The microbiological status of prawns from retail and wholesale outlets in the Brisbane region.

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Cooked prawns from retail and wholesale outlets in the Brisbane region included a large proportion with high bacterial counts (10^6-10^8/g) indicating a short remaining shelflife. Microbially inferior product entering the wholesale and retail trade indicated poor handling and storage practices from point of capture all along the distribution chain to the retail outlets. Current handling practices need to be upgraded and HACCP principles adopted.

The shelflife and safety of packaged prawn products are dictated by the number and types of the bacterial flora. Bacterial levels on freshly caught Australian prawns were reported by Montgomery & others (1970) as being in the region of 10^4/g on freshly landed material which, after cooking, were reduced to below 10^2/g. Cooked iced prawns in the Sydney Fish Market had counts between 10^4 and 10^5/g and condemned prawns had counts exceeding 10^6/g up to 1.6 x 10^7/g. Gillespie and Macrae (1975) also found bacterial levels 10^5-10^6/g on freshly caught prawns which could be reduced to below 10^4/g by washing. Poole & others (1989) reported similar levels, with other unpublished results for both raw and cooked prawns in the region of 10^7/g.

As part of a project on packaging and development of prawn products, funded through the Fisheries Research & Development Corporation, the microbial status of typical material currently available to processors and consumers was surveyed.

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Materials

A random selection of outlets in the northern suburbs of Brisbane was established as the study area from which product could conveniently be sampled. This region was selected as it contained a wholesale market, retail fish shops and supermarkets which regularly deal with the marketing, distribution and processing of fish and fishery products. Some samples were also obtained directly from boats (Chinivasagam & others 1996). In addition to taking samples of prawns, observations were made on the current practices of cooking, handling and transportation of prawns both on board and on shore. The source, storage form, product and presentation of the various prawn types are given in Table 1.

Wholesalers provided 30% of the samples, retailers 57% and the remainder were obtained directly from the boat as the catch was landed.

Cooked prawns made up the majority (70%) of the samples; this is the common manner in which the industry presents prawns to the consumer. Most (64%) of the samples came from chill storage cabinets while 15% were stored in ice, 15% were in slurry and 6% were frozen.

Samples were obtained at random intervals approximately on a monthly basis. The number of samples obtained on a particular day depended on availability. The samples purchased from a particular source were sealed in sterile bags, stored on ice, brought to the laboratory within an hour and tested immediately. Samples from the wholesale market were obtained under aseptic

Table 1. Source, storage form and presentation of the seven types of prawns sampled.

Type of Prawn	Number of Samples	Boat				Wholesaler/Processor						Retail Outlet			
		Slurry		Ice		Chilled		Slurry	Frozen		Ice	Chilled		Frozen	
		Raw	Cooked	Raw	Cooked	Raw	Cooked			Cooked	Raw	Cooked	Raw	Raw	
Tiger	8	1	2	1	1	1	1					1			
King	18	3	1		1						1	9	2	1	
Coral	4				1							3			
Greasy	9	1	1		4					1		2			
Endeavour	4				1		1					2			
Banana	7	2								1		1	3		
Unknown	3[a]											3			
Total	53	7			16							30			

[a] Peeled prawn meat.

conditions in sterile bags and were similarly transported to the laboratory for immediate testing.

It was not practical to measure the temperature of the product on display since this breached health regulations in that it may have contaminated the product. The temperature of some samples was taken immediately after purchase, when outside the premises.

Table 2. Percentage distribution of total bacterial counts found on cooked and raw prawns.

	Percentage distribution				
Total count/g:	$<10^4$	10^4-10^5	10^5-10^6	10^6-10^7	10^7-10^8
COOKED PRAWNS[1]					
Mesophilic count[2]	0	9.5	52.5	28.5	9.5
Psychrotrophic count[3]	5	19	28.5	38	9.5
RAW PRAWNS[4]					
Mesophilic count[2]	14	22	64	0	0
Psychrotrophic count[3]	14	29	57	0	0

[1] Cooked prawns stored in retail chill displays
[2] Plates incubated at 30°C for 2 days
[3] Plates incubated at 5°C for 10 days
[4] Raw prawns in retail outlets

Table 3. Total bacterial counts* for various prawn samples obtained at two incubation temperatures.

Comparison	Number	Mesophils+		Psychrotrophs§	
Type of Prawn					
Tiger	16	5.40^{bc}	(1.65)	5.14^{a}	(1.85)
King	36	5.35^{bc}	(1.15)	5.40^{a}	(1.16)
Coral	8	6.06^{ab}	(0.76)	6.07^{a}	(0.90)
Greasy	18	5.30^{bc}	(0.64)	5.18^{a}	(0.71)
Endeavour	8	4.65^{c}	(1.92)	4.11^{a}	(2.46)
Banana	14	4.88^{c}	(0.81)	4.77^{a}	(1.21)
Unknown	6	6.60^{a}	(0.54)	5.78^{a}	(1.12)
Source of prawn					
Boat	14	4.30^{a}	(0.81)	3.89^{a}	(0.86)
Retail	60	5.57^{b}	(0.98)	5.46^{b}	(1.08)
Wholesaler	32	5.43^{b}	(1.50)	5.33^{b}	(1.75)
Storage form					
Ice	16	5.07^{a}	(0.80)	4.99^{a}	(0.94)
Chill	70	5.81^{b}	(1.04)	5.72^{b}	(1.20)
Slurry	14	4.61^{a}	(0.85)	4.22^{a}	(1.01)
Frozen	6	2.89^{c}	(0.50)	2.54^{c}	(0.85)
Presentation					
Cooked	74	5.67^{a}	(1.24)	5.56^{a}	(1.42)
Raw	32	4.63^{b}	(0.77)	4.41^{b}	(0.92)
Weight range (g)					
0-10	32	5.69^{a}	(0.83)	5.59^{a}	(0.90)
11-20	62	5.36^{a}	(1.37)	5.18^{a}	(1.61)
21-50	4	4.94^{ab}	(0.39)	4.79^{a}	(0.70)
>51	8	4.25^{b}	(0.64)	4.19^{a}	(0.87)

* Logarithms of the mean with group standard deviation in brackets. Values significantly different ($P \leq 0.05$), within a comparison are marked with different superscripts.
+ 30°C incubation 2-3 days.
§ 5°C incubation 7-10 days.

Methods

Whole prawns (approx. 250g) were transferred into a sterile stomacher bag inside a second bag and macerated in a *Colworth* stomacher to form a uniform composite sample. The bag was shaken to mix the sample and 10 g was weighed into sterile stomacher bags. Total bacterial counts were carried out by preparing serial dilutions using 0.1% peptone water for plating on nutrient agar. The plates were incubated at two temperatures, 30°C for 2 days (to estimate the mesophilic count) and 5°C for 7-10 days to estimate the psychrotrophic count. The analyses were done in duplicate and the resulting bacterial counts $\log_{10}$ transformed and subjected to analysis of variance. Testing for the pathogens *Salmonella, Vibrio parahaemolyticus, Staphylococcus aureus* and *Escherichia coli* was carried out according to Australian standards AS1766.2.5-1991, AS1766.2.9-1991, AS1766.2.4-1986 and AS1766-1987 respectively.

Results and discussion

Temperatures

When temperatures of prawns from six different retail outlets were measured outside the shop, one sample was at 10°C and the others were between 5 and 6°C. A temperature of 10°C is far too high for storage of prawns since at this temperature psychrotrophic spoilage bacteria can multiply very rapidly and cause fast deterioration. If allowance is made for the delay in measuring the temperatures, then the rest of the samples were probably at temperatures near 4°C. The rate of spoilage at 4°C is about half that at 10°C, but at 0°C the rate would halve again (Bremner & others 1987).

Temperatures of the prawns at the wholesalers were generally lower than at retailers; of ten samples, six were below 2°C, two were at 3°C, one at 5°C, and one at 7°C.

Cooked prawns

In the retail sector, the majority of the cooked prawns were stored in chilled display cabinets (Table 1). All the raw prawns tested had total bacterial counts less than 10^6/g while the count for cooked prawns ranged from $<10^4$/g to 10^8/g (Table 2).

In the wholesale sector, the most common form of storage was chilled display (50%). Total bacterial counts for samples in ice ranged from 10^4 to 10^7/g while those in chillers had counts between 10^4 and 10^8/g. All the frozen cooked prawns had counts lower than 10^3/g.

The high counts on cooked prawns are a matter for concern. Trials in this laboratory have indicated that a rapid reduction of bacterial load occurs when prawns are cooked. If the prawns are not recontaminated there should be no reason why counts of 10^2/g or lower cannot be obtained. The high counts observed on cooked prawns

are most likely due to a combination of post process contamination and elevated storage temperatures.

Raw prawns

Most of the raw prawns from boats were obtained in the course of other experiments and had been properly handled by the catchers and experimenters; 86% had counts below 10^5/g and 10% had counts near 10^6/g (Chinivasagam & others 1996). In the retail sector, raw prawns were mostly stored in chillers (71%) with counts mostly 10^5-10^6/g (Table 2). A similar range of counts was obtained with samples taken at wholesalers. It has already been established that bacterial counts of 10^6/g are quite usual on freshly caught raw prawns (Gillespie & Macrae 1975, Chinivasagam & others 1996). With chilled storage these counts often decrease to levels nearer 10^4/g since the Gram positive component of the flora fails to survive chilling and they are not spoilage organisms (Chinivasagam & others 1996).

Coliforms

Out of the 53 samples, 22 had detectable coliform counts. Of these, five samples were below 10, nine were between 11 and 100, seven were between 101 and 1000 and one sample had a coliform count above 1000/g. In three samples the coliforms were of faecal origin. Coliforms are not usually present in prawns and contamination should be completely destroyed by cooking. But, with the exception of one sample, all the coliforms found were present on cooked prawns and their presence must be due to post-cooking contamination. The presence of faecal coliforms is caused by poor hygiene, with the contamination coming from the cooling water, from the storage medium, from the implements used to handle the prawns or from direct contact by humans.

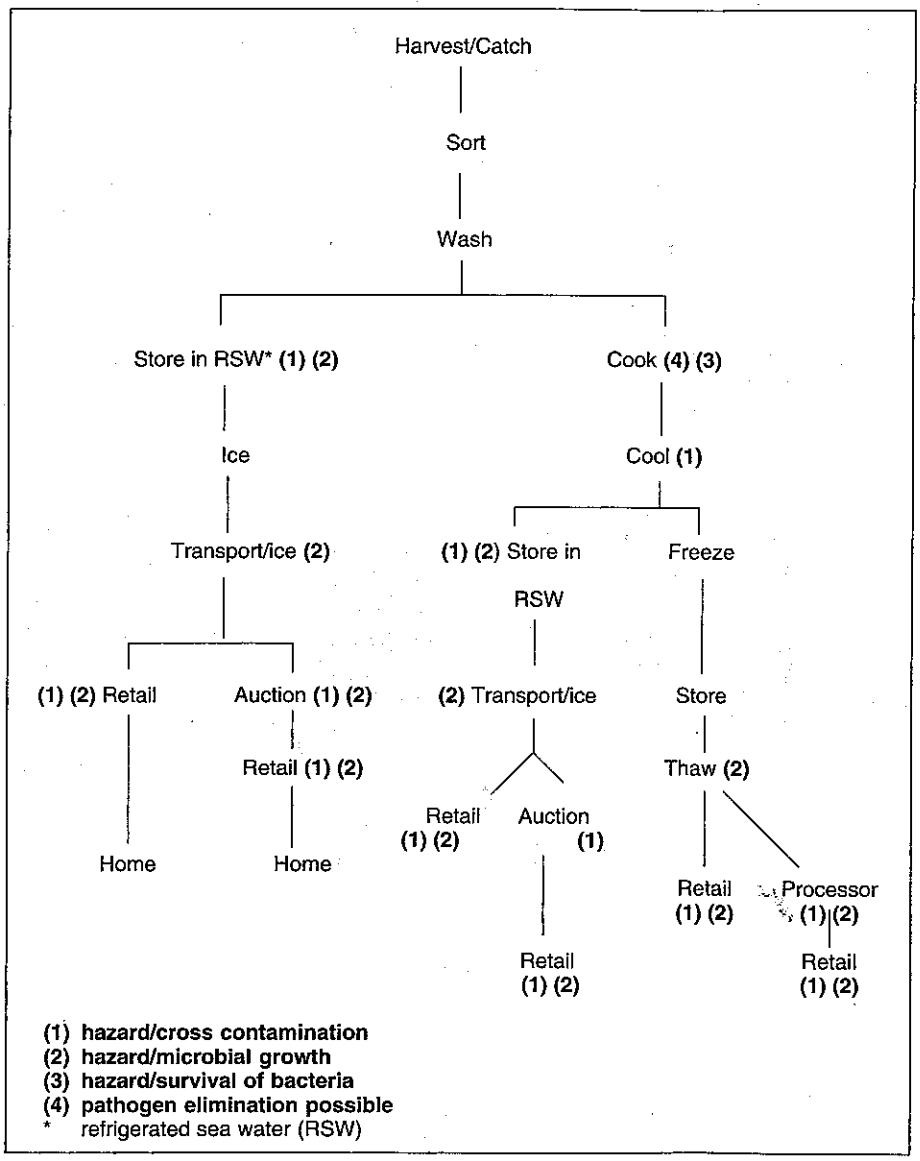

Figure 1. Hazardous points in prawn processing.

Staphylococci

Twelve samples tested positive for staphylococci and most were the same samples that showed coliforms. The levels were generally lower than 100/g with only three samples having > 200/g. Two samples were of raw prawns indicating that contamination can occur in the raw state. These are low levels, but they indicate contamination from humans after cooking. At high levels this may represent a problem since *Staphylococcus aureus* is able to produce toxin which is not inactivated on cooking.

Vibrio

Vibrio were present but none were the pathogenic *Vibrio parahaemolyticus*.

Overall microbiology

The overall microbiological results are presented in Table 3. Some general conclusions can be drawn from these observations, the results for both cooked and raw prawns being combined. The peeled prawn meat of unknown history and the coral prawns had the highest bacterial counts; while the bananas and endeavours had the lowest counts. Coral prawns do not fetch a high price, are not very popular, are generally incidental to a main catch and

Table 4. Total viable bacterial counts on cooked prawns, re-expressed from Poole & others (1989).

Species	Number of samples	Percentage of samples at levels specified					
		Total count			Psychrotrophs		
		Mean x 10^6	Range 10^5	Range 10^7	Mean x 10^5	Range 10^5	Range 10^7
Bay (mixed)	83	12	13	21	7.3	30	8
King (raw)	12	18	8	25	4.6	50	25
King (cooked)	16	53	7	19	2.4	38	6

do not generally receive as careful a handling as higher priced species.

Raw prawns obtained directly from the boat had low counts typical of the natural flora present on the prawn after catching and chilling (Chinivasagam & others 1996) and the average count of 10^4/g could be considered quite low. Frozen prawns had low counts and those in slurry (mostly obtained directly from the boat) were also quite low.

The highest counts were found in prawns stored chilled (cabinets or chillers) and these were mostly in the cooked (85%) ready to eat form, which is how most product is displayed and sold. All cooked prawns had much higher counts than raw prawns. These results agree with those of Poole & others (1989) who found average bacterial counts were high on cooked prawns in Brisbane (Table 4). The situation has not improved in the period between the surveys.

Observations on hygiene

The observations and the microbial counts indicate there is a need for improved procedures for handling prawns at every step in the chain from the boat through to the retail outlets. On board some boats tanks of refrigerated seawater contained water which was contaminated and had not been changed for several days. In addition both cooked and raw prawns were often stored in the same tank. This allows the selection and development of a 'soup' of cold tolerant spoilage organisms which can provide a massive contaminating microbial dose to fresh new product. Thus prawns which after cooking should have only very low bacterial counts would be recontaminated with high levels of cold tolerant spoilage bacteria.

The water in the prawn cookers was also often not changed for several days. This results in bacterial growth and contamination with bacterial byproducts in the period when the cooker is not in use between trips. These byproducts can then contaminate fresh incoming prawns. The same baskets and buckets were used for on board sorting, storage and transport of cooked and raw product. They were often only poorly cleaned by a quick rinse with the deck hose.

These are poor practices which allow cross contamination and recontamination of product. Better practices are needed on boats to prevent cross contamination of cooked and raw product and better control procedures on cooking and cooling are required with more frequent changes of both cooking and chilled water. More attention should be given to the proper cleaning of buckets and other utensils.

In retail display, many opportunities for cross contamination were observed, the same utensils such as tongs or scoops being used for cooked and raw products as well as to serve or replenish ice. Cooked product was often found in contact with raw product and raw prawns were often adjacent to other seafood such as oysters which would be eaten raw.

The facilities on most boats provide many opportunities for cross contamination of cooked product and this situation persists through the distribution chain. The product at the retail stage is thus close to the end of its storage life instead of being only at the beginning. At the retailer more consideration should be given to controlling storage temperatures and to prevention of cross contamination. Given that the majority of prawns currently sold retail are cooked, better handling and storage procedures starting at the point of catch are essential.

It is clear from this study that the application of hazard analysis and critical control point procedures in the prawn industry may assist in improving both the safety and quality of prawns. A HACCP plan where procedures need to be tightened is displayed in Figure 1.

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