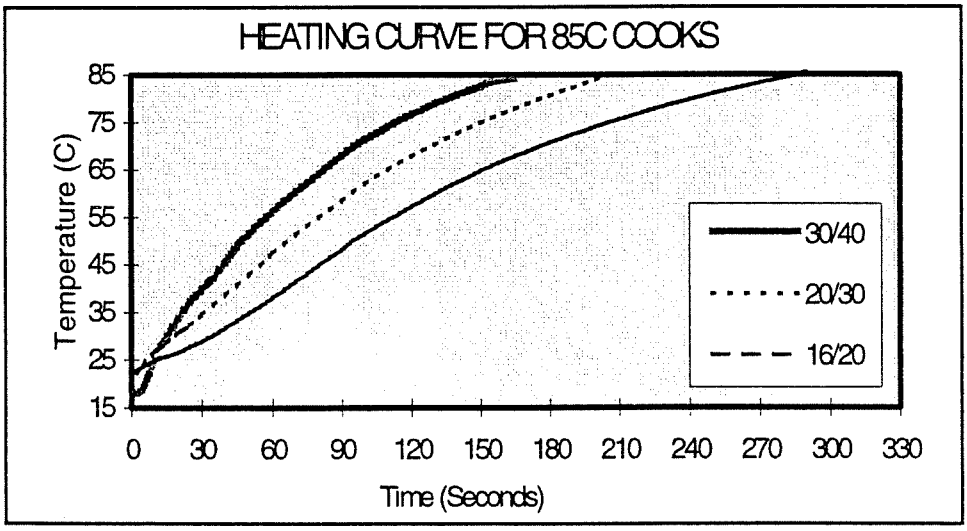
COOK TRIALS

Table 1: Recommended cook times for each grade to reach a core temperature of 75°, 80° and 85°C

Grade	16/20	16/20	16/20	20/30	20/30	20/30	30/40	30/40	30/40
Temperature °C	75	80	85	75	80	85	75	80	85
Time required when basket agitated	3:30	4:15	4:55	2:35	2:55	3:35	2:00	2:15	2:40
Age of Prawn (Days)	1	1	1	2	2	2	2	2	2
Time required when basket not agitated	N/a	N/a	N/a	3:11	3:45	4:11	2:15	3:05	3:20
Age of Prawn (Days)	N/a	N/a	N/a	23	3	3	3	3	3

When the basket was agitated a quicker and more even heating occurred. (See Appendix 1). In the 20/30 and 30/40 trials where the basket was not agitated the prawns tended to float within a minute of the commencement of cooking and were only partially submerged. This may have contributed to the large variation in core temperatures. (Age of the prawns and precooking treatment may have attributed to this).

Figure 1: Heating profile of prawns being cooked to a core temperature of 85°C



The water temperature surrounding the prawns was initially 3°C to 5°C less then the water temperature at the surface. This rose rapidly to within 1 degree of the surface temperature in the trials where the baskets were agitated. (See Appendix 2). In several trials where the baskets were not agitated (trials #2) the water temperature surrounding the prawns remained lower then the water temperature at the surface throughout the entire trial.

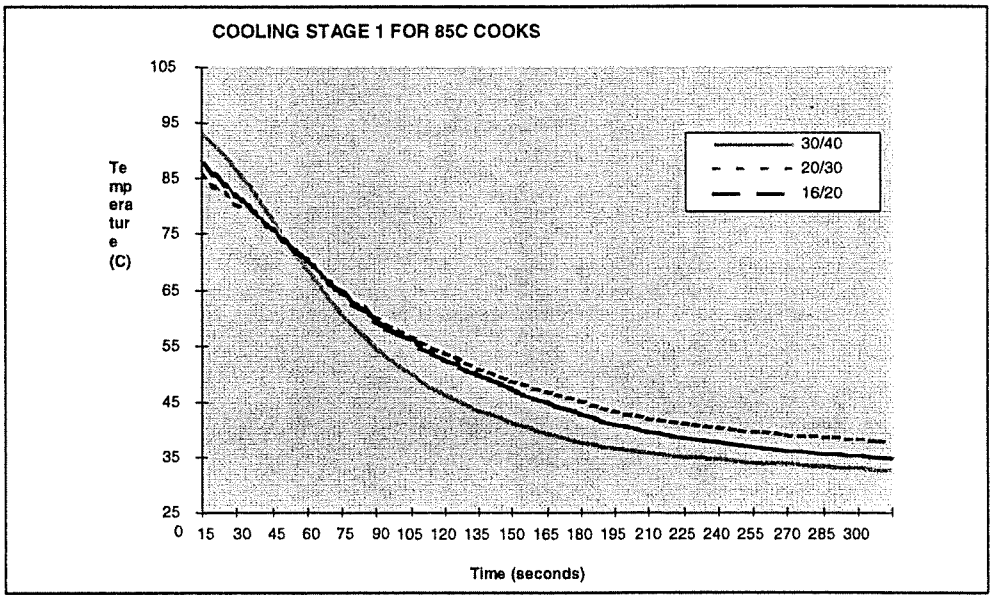
The water temperature rarely reached 100°C by the time the required core temperature was achieved. In most cases, the water temperature fell from 100°C to 90°C ±2°C at the commencement of the cooking trial and rose steadily to ≥96°C by the time the desired core temperature was reached.

Within 30 seconds of placing the baskets into the cooker ≈93°C water temperature, strong convective currents were observed suggesting a temperature differential between the bottom and surface temperature.

COOLING STAGE 1

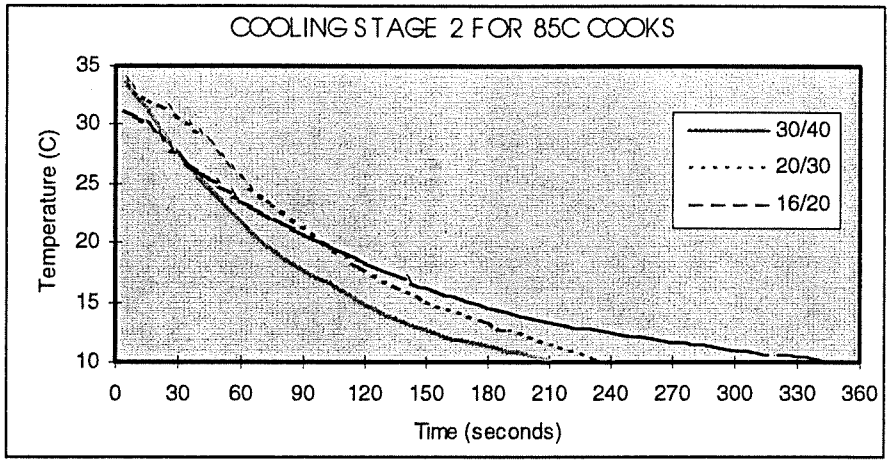
Figure 2 is a graph of the typical cooling curve during stage 1. All core temperatures reduced to within 5°C of the water temperature in the 5 minutes of recording (refer to Appendix 1). Cooling rates suggest that the prawns could be removed to the chilled water tank (cooling stage 2) after 3 minutes. The smaller 30/40 prawns even earlier.

Figure 2: The change in core temperatures during cooling Stage 1
* water temperature 25°C



COOLING STAGE 2 - CHILLED WATER

Figure 3: Changes in the core temperatures during cooling stage 2



There were no obvious differences in the rate of cooling between agitated and non-agitated product. Times required for the temperatures to reduce in each cook varied considerably, the 30/40 prawns having the fastest cooling rate and the 16/20 the slowest. A minimum time of 4, 5 and 7 minutes would be the required in a chilled water tank for the 30/40, 20/30 and 16/20 prawns to be reduced to a core temperature of 10°C respectfully. Little benefit would be achieved by prolonging this time if the chilled water is around 5°C.

DRAIN WEIGHTS POST COOKING

Ten-minute drain weights were recorded immediately after the second cooling stage. The trials on the 16/20 prawns could be considered the closest to actual production as the product was cooked within a few hours of harvesting. The combined drain weights of trials 1 and 2 for each cook temperature gave the following recoveries: 100% at 75°C, 98.5% at 80°C and a 96.6% recovery when the core temperature was heated to 85°C. This suggests that there is a loss factor with increase in cook time/core temperature (see Table 2).

The drain weights for the initial trials to core temperatures of 75°C, 80°C and 85°C in the 20/30 and 30/40 grades showed very small increases during the cooking and subsequent cooling stages. The handling of this product prior to the trials may have influenced these results. The prawns were stored for 2 days in eskies under chilled conditions. Some ice was layered over the surface of the product. Inspection prior to the trial showed that only a small amount of ice had melted and the prawns appeared dry. The eskies were opened and the prawns placed into fresh water to remove the ice prior to cooking. The duplicate cooks were conducted the following day after the product was held in a 1% ice brine overnight. The duplicate trials all showed considerable weight loss, again the cooks to the higher core temperatures having the greatest loss (see Table 2).

Table 2: Weight recoveries after cooling stage 2

Product	Cook Temperature	Cooks	Input	Output	Recovery %
16/20	75	1 & 2	32020	32030	100
	80		32110	31650	98.5
	85		31870	30780	96.5
20/30	75	2	16010	15120	94.5
	80		16010	15070	94.1
	85		15990	14550	91.0
30/40	75	2	14610	13970	95.6
	80		16000	15230	95.2
	85		16050	15080	93.9

DRAIN WEIGHT POST 20 HOUR SOAK

Batches of approximately 5kg from the initial trials of each grade were weighed prior to and after 20 hours immersion in solutions of different salinities. Results indicated no significant changes with the maximum variation from pre-soak to post-soak weight of 1.45%. (see Appendix 1). In all cases, there was a loss where product was held in a 3% salt solution. Five of the 9 trials where the product was held in 0.0% or 1.5% salt solutions showed a slight gain.

DRAIN WEIGHTS UNDER CHILLED STORAGE

Weight changes of product cooked to varying core temperatures were briefly examined. Prawns were held on ice in a chiller and 10-minute drain weights were made on days 1, 4 and 10. A continual loss in weight over the 10 days occurred (see Table 3). The smaller 30/40 prawns had a loss of up to 5.5% after 10 days, this appeared to be less in the larger grades. No obvious difference occurred in the drain weights of the products cooked to varying core temperatures .

Table 3: Changes in weight of cooked product over 10 days in chilled storage

Grade	Cook Temperature	Weight day 1	Weight day 4	Weight day 10	Recovery %
16/20	75	638	N/a	613	96.1
16/20	80	937	N/a	900	96.1
16/20	85	596	N/a	587	98.4
20/30	75	508	497	491	96.6
20/30	80	503	499	489	97.3
20/30	85	504	497	489	96.9
30/40	75	507	494	480	94.6
30/40	80	508	506	494	97.2
30/40	85	499	486	472	94.5

TASTE DIFFERENCE

A triangle test was used to determine if a taste difference was noticeable in the prawns after soaking in different amounts of salt.

Table 4: Results from triangle test - Number of panellists = 12

Test	Result	Probability
0% salt against 1.5%	11/12	0.005
0% salt against 3.0%	9/12	0.001
1.5% salt against 3%	5/12	significant

An example of the questionnaire is in Appendix 3. Table 4 indicates that a significant difference was perceived between the prawns soaked overnight in fresh water and those in 1.5 and 3% brine, however, no noticeable taste difference was observed between the 1.5 and 3% solution.

The salt content was analysed in the flesh in the above products. Analysis of cooked prawns soaked overnight in brine from a local processor and raw prawn immediately after harvesting were also made (see Table 5).

Table 5: Salt content in the flesh of cooked and raw prawns

Percentage salt in solution	State of flesh	Salt content of prawn meat (g/100g)
0.0	Cooked	0.2
1.5	Cooked	0.5
3.0	Cooked	0.6
5.5	Cooked	1.1
-	Raw	0.3

SHELF LIFE

A freshness score sheet developed for cooked *P. monodon* by A.Reilly (Tropical Development and Research Institute - London) and M.A. Bernarte and E. Dangla (Department of Fish Processing Technology - Philippines) was used to evaluate the acceptability of the prawns over the shelf life trial. (see Appendix 4). The cooked samples were rejected principally on account of fishy, sulphurous and ammonia type flavours and odours.

Microbial analysis was conducted to compare to the sensory findings. Standard plate counts were determined for both 10°C and 4°C product on days 1, 4, 7, 10 and 14. Psychrotrophic counts were conducted on product stored at 4°C on days 10 and 14. Counts of *Escherichia coli* and coagulase positive *Staphylococci* were made on day 7 to compare with the microbiological standard for the flesh of cooked crustaceans (ANZFA

Food Standards Part D1) (10d). The results of the shelf life trials are in Appendix 5. Most prawns cooked to a core temperature of 75°C displayed blackening within 48 hours. Product cooked to an 80°C core temperature showed some minor blackening in the larger slightly out of grade product. Around day 5, some browning of the carapace particularly around the gill region occurred in the prawns cooked to a core temperature of 80°C. Again this was most obvious in the larger prawns. Prawns cooked to an 85°C core temperature were visually acceptable even after the product was deemed rancid.

Prawns stored at 4°C were edible 10 days after cooking, although a loss of flavour was apparent and a slight ammoniacal odour present. Prawns held at 10°C were deemed inedible at 7 days. At 5 days the product had lost its characteristic sweet flavour and had a mild ammoniacal odour.

DISCUSSION AND CONCLUSION

This report outlines an operational procedure for the cooking of *P.monodon*, it discusses critical control points within the process and gives an indication of best practices. The work conducted should be considered as a snap shot of the process and used as a starting point for further investigation. Appendix 4 is a flow chart of the process from cooking to brining outlining critical controls and recommended procedures.

Precooking procedures require further investigation as to the best practices. It may be ventured to say that 3 precooking treatments were examined during the trials, one of prawns cooked within several hours of harvesting where progressively greater losses occurred with trials to higher core temperatures. In the second, prawns were chilled for 2 days prior to cooking and showed no obvious loss during any of the subsequent trials. In the third, prawns were held in a 1% brine for a minimum of 15 hours and showed considerable losses during cooking becoming progressively greater in trials at higher core temperatures. Initial weights pre and post soaking were not recorded but an increase would be expected. At present, prawns are generally harvested, washed, stunned in chilled water, graded, weighed and cooked. An improved yield may be achieved by holding prawns in fresh water prior to grading allowing an uptake of water as is traditional in the crayfish industry. A literature search did not find any information to give an indication of possible end results.

Boiling prawns to a core temperature of 75°C was sufficient to cook the flesh but did not prevent the development of blackspot. This occurred within 48 hours in the lower head regions, around the first and second pleopods and at the base of the legs. At 80°C core temperature, very minor blackspot appeared in the lower head region of a few of the larger prawns. No blackspot occurred where prawns had been dipped precooking in an antioxidant. The head did darken around the gill region of the larger 16/20 prawns to a light brown/red colour after 5 to 7 days. This was most noticeable when prawns were compared to product cooked to 85°C, which showed no blackspot or discolouration even when product had become putrid.

To achieve the fastest most even cooks it is recommended that the cook water is brought to the boil. The baskets are then submerged and agitated at least initially. Recommended cook times to achieve an 85°C core temperature when the baskets are agitated. In a 5:1 ratio, water to prawns with a minimum gas pressure of 120kpa are:

16/20 - 4:55 minutes
20/30 - 3:35 minutes
30/40 - 2:40 minutes

If the baskets are not agitated then cook times to an 85°C core temperature are outlined in Table 1 of the result section. If the prawns are consumed within 5 days when held at chilled temperatures of 4°C or below and an antioxidant treatment is used, the final core temperature during cooking could be reduced to the 80°C (see Table 1). Tests on taste differences of cooked product treated with an antioxidant compared to those untreated have not been examined. For information on treatments see an article by S.Slattery (Meta dipping most effective for blackspot. Australian Fisheries v.42, No.4, pp.825-826.).

The initial cooling stage in ambient water (26°C ±4°C) should be for at least 3 minutes prior to placing the product into a chilled water tank. After 3 minutes the rate of cooling decreases rapidly at approximately 4 minutes temperature plateaus. A minimum of 4, 5 and 7 minutes is required in a chilled tank for the 30/40, 20/30 and 16/20 prawns to drop

to 10°C respectively. Little benefit would be achieved by prolonging soak times if the chilled water is around 5°C. As no significant time differences occurred between agitated and non-agitated baskets and the time required for the temperatures to reduce is short, the benefits of having a circulating system may not equal the costs.

Little variation occurred in the drain weights of the prawns soaked overnight using different salt concentration within an ice slurry. Prawns soaked in a 3% salt solution did display a loss whereas minimal gains could be expected if soaking in fresh water. Taste differences were detected between product soaked in fresh water and those in a salt solution but as the gains are small, catering for a customers taste preference would be recommended. Chemical analysis of the tested product confirmed an increase in the levels of salt absorbed by the flesh with an increase in salt within the solution. Levels of absorption between the prawns soaked in a 1.5 and 3% solution was small. There was no significant taste difference between these samples. Commercially processed prawns had levels as high as 1.1% salt after soaking overnight in a 5.5% salt solution.

A shelf life of 7 days at a chilled temperature of 4°C produced only small changes in the flavour, odour and texture. Microbial levels were also very low (total counts around 1000 cfu/g). By day 10, a noticeable reduction in quality occurred with an increase of microbial levels to the vicinity of 100 000 cfu/g and the presence of a slight ammoniacal odour. Although the prawns were still edible the sweet, firm and juicy flavour and texture was replaced by a bland flavour and slightly dry texture. Counts of *E.coli* and Coagulase Positive *Staphylococci* were very low and well within the Australian Standards. Product stored for 14 days were above the microbial limits and produced undesirable odours and an offensive flavour.

At the abuse temperature of 10°C, the prawns were still acceptable after 5 days but of poor quality. By day 7, most product was unacceptable in both sensory and microbial assessments.

Additional product was held in brine at 4°C for 10 days. Visual and microbial assessments suggested the prawns were in good condition but the flesh appeared to have absorbed a freon type flavour and were not considered desirable.

APPENDIX 1: Cook Trials for P.monodon

Cooking

Grade	16/20	16/20	16/20	16/20	16/20	16/20	20/30	20/30	20/30	20/30	20/30	20/30	30/40	30/40	30/40	30/40	30/40	30/40
Weight range probed product	29-31g	29-31g	29-31g	29-31g	29-31g	29-31g	21-23g	21-23g	21-23g	21-23g	21-23g	21-23g	14-16g	14-16g	14-16g	14-16g	14-16g	14-16g
Initial Temperature	21-23C	20-22C	21-23C	19-22C	22-24C	18-21C	18-19C	14-17C	18-19C	17-19C	17-19C	18-20C	19-21C	18-20C	19-21C	12-16C	19-21C	19-22C
Product agitated	Yes	Yes	Yes	Yes	Yes	Yes	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
% salt in cook	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%
Gas cyclinder Kpa	340	300	440	300	320	280	180	380	200	400	400	400	320	180	300	80	300	380
Raw weight of Prawn in basket	15.99Kg	16.03Kg	16.04Kg	16.07Kg	15.83Kg	16.04Kg	16.00KG	16.01Kg	16.00Kg	16.01Kg	16.03Kg	15.99Kg	16.00Kg	14.61Kg	16.00Kg	16.00KG	16.00Kg	16.05kg
Cooked weight prawns in basket	16.18Kg	15.85Kg	16.06Kg	15.59Kg	15.27Kg	15.51Kg	16.04Kg	15.12Kg	16.08Kg	15.07Kg	16.03Kg	14.55Kg	16.34Kg	13.97Kg	6.30Kg	15.23Kg	16.32Kg	15.08Kg
Probe	H	M	O	M	H	L	J	J	F	I	G	G	K	F	F	J	F	J
Time for core to reach 75 C	3:16	3:30	3:30	3:25	3:28	3:25	2:35	2:35*	2:20	3:11	2:25	2:35	2:00	1:55	1:57	2:13	1:50	1:58
Time for core to reach 80 C	N/a	N/a	4:17	4:13	4:09	4:06	N/a	N/a	2:55	3:45*	2:54	3.01	N/a	N/a	2:17	3:04	2:15	3:05
Time for core to reach 85 C	N/a	N/a	N/a	N/a	4:54	4:56	N/a	N/a	N/a	N/a	3:35	4:11	N/a	N/a	N/a	N/a	2:40	3:20
Temperature range	75-80	75-84	80-89	80-88	85-90	85-91	75-81	75-80	80-85	80-92	85-91	85-91	75-81	75-94	80-87	80-96	85-89	85-94

Cooling Stage 1- Agitation in water at ambient for 5 minutes

% salt in solution	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%
Water temperature (ambient)	27.4C	27.2C	24.2C	27.4C	27.2C	25.9C	29C	22C	28C	22C	25C	21C	26C	24C	31C	26C	29C	25C
Water temperature at 5 minutes	31.8C	35.4C	30.5C	33.3C	33.2C	30.9C	36C	25C	34C	27C	30C	26C	30C	29C	36C	30C	36C	30C
Prawn temperature after 5 minutes	36.7C	38.2C	35.7C	37.6C	41C	36.4C	37C	30C	37C	31C	33C	30C	34C	29C	38C	31C	37C	31C

Cooling Stage 2 - Product into chilled water until temperature reaches 10 C

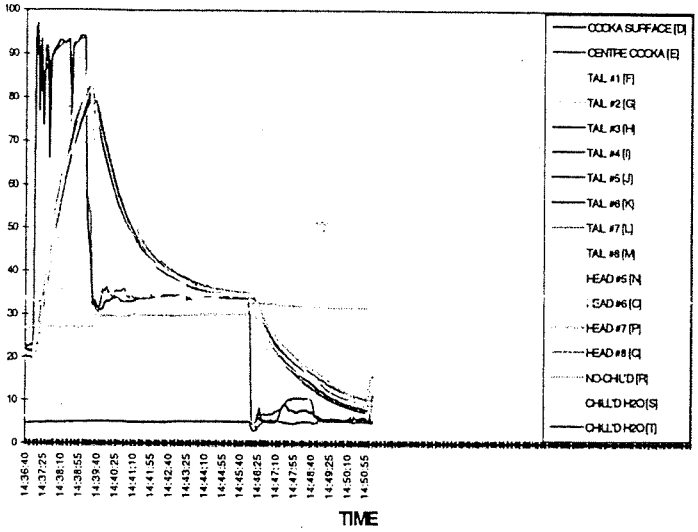
% salt in solution	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%	0.00%	3.00%
Product agitated	Yes	No	Yes	No	Yes	No	yes	no	yes	no	yes	no	yes	no	yes	no	yes	no
Temperature of chilled water	5.3C	3.3C	4.8C	3.2C	5.2C	4.5C	2.0C	2C	2C	1C	3C	1C	3C	3C	2C	3C	3C	3C
Time for product to reach to 10C	6:36	5:23	3:45	6:45	7:07	7:04	4:49	4:47	3:53	5:10	4:25	3:48	4:12	3:20	4:47	3:58	3:38	3:30

Stage 3 - 20 hour soak in ice water / brine

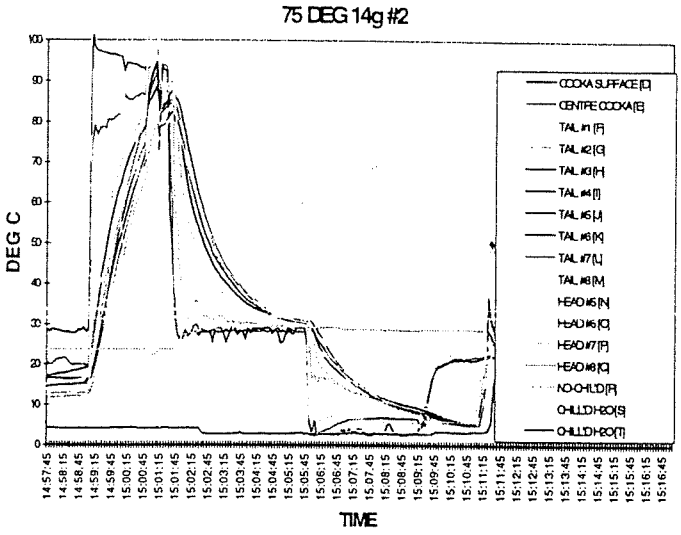
Initial weight into ice water	5050g	N/a	5004g	N/a	5048g	N/a	5013g	n/a	5004g	n/a	5058g	n/a	5009g	N/a	5004g	N/a	5010g	N/a
Final weight after soak	5099g	N/a	4977g	N/a	5093g	N/a	5052g	n/a	5069g	n/a	5101g	n/a	5000g	N/a	4970g	N/a	4988g	N/a
Initial weight into 1.5% Brine	5041g	N/a	4988g	N/a	5036g	N/a	5004g	n/a	5016g	n/a	5052g	n/a	5014g	N/a	5012g	N/a	5003g	N/a
Final weight after soak	5060g	N/a	4952g	N/a	5085g	N/a	5030g	n/a	5018g	n/a	5219g	n/a	5010g	N/a	4958g	N/a	4952g	N/a
Initial weight into 3.0% Brine	5029g	N/a	4980g	N/a	5025g	N/a	5005g	n/a	5002g	n/a	5052g	n/a	5004g	N/a	5002g	N/a	5003g	N/a
Final weight after soak	4996g	N/a	4907g	N/a	5026g	N/a	5059g	n/a	4981g	n/a	5005g	n/a	4942g	N/a	4942g	N/a	4977g	N/a

Appendix 2A

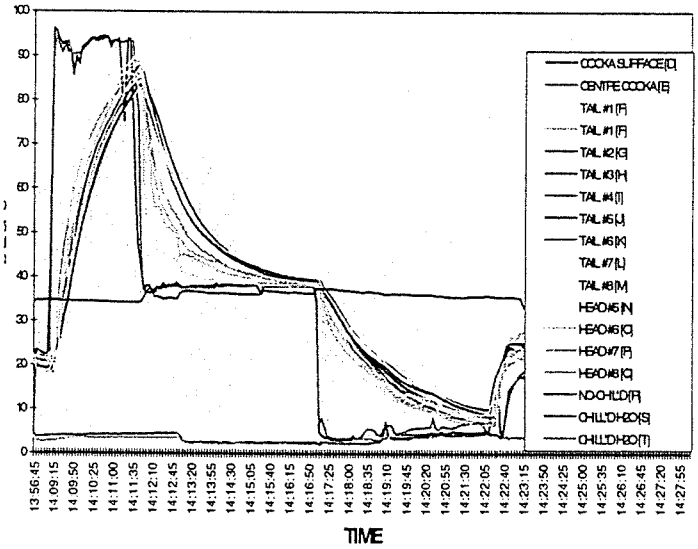
75 DEG 14g #1



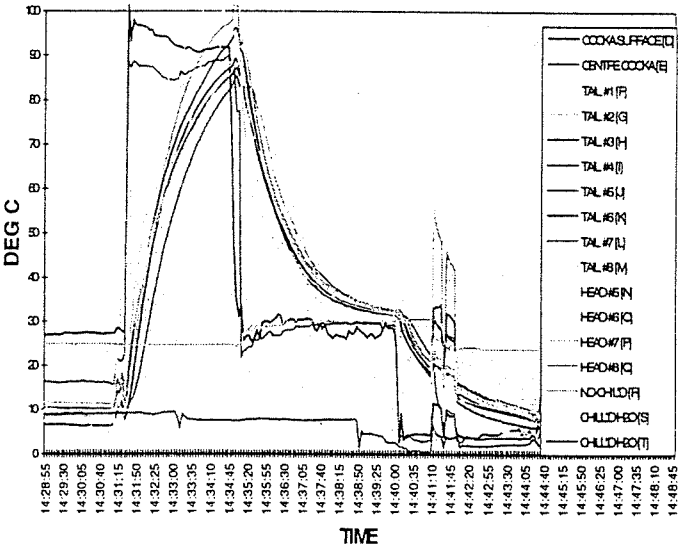
75 DEG 14g #2



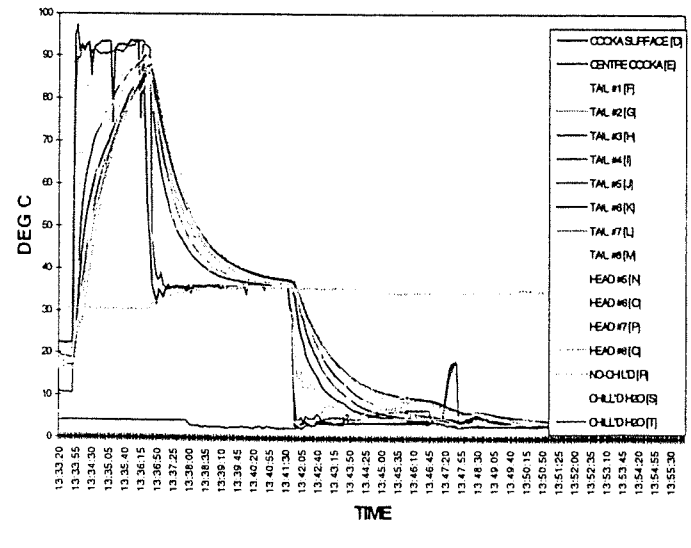
80 DEG 14g #1



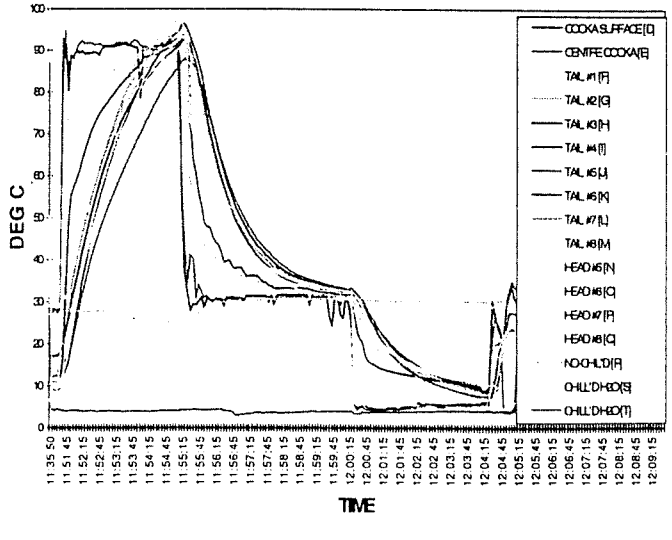
80 DEG 14g #2



85 DEG 14g #1

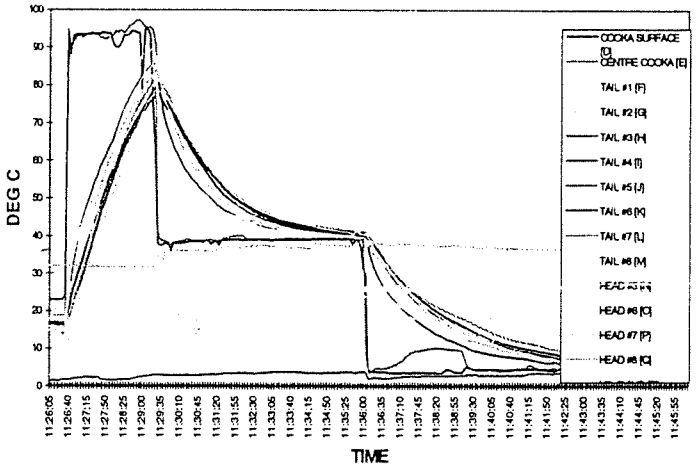


85 DEG 14g #2

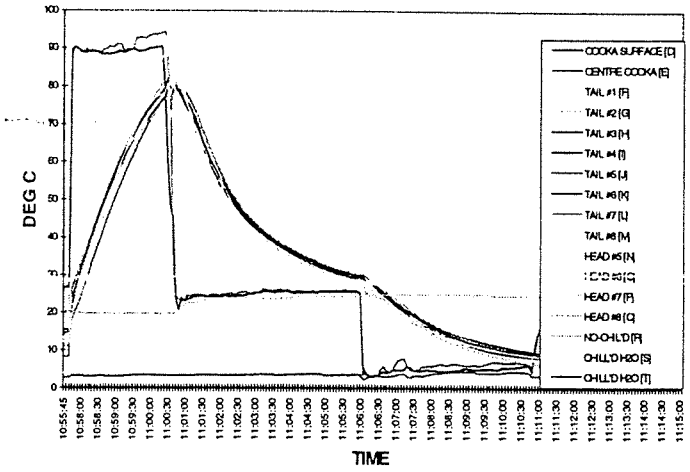


Appendix 2B

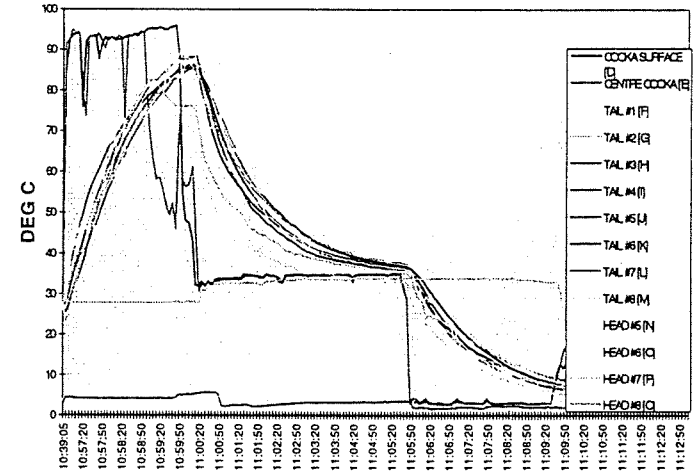
745 DEG 22g #1



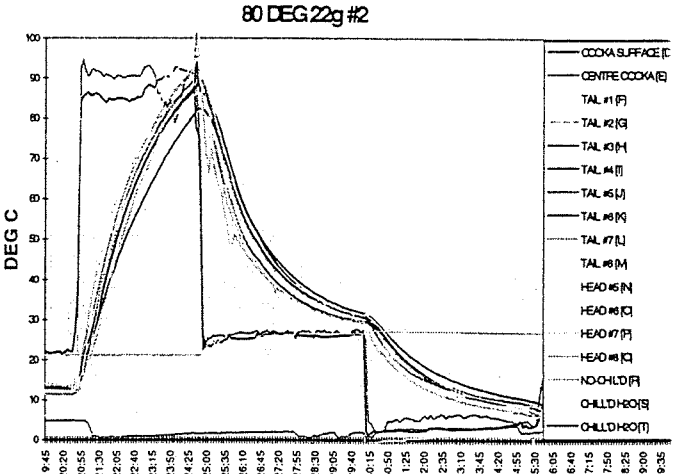
75 DEG 22g #2



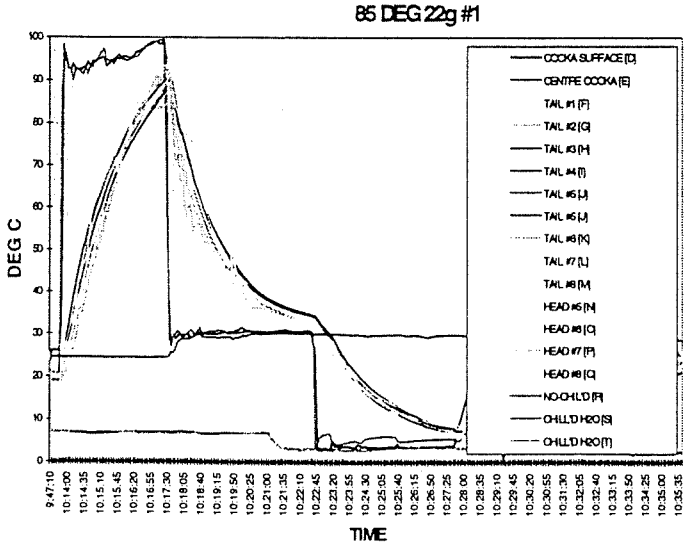
80 DEG 22g #1



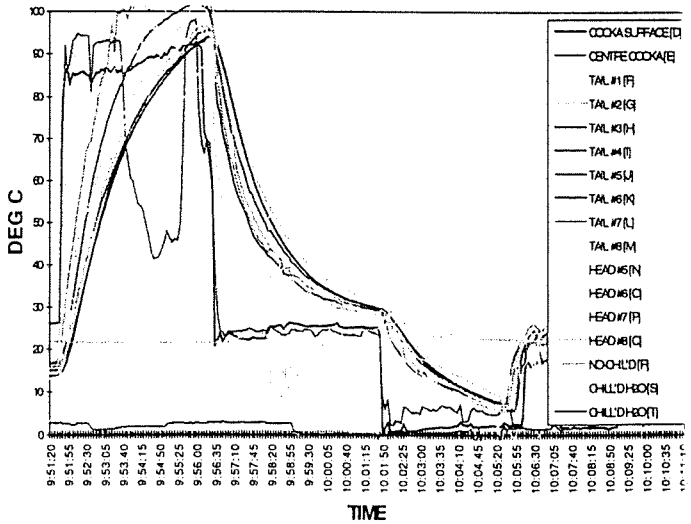
80 DEG 22g #2



85 DEG 22g #1

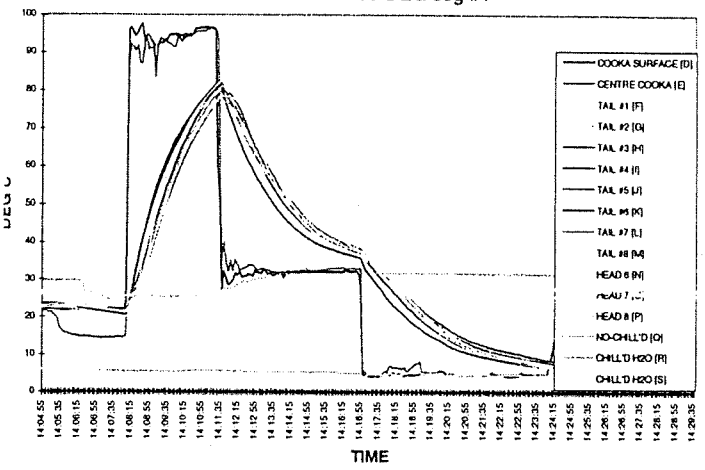


85 DEG 22g #2

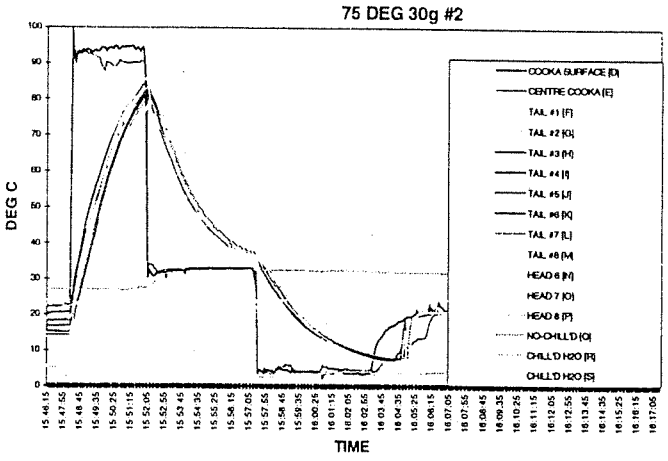


Appendix 2C

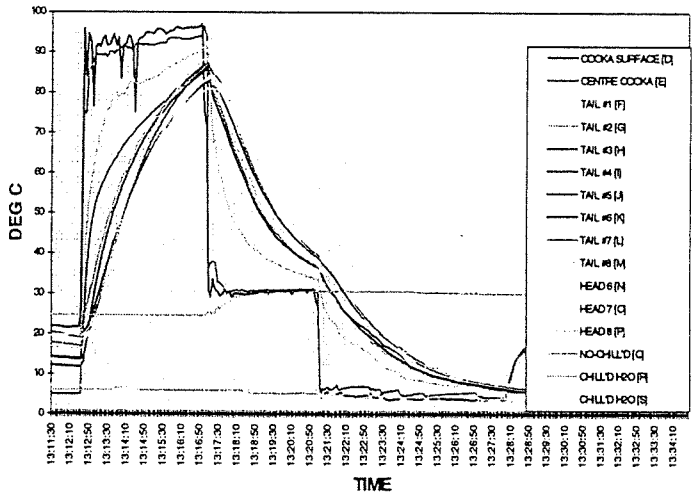
75 DEG 30g #1



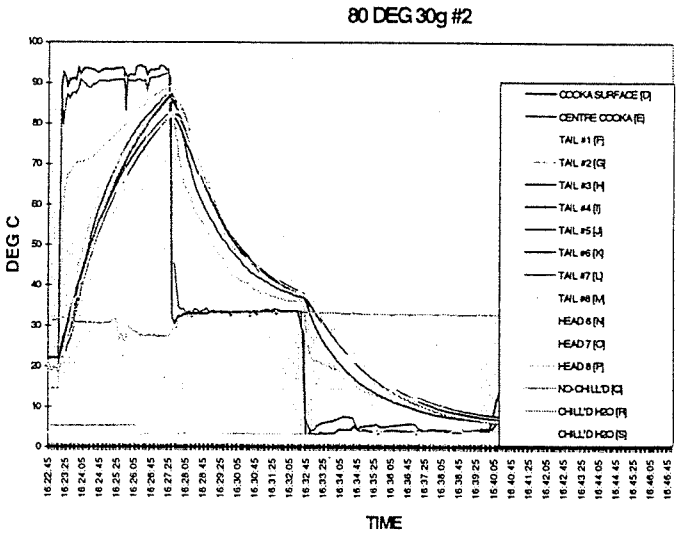
75 DEG 30g #2



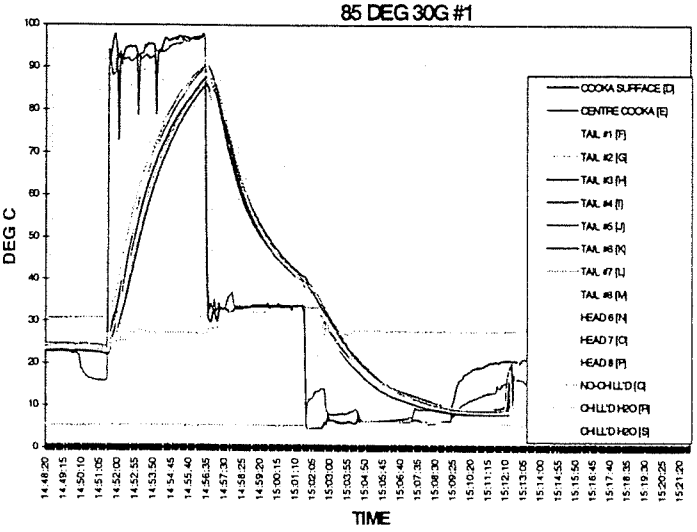
80 DEG 30g #1



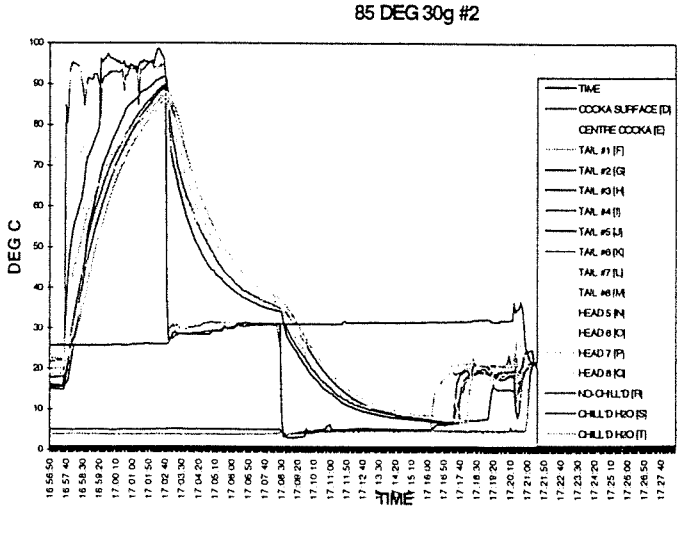
80 DEG 30g #2



85 DEG 30G #1



85 DEG 30g #2



APPENDIX 3

AN EXAMPLE OF THE TRIANGLE TEST USED TO DETERMINE IF A TASTE DIFFERENCE EXISTED BETWEEN PRAWNS SOAKED IN FRESH WATER AND THOSE IN A 1.5% AND / OR 3% BRINE.

TEST TYPE: TRIANGLE

PRODUCT: Cooked Prawns

TEST 1:

Two samples are the same and one is different. Taste each of the samples in the order shown below and place a circle round the code of the sample which you think is different.

1. Sample code: 642 2. Sample code: 124 3. Sample code: 548

YOU MUST MAKE A CHOICE

Comments: _____

_____

TEST 2:

Two samples are the same and one is different. Taste each of the samples in the order shown below and place a circle round the code of the sample which you think is different.

1. Sample code: 988 2. Sample code: 457 3. Sample code: 364

YOU MUST MAKE A CHOICE

Comments: _____

_____

TEST 3:

Two samples are the same and one is different. Taste each of the samples in the order shown below and place a circle round the code of the sample which you think is different.

1. Sample code: 478 2. Sample code: 182 3. Sample code: 463

YOU MUST MAKE A CHOICE

Comments: _____

_____

Name: Date: Time:

APPENDIX 4 :

Freshness score sheet for *P.monodon* cooked prawns

SCORE	ODOUR	FLAVOUR	TEXTURE
10	CRABBY, CHARACTERISTIC ODOUR OF SPECIES, SWEET, SEAWEEDY	SWEET, MEATY, CRABBY CHARACTERISTIC ODOUR OF SPECIES	MEATY, JUICY, FIRM
9	CRABBY, CHARACTERISTIC ODOUR OF SPECIES, SWEET, SEAWEEDY	SLIGHTLY SWEET TO BLAND, DETECTABLE AFTERTASTE	MEATY, JUICY, FIRM
8	SLIGHTLY SWEET, SEAWEEDY	SLIGHTLY SWEET TO BLAND, SLIGHT BITTER AFTERTASTE	FIRM, CHEWY
7	fRESH CUT GRASS, SLIGHTLY AMMONIACAL, VERY SLIGHT URINAL	SLIGHTLY SWEET TO BLAND, SLIGHT BITTER AFTERTASTE	FIRM, CHEWY
6	SLIGHTLY AMMONIACAL, SLIGHLY SWEET CHARACTERISTIC ODOUR	SLIGHT SWEETNESS ALMOST NEUTRAL, BLAND	SLIGHTLY FIRM TO DRY
5	STRONG AMMONIACAL ODOUR	BLAND, NEUTRAL TO SLIGHTLY FISHY	SLIGHTLY FIRM TO DRY
4	STRONG AMMONIACAL ODOUR, STRONG URINAL	BLAND TO FISHY, OFFENSIVE SULPHIDY	SLIGHTLY FIRM TO DRY
2	STRONG AMMONIACAL ODOUR, STRONG URINAL	BLAND TO FISHY, OFFENSIVE SULPHIDY	DRY, LUMPY
0	FAECAL, PUTRID, STRONG URINAL	SULPHIDY, STRONG BITTER FLAVOUR	SOFT, DRY, LUMPY

APPENDIX 5A

SHELF LIFE RESULTS FOR 16/20 COOKED PRAWNS AT 4 AND 10 DEGREES C

Core Temp	Storage Temp.	AgeDays	Flavour	Odour	Texture	General appearance	SPC	Psychrotrophic	E.coli	Staph +ve
75	N/a	1	9	9	10	Product good, meat cooked through				
80	N/a	1	9	9	10	Product good, meat cooked through				
85	N/a	1	9	9	10	Product good, meat cooked through	<100			
75	4	7	8/9	7/8	8	B/s prevelant in head, minor at base of legs,				
80	4	7	8/9	7/8	8	Slight darkening of head. mnor B/s in head of larger product				
85	4	7	8/9	7/8	8	Head firm some minor brown discolouration to head	1000			
75	10	7	5	4/5	5	B/s 9/11 prawns severe in 5, bacterial slime present				
80	10	7	5	4/5	5	V. minor B/s in some prawns particularily at base of 1st & 2nd pleopods				
85	10	7	5	4/5	5	No B/s. Bacterial slime starting	<2000000			
75	4	10	6/7	6/7	5/6	B/s prevelant in head body slimy				
80	4	10	5/6	5	6	Slight slime, no B/s, head going slighly brown				
85	4	10	6/7	6	7	Slight slime, no B/s, head going slighly brown	160000		>1	<100
75	10	10	N/a	1	2	B/s prevelant, body soft, bad odourous bacterial slime				
80	10	10	N/a	0	2	No B/s, head going soft, bad slime				
85	10	10	N/a	1	4	No B/s, head going soft, bad slime	14000000			
75	4	14	5	6	5	B/s prevelant, head becomming soft				
80	4	14	4	5	5	V.Minor B/s head slightly darker then 85C product				
85	4	14	5	6	5	No B/s head still firm	960000	>1000000		
75	10	14	N/a	2	0	Head loose, meat soft, bad slime, product rancid				
80	10	14	N/a	2	0	Meat softening, bad slime, product rancid				
85	10	14	N/a	2	0	Meat softening, bad slime, product rancid				
85	chilled water	14	5	7	6	Freon taint in flesh, no slime or B/s	150000			

APPENDIX 5B

SHELF LIFE RESULTS FOR 20/30 COOKED PRAWNS AT 4 AND 10 DEGREES C

Core Temp	Storage Temp.	AgeDays	Flavour	Odour	Texture	General appearance	SPC	Psychrotrophic	E.coli	Staph +ve
75	N/a	1	9	9	10	Product good, meat cooked through				
80	N/a	1	9	9	10	Product good, meat cooked through				
85	N/a	1	9	9	10	Product good, meat cooked through	<100			
75	4	5	7	7/8	7	B/s in head 5/7 head going darker slightly undercook texture				
80	4	5	9	7/8	9	no B/s head slightly darker				
85	4	5	9	7/8	9	No B/s prawns in good condition	5400			
75	10	5	7	6	7	slight B/s in head 3/11 brown of head obvious in all prawns				
80	10	5	6	5	6/7	No B/S, slight browning in head				
85	10	5	7	6	7	No B/s product appears good	610000			
75	4	7	7	5/6	6	B/s prevelant, head becomming loose				
80	4	7	7	7	6	No B/s, head firm				
85	4	7	7	7	6/7	No B/s, head still firm				
75	10	7	N/a	2	2	Bad B/s, Head loose, bad slime, rancid odour				
80	10	7	N/a	2	4	Minor B/s head darkening, head becomming loose, bad slime				
85	10	7	N/a	2	4	No B/s, visually good, bad slime	5500000			
75	4	10	4/5	5	5	Head very dark, no neck meat present, slime starting				
80	4	10	6	5	5	Heads only slightly darker then 85C product, slime starting				
85	4	10	6	5	4	visually good slime starting	64000		<1	<100
75	10	10	N/a	0	1	B/s prevelant, head becomming loose, no neck meat, rancid				
80	10	10	N/a	2	1	B/s present in head, no neck meat, rancid				
85	10	10	N/a	2	2	Head darkening, little neck meat, rancid.				
85	Chilled water	14	5	5	6	Freon taint in flesh	93000			

#nb: product assessed was from local material collected day of cooking.

APPENDIX 5C

SHELF LIFE RESULTS FOR 30/40 COOKED PRAWNS AT 4 AND 10 DEGREES C

Core Temp	Storage Temp.	AgeDays	Flavour	Odour	Texture	General appearance	SPC	Psychrotrophic	E.coli	Staph +ve
75	N/a	1	9	8	9	Product good, meat cooked through				
80	N/a	1	9	8	9	Product good, meat cooked through				
85	N/a	1	9	8	9	Product good, meat cooked through	<100			
75	4	5	9	8	8	head section slightly darker				
80	4	5	9	8	8	visually good, may be some slight darkening				
85	4	5	9	8	8	visually good	1700			
75	10	5	5	5	5	Head section darker				
80	10	5	4/5	6	5	Discolouration starting in head				
85	10	5	5	6	6	visually good	1500000			
75	4	7	6	6	6	Head slightly darker then 80, head firm				
80	4	7	5	6	5	slightly darker, head firm				
85	4	7	5	7	5	visually good	100000		<1	<1
75	10	7	N/a	2	2	some B/s, head soft, large bacterail slime, odour very strong				
80	10	7	N/a	2	4	V. minor B/s, head soft, large bacterail slime, odour very strong				
85	10	7	N/a	2	4	No B/s, head soft, large bacterail slime, odour very strong	6000000			
75	4	10	4	6	5	Product similar to 80 and 85C, slight slime present				
80	4	10	5	7	5	Product not dipped showing signs of B/s. slight slime				
85	4	10	5	7	5	slight Bacteria slime on shell	440000	10000000		
75	10	10	N/a	0	1	Head falling off, product putrid				
80	10	10	N/a	2	1	same above, darkening of the shell				
85	10	10	N/a	0	1	Same above darkening of the shell	43000000			
75	4	14	N/a	0	N/a	Product putrid, head soft				
80	4	14	N/a	2	N/a	Product putrid, head soft				
85	4	14	N/a	0	N/a	Product putrid, head soft	9100000	10000000		
85	Chilled water	14	5	7	6	Freon taint in flesh	240000			

APPENDIX 6:
PRAWN COOKING PROCESS

Process	Symbol	Potential hazard	Recommendation
Raw Material Received		Soft damaged prawns.	Record molting cycle for each pond.
Storage		Quality loss Weight Loss	Minimise time of storage. Trials on holding prawns in fresh water?
Weigh		Incorrect weights	Scale calibration
Wash		Damage by overwashing Prawns still soiled - underwashing	Trials on maximum and minimal wash times.
Inspect		Damaged inferior product	Inspection belt speed
Sort		Out of grade causing over/under cooking.	Continuous checks. Adjustment grader.
Weigh		Incorrect quantity causing over/under cooking.	Mark baskets to fill level or weigh batches individually.
Identifying grade		Cooked to incorrect time causing over/under cooking	Use coloured pegs on cook baskets for specific grades
Cook		Over/under cooking	16/20 - 4:55 * 20/30 - 3:35 30/40 - 2:40 This is to 85°C when **baskets are agitated. 16/20 product may be reduced as the time gap experienced between 80 and 85 °C core temperatures was longer then expected.** Check burners to ensure gas flow unimpeaded. Monitor gas pressure minimum pressure 120 kpa recommended. Water to prawn ratio 5:1 mark cooker at 80 litres if cooking 16 kg batches

Process	Symbol	Potential hazard	Recommendation
			Have 2 adjustments set for gas flow 1. Flat out to bring water to boil and 2. 1/3 to 1/4 flow to maintain boil recommend simple 2 position switch. Inspect a large prawn in each batch to ensure flesh adequately cooked and texture is desirable.
		Contamination	Water should be changed when it begins to look like soap.
Cooling/Washing Stage 1		Water temperature high. Contamination.	Maintain temperature with water or ice topups. Water exchanged frequently to reduce risk of contamination.
		Prawn not cleaned sufficiently	Water should be strongly agitated to remove protein/fat scum.
		Time in Stage 1 too short causing strain on chilled water system.	3 to 4 minutes required to reduce core temp of prawns to within a few degrees of water temp.
Cooling Stage 2 chilled wash		Insufficient reduction in temperature	Maintain water temperature around 5°C. Agitate basket initially. Time required: 16/20 - 7 minutes 20/30 - 5 minutes 30/40 - 4 minutes
Overnight brining		yield loss. Excess salty flavour	Use only enough salt to ensure customers specifications are met.

Appendix 6B

Other Considerations

1	Harvest Technique	The quantity of prawns in the codend will greatly influence the amount of damage to product.
2	Harvest Time	Prawns harvesting a couple of days prior to molting may have a high concentration of enzymes which directly effect blackspot formation. Recommend harvest at least 1 week prior to molt. Harvesting newly molted prawns can cause excessive damage, grading and cooking problems. Recording molting cycles for each pond may be of assistance.
3.	Pre Harvest Feeding	Recommend no feeding 24 to maximum 48 hours prior to harvest to reduce gut content and potential microbial load.
4.	Prawns floating during cooking	A large number of prawns harvested 3 days prior to processing floated to the surface in the early stages of cooking. This caused an increase in the cook times due to only partial submergence in the cook water. Processors have also indicated that this occurs with newly molted product. A lid on a basket that sits below the water line should prevent over/under cooking in this situation.
5.	Brining	The longer the soak period in brine the greater the salt/moisture migration (until equilibrian is reached). Trials on salt absorption (& yield loss) in flesh over time and its effects on flavour has not been fully examined. A hydrometer could be used to check salinity levels.
6.	Weighing/ Packing	Work on drain weights for packouts (our pack requirements) post brining and the effects of yield/quality during transport are yet to be examined
7.	Antioxidants	The use of an antioxidant in post or pre cooking may help prevent blackspot and reduced cook times to improve yields. Treatment may also ensure larger out of grade product does not turn black.