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Microbiological evaluation of South Australian rock lobster meat

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SUMMARY

Samples of frozen precooked rock lobster meat from five South Australian fish-processing plants situated in the West Coast and south-east regions were tested over a period of six months during the 1974/5 lobster fishing season. The most probable number (MPN) of *E. coli* and coliforms, *Staphylococcus aureus* and *Salmonella*, as well as total plate count (TPC) were determined in 480 samples. Monthly geometric mean TPC ranged from 1600/g to 25,000/g. The highest geometric mean of the MPN of coliforms and *E. coli* were 4·9/g and 1·8/g respectively. The highest geometric mean number of staphylococci was 18·6/g. *Salmonella* was not detected in the 480 units tested. Only 0·4 % of the samples had TPC exceeding 100,000/g. Coliforms and *E. coli* were not present in 76·1 % and 92·7 % respectively of the samples tested. *Staphylococcus aureus* was not detected in 67·7 % of the samples. The numbers of organisms in 82 % of the samples fall within the microbiological standards proposed by the National Health and Medical Research Council of Australia for frozen precooked foods. The results of this study demonstrate the microbial quality of precooked lobster meat attainable when good manufacturing practices are used.

INTRODUCTION

The Southern Rock lobster (*Jasus novaehollandiae*) is found in the rocky coastal waters of Tasmania, Victoria and South Australia, within 40 miles (65 km) of the coast, and around the islands in Bass Straits (Muir, 1973). The main fishing season for rock lobster in South Australia is from 1 November to 31 May, and it is carried out in three geographical regions, the western, central and south-eastern parts of the coastline. The annual production in South Australia is approximately 6 million lb. The monetary value of this fishery is one of the highest in the fishing industry in South Australia. The lobster has traditionally been sold as frozen raw tails predominately to overseas markets and cooked (whole) for local and overseas consumption. The production of precooked lobster meat which was essentially for the local market was relatively insignificant before 1968. However, in recent years, the demand for lobster meat by local and overseas consumers had increased immensely. Production of lobster meat in 1968/9 by the largest processing company was 150,000 lb. In 1973/4, 330,000 lb were produced, an increase of 128 %.

Lobster meat, which is extracted from the legs and thoracic segments (generally

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referred to as 'spiders') of the lobster, represents 10–15 % of the catch, compared with 40 % for tails. As far as the author is aware, lobster meat production is insignificant or non-existent in Western Australia, Victoria and New South Wales. It is estimated that about 90 % of precooked rock lobster meat produced in Australia comes from South Australia. In New Zealand the raw 'spiders' are discarded into the sea during tailing on board the boat (J. L. Sumner, pers. comm., 1975).

The microbial quality of the cooked lobster meat is influenced to a very large extent by the sanitary conditions under which it is processed. However, there is no published information on the microbiological status of the product. In this study, samples from five of the main lobster meat processing plants in South Australia were tested during the main rock lobster fishing season, and the findings are presented.

MATERIALS AND METHODS

Frozen precooked lobster meat was obtained from five South Australian fish processing plants, three designated as A, B and C, on the south-eastern region, and two designated as X and Y, on the western region, during the 1974/5 lobster fishing season. Both small and large processing plants were included. The nearest plant (A) is situated 200 miles (322 km) from the testing laboratory in Adelaide and the farthest plant (Y) 600 miles (966 km). Consequently, test samples had to be sent by refrigerated trucks to the laboratory.

Precooked lobster meat is packed in 1 kg lots in polythene bags. Two 1 kg lots are placed in a cardboard box (1 unit) with dimensions $31{\cdot}5 \times 21 \times 3{\cdot}5$ cm. After packing, the boxes of meat are placed in a blast freezer for rapid freezing. For bacteriological testings, one to two frozen units were randomly picked from each day's production. Owing to the irregularity of transport from plants X and Y to the laboratory, it was not possible to obtain samples from every production. A total of 480 sample units were received from the plants. Their distribution is shown in Table 1 in parentheses. On arrival at the laboratory, the frozen samples were tested immediately, when possible. Otherwise they were kept frozen and tested on the following day.

The sanitary conditions of the plants were assessed by inspection during the season. Sanitation was judged by observing plant and equipment cleanliness, housekeeping, processing and handling techniques and employee hygienic practices.

Previous work (unpublished data) carried out by the author had shown that total plate counts were influenced by ambient temperature during processing. Accordingly, temperature data of the Commonwealth Bureau of Meteorology, Adelaide, were obtained for the centres which are located at or near the plants. The mean maximum temperatures from the months November 1974 to April 1975 are presented as histograms in association with the total plate counts (Fig. 1).

Bacteriological tests

Using aseptic techniques, the polythene covering the frozen meat was removed to expose the top surface. A representative sample of meat was extracted by using

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a $\frac{1}{4}$ in sterile drill bit attached to a variable-speed electric drill. Twenty or more places on each unit were drilled to give approximately 100 g of meat shavings.

10 g of the meat shavings were aseptically weighed into 90 ml of 0·1 % sterile peptone broth and immediately shaken with a variable-speed mechanical shaker for 10 min. The resultant homogenate was tested for total (aerobic) plate count (TPC), the most probable number (MPN) of coliforms, and *E. coli* and *Staphylococcus aureus*.

Decimal dilutions were prepared by using 9 ml diluent (0·1 % peptone broth) plus 1 ml of the previous dilution. For TPC, duplicate pour plates of 10^{-2} and 10^{-3} dilutions in nutrient agar (BBL) were incubated at 37 ± 1 °C for 48 h.

The MPN of coliforms and *E. coli* were determined by the following method. 1 ml of each of 10^{-1}, 10^{-2} and 10^{-3} dilutions of the samples were inoculated into each of 3 separate tubes of single strength of MacConkey broth (BBL). The tubes were incubated in a water bath at 37 ± 1 °C for 24 and 48 h. Tubes showing acid and gas were selected after 24 and 48 h and the MPN of coliforms determined.

A tube of brilliant-green lactose bile (BGLB) broth (BBL) and a tube of 1 % peptone water (1 set) were inoculated from a tube of MacConkey broth showing acid and gas. Both media were incubated for 24–48 h in a water bath at 44 ± 1 °C. After 24 h interval, the BGLB broth tube was examined for gas production and peptone water tested for indole. A positive result in each tube was considered to be indicative of the presence of *E. coli*. The MPN of *E. coli* was determined from the number of positive sets of tubes.

Staphylococci were enumerated by Method I as described in Thatcher & Clarke (1968) with the following modification. All suspect colonies were tested for DNase activity. Colonies showing positive DNase activity on DNase Agar (Oxoid) were considered *Staphylococcus aureus*.

For *Salmonella* detection, 25 g of the meat shavings were aseptically weighed into 100 ml sterile nutrient broth for pre-enrichment. After incubation for 24 h at 37 ± 1 °C, 1 ml of the pre-enrichment broth was inoculated into each of 2 separate tubes containing 10 ml selenite brilliant-green sulphapyridine (SBGS) enrichment broth (DIFCO) and 10 ml tetrathionate broth (BBL). The SBGS broth was incubated at $43 \pm 0{\cdot}2$ °C for 18–24 h and the tetrathionate broth at $37 \pm 0{\cdot}2$ °C for 18–24 h.

Enrichment cultures were streaked on brilliant-green sulphadiazine agar (BBL) and Heckteon Enteric agar (Oxoid) or bismuth sulphite agar (BBL). Inoculated plates were incubated at 37 ± 1 °C for 24–48 h. Three suspect *Salmonella* colonies from each selective agar plate were selected for biochemical screening tests using triple sugar iron (TSI) agar (BBL); lysine iron agar (LIA) (BBL) and O.N.P.G. broth. After incubation at 37 ± 1 °C for a minimum of 24 h, any isolate giving reactions typical of *Salmonella* in TSI agar and LIA agar slants and O.N.P.G. broth was submitted to serological tests.

RESULTS

A total of 480 sample units were tested for TPC, the MPN of coliforms and *E. coli* and *Salmonella*. Only 368 of these were tested for *Staphylococcus aureus*. Monthly mean (geometric mean) TPC and mean maximum temperatures for the

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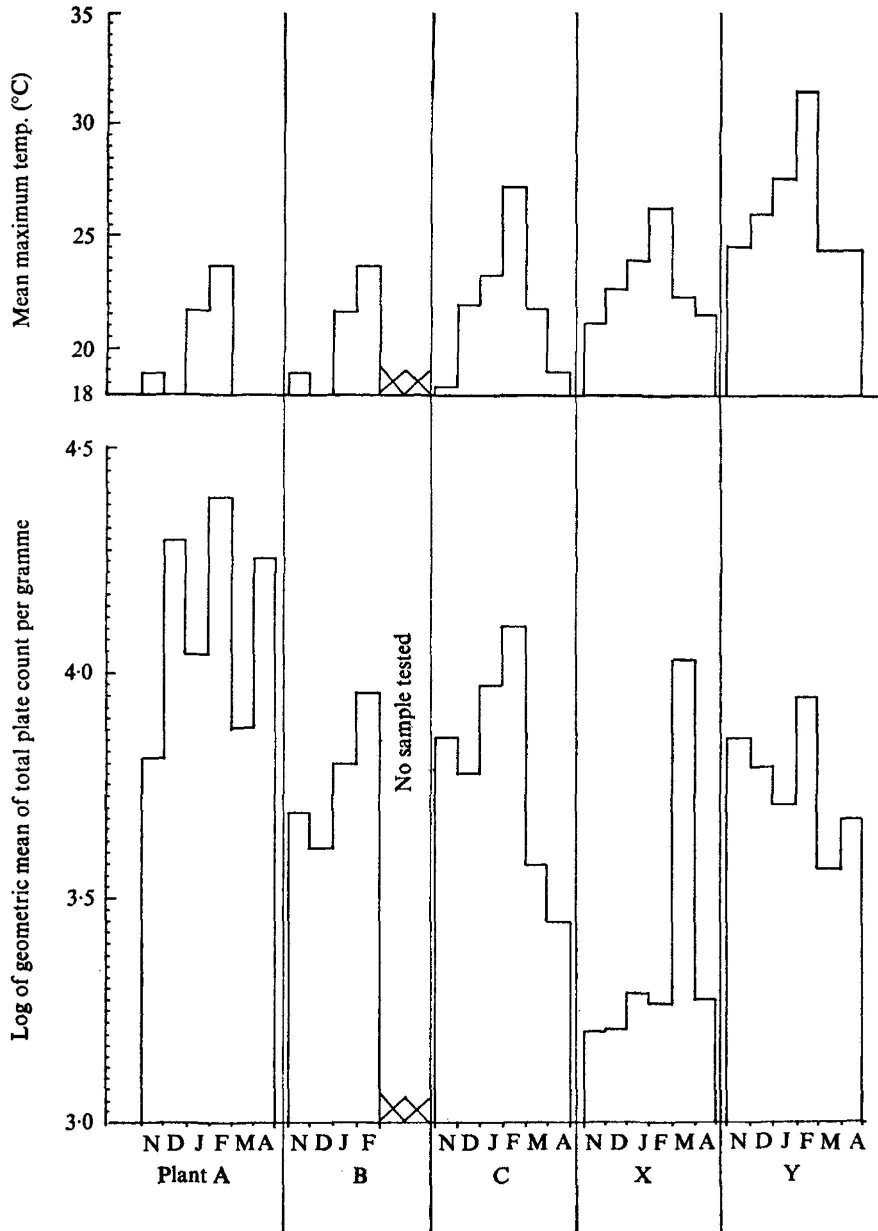

Fig. 1. Geometric mean of total plate counts, and mean maximum temperatures, at five different plants.

months of November 1974 to April 1975, are presented in Fig. 1. Mean TPC ranged from 1600/g in November (plant X) to 25,000/g in February (plant A). Temperature variations in the plant and their effects on the generation time of the microbial flora on the product are reflected by the change in TPC. Increases in TPC coincided with increases in temperature. TPC rose to a peak in February in plants A, B, C and Y, coinciding with the highest mean maximum temperature.

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Table 1. *Geometric mean of staphylococci and the MPN of coliforms and* E. coli (1974–1975)

	Geometric mean of MPN of coliforms/g					Geometric mean of MPN of *E. coli*/g					Geometric mean of *Staphylococcus aureus*/g				
	Plant					Plant					Plant				
Month	A	B	C	X	Y	A	B	C	X	Y	A	B	C	X	Y
November	1·8 (21)*	1·5 (40)	1·1 (42)	1·5 (30)	0 (9)	1·1 (21)	1·2 (40)	1·0 (42)	1·3 (30)	0 (9)	1·9 (11)	0 (28)	3·8 (42)	0 (10)	—
December	1·9 (14)	1·9 (20)	1·2 (33)	4·9 (25)	1·4 (20)	0 (14)	0 (20)	0 (33)	1·7 (25)	1·1 (20)	0 (7)	1·3 (7)	17·1 (33)	1·4 (14)	2·4 (11)
January	1·1 (19)	1·2 (6)	1·9 (24)	1·1 (11)	1·2 (9)	0 (19)	0 (6)	1·1 (24)	0 (11)	1·1 (9)	1·3 (18)	11·4 (6)	14·5 (18)	18·5 (11)	8·7 (9)
February	2·1 (13)	2·1 (13)	1·5 (22)	4·7 (18)	1·6 (8)	1·3 (13)	0 (13)	0 (22)	1·2 (18)	0 (8)	1·5 (11)	2·5 (13)	18·6 (15)	18·6 (18)	2·7 (8)
March	1·7 (10)	—	1·3 (15)	1·7 (9)	1·0 (14)	0 (10)	—	1·1 (15)	1·3 (9)	0 (14)	0 (10)	—	1·9 (13)	3·0 (9)	1·5 (14)
April	2·3 (6)	—	1·1 (12)	1·9 (8)	2·1 (9)	1·7 (6)	—	0 (12)	1·1 (8)	1·8 (9)	2·0 (6)	—	1·4 (9)	18·6 (8)	4·5 (9)

* Figures in parentheses indicate number of samples tested.

Table 2. *Numbers of organisms in precooked rock lobster meat 1974/5 season*

Range	Number (and %) of samples*
Total plate count/g (not greater than 10^5/g)†	
Less than 10^3	31 (6·5)
10^3–10^4	346 (72·1)
10^4–10^5	101 (21·0)
10^5–10^6	2 (0·4)
MPN coliforms/g	
Absence	365 (76·1)
1–10	85 (17·7)
11–10^2	25 (5·2)
10^2–10^3	4 (0·8)
Greater than 10^3	1 (0·2)
MPN *E. coli*/g (not greater than 9/g)†	
Absence	445 (92·7)
1–9	33 (6·9)
Greater than 9	2 (0·4)
Staphylococcus aureus/g (not greater than 100/g)†	
Absence	249 (67·7)
1–10^2	59 (16·0)
10^2–10^3	56 (15·2)
Greater than 10^3	4 (1·1)

* 480 sample units tested for TPC, coliforms and *E. coli*; 368/480 units for staphylococci.
† Denotes NHMRC Approved Standards.

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Table 1 shows the geometric mean of the MPN of coliforms and *E. coli* and the geometric mean of *Staphylococcus aureus*. The number of sample units tested per month for each plant is shown in parentheses. The highest geometric mean of the MPN of coliforms and *E. coli* was 4·9/g (plant X) and 1·8/g (plant Y) respectively. Coliform organisms were not detected in the nine sample units received from plant Y in November. *E. coli* was absent in all sample units tested for the months December, January and March for plant A, December through February for plant B, December, February and April for plant C, January for plant X, and November, February and March for plant Y. The highest geometric mean number of staphylococci was 18·6/g (plants C and X). Staphylococci were not detected in all samples tested in December and March for plant A and November for plants B and X. *Salmonella* was not detected in the 480 sample units tested.

Table 2 illustrates the distribution of TPC, MPN of coliforms and *E. coli* and staphylococci obtained on samples taken from all 5 plants during the season. Of the 480 samples tested 346 (72·1 %) had TPC in the range of 10^3–10^4/g. Only 0·4 % of the samples had TPC exceeding 100,000/g. Coliforms and *E. coli* were not present in 76·1 and 92·7 % respectively of the total samples tested. Five (1 %) samples had MPN of more than 100 coliforms/g. Two (0·4 %) samples exceeded an MPN of 10 *E. coli*/g.

Staphylococcus aureus was isolated from 119 (32·3 %) samples. Sixty (16·3 %) samples had staphylococci exceeding 100/g. Of these, 30 samples came from plant C, and 14 from plant X.

DISCUSSION

Bacteriological standards which have been suggested by various sources in U.S.A. and U.K. for fish and fishery products and frozen precooked or partially cooked foods have been reviewed by Shewan (1970). Standards recommended by the National Health and Medical Research Council (NHMRC) of Australia (NHMRC, 1975) for frozen precooked foods are: aerobic plate count not greater than 100,000/g, *E. coli* (MPN) not greater than 9/g, *Staphylococcus aureus* not greater than 100/g, and absence of *Salmonella*. It will be seen that the numbers of organisms present in the lobster meat in this study are generally low and 82 % or more are within the limits suggested by the above sources. Only 0·4 % of the samples had TPC and *E. coli* in excess of 100,000/g and 9/g (MPN) respectively, the limits proposed by NHMRC. The low incidence of *E. coli* contamination and the absence of *Salmonella* indicate that employees were aware of and employed good personal hygiene practices.

The highest failure rate was with the test for staphylococci, where 16·4 % of the samples failed to reach the proposed NHMRC standards because they contained staphylococci in excess of 100/g. 50 % of these samples were from one plant (C). The main mode of infection of food by staphylococci is from the hands of the food handler or from his nose via his hands to the food (Troller, 1973), and indeed this has been shown to be the case when an investigation was carried out to determine the source of *Staphylococcus aureus* contamination in plant C. It was found that

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the bulk of the meat produced in this plant was contaminated by a packer who was a chronic nasal carrier of *Staphylococcus aureus*. Remedial action led to a significant decrease in the incidence of staphylococcal contamination and a dramatic drop in the number of staphylococci in the samples in March and April 1975 (Table 1).

The microbial quality of a product reflects the sanitary conditions under which the product is processed (Harrison & Lee, 1968; Olson & Shelton, 1973). Inspectional observations which formed the basis of assessing the sanitary conditions of the plants, indicated that sanitation was generally good throughout the season. The total (aerobic) plate count serves as a rough guide to plant sanitation and will fluctuate with production processes and time-temperature control of the product. Coliform organisms are associated most directly with equipment and employee sanitation (Varga & Anderson, 1968; Thatcher & Clarke, 1968). *Salmonella* and *E. coli* because of their association with the gastro-intestinal tract may be considered an indication of faecal contamination (McCoy, 1974; Cooke, 1974). Isolation of appreciable numbers of *Staphylococcus aureus* from food indicates direct human pollution of the product (Idziah, 1973). Hence, bacteriological studies are useful in determining whether a food has been prepared, packed or handled under unsanitary conditions. The results of this study clearly demonstrates the microbial content of precooked rock lobster meat attainable when good manufacturing practices are used. Further, the results obtained could serve as guidelines for action by commercial institutions and regulatory agencies in the formulation of microbiological specifications or standards.

The above work was carried out while I was a Food Microbiologist employed by the South Australian Fishermen's Co-operative Limited, Adelaide. I wish to express my gratitude to the Management for allowing me to publish the findings, Dr D. E. Bottrill for his helpful advice, Miss Nell Broadbent for her capable technical assistance and to various employees for their assistance and co-operation.

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