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Royal Melbourne Institute of Technology

Department of Applied Chemistry

Food Technology Unit

FISH CANNING QUALITY CONTROL AND NEW PRODUCT DEVELOPMENT

FINAL REPORT OF ACTIVITIES FUNDED BY THE FISHING INDUSTRY RESEARCH TRUST ACCOUNT (FIRTA):
OCTOBER 1981 — DECEMBER 1983

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FISH CANNING QUALITY CONTROL AND NEW PRODUCT DEVELOPMENT.

FINAL REPORT OF ACTIVITIES FUNDED BY THE FISHING INDUSTRY RESEARCH TRUST ACCOUNT (FIRTA): OCTOBER 1981 - DECEMBER 1983.

BY

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FOOD TECHNOLOGY UNIT
ROYAL MELBOURNE INSTITUTE OF TECHNOLOGY.

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Appendix 11 Warne, A.D. and Brown, N. Abalone canning: factors affecting product safety, sensory quality and profitability. Infofish Marketing Digest. 5: 42-44; 1984.

1. Introduction.

The Food Technology Unit at Royal Melbourne Institute of Technology (RMIT) completed in December 1983, a twenty seven month study (1 October 1981 - December 31, 1983), funded by FIRTA, on fish canning quality control and new product development. The grant funded two research assistants over the duration of the project. These were Mr.Daniel Capaul (October 1 1981 - December 31 1982) and Ms. Deborah Schaper (January 1 - December 31, 1983), both of whom were completing the final year in their B. App. Sci. (Food Science and Technology) degree at RMIT.

2. Summary of activities and major findings.

Throughout the period of the grant work was completed in the Food Technology Unit at RMIT, commercial canneries and Food Research Laboratories of CSIRO. At the start of the programme twelve export registered fish canneries received a letter offering an evaluation and confidential report of their canning operations; of those approached four manufacturers granted access to their canneries, while the remainder either declined on the grounds of confidentiality or failed to reply. The level of involvement in canneries varied according to the expertise of cannery personnel and the nature of products packed.

The results of these activities and those which were initiated in response to requests from cannery personnel are summarised in this report, under the following headings:

- Evaluation of thermal process schedules and retorting procedures
- Industry training
- New product development - abalone
- Processing of canned scallops
- Processing of canned tuna
- Thermobacteriology

2.1 Evaluation of thermal process schedules and retorting procedures.

Four export registered canners, manufacturing collectively canned abalone, canned tuna, canned scallops and canned fish paste,had their thermal process schedules evaluated, their retorts calibrated and retorting procedures assessed. In three cases manufacturers received a confidential detailed report (see Appendices 1, 2 and 3); the fourth canner received recommendations for significant reductions to the severity of this thermal processing schedule. In two cases, the manufacturers used data from these reports when filing their thermal process schedule with the Department of Primary Industry (DPI). One manufacturer's retort was found to be inadequate and incapable of operating according to good manufacturing practice guidelines; recommendations were adopted by the manufacturer and modifications made under guidance of RMIT.

2.2 Industry Training

The Abalone Fisherman's Co-operative at Mallacoota, Victoria installed a new abalone canning line during 1981. At that time the company had no expertise in canning and received assistance from RMIT when selecting and installing equipment and defining critical process parameters. Soon after the cannery opened, a three day in-house training course was conducted at the Co-operative for operators and line managers. The course provided training in the principles and applications of quality control for canned abalone manufacture. All participants were supplied a course manual. Less formal training took place at Russell Crayfish, Victoria where the technical assistant funded by the grant spent four weeks between October 1981 and September 1982, working with, and advising, quality control personnel during commercial canning operations. The writer and the technical assistant spent three days at Tasmanian Seafoods, evaluating thermal process schedules and calibrating retorts. As the factory manager was not familar with canning operations, time was allocated to demonstrate standard retort operating procedures and to discussion of the recommended methods for monitoring production at critical control points. Similar ad hoc training was carried out at Port Lincoln Tuna Processors while determining F_0 values for 425g tuna packs processed in crateless retorts.

2.3 New product development: canned abalone.

The major component of new product development related to the selection of processing conditions for manufacture of canned abalone. Initially this work was carried out in co-operation with the Abalone Fisherman's Co-operative at Mallacoota, which, prior

to the employment of a staff member from within the fish canning industry, had no experience in canning abalone; however some aspects of the product develpment programme were undertaken in conjunction with Tasmanian Seafoods Pty. Ltd., and Russell Crayfish Supply Ltd.
The objective of the programme was to determine the criteria of major importance in selection of process variables which when adopted would enable production of safe canned abalone, while providing adequate yields and profits for the canner and desirable sensory attributes for the consumer. The methodology and results of this research have been published in scientific journals (Appendices 4,5 and 6) and in trade journals as semi-technical papers (Appendices 7 to 11).
In summary new product development for canned abalone has identified three factors of importance to the manufacturer. These are:

2.3.1 Yields (weight loss on canning). Thermal processing can result in abalone weight losses in canning of over 30%. While "mild" processes protect yields, they have the disadvantage of producing a greater risk of underprocessing spoilage than would occur with "severe" processes, which although adequate with respect to the elimination of heat resistant bacteria,may be unsatisfactory because of their adverse effect on drained weight.
In Table 1 are shown the results of trials in which were studied the effect on yields of altering process time at constant retort temperature.

Table 1. The effect of retorting time at 115.6C on minimum F_o values and weight loss for canned fresh abalone[1]

Retorting time (min at 115.6°C)	Minimum F_o value[2] (min)	Average weight loss/abalone (%)
34	0.1	17.0
47	0.7	22.0
64	3.1	29.0
70	4.3	30.2

Note 1. Two abalone/can; maximum abalone weight = 180g

2. For slowest heating of 24 replicate cans $j=1.3$ and $f_h = 36$ min.

Frozen storage prior to thermal processing was found to decrease f_h values for comparably sized abalone and also reduce the yield after canning. The data in Table 2 reveal that freezing reduced f_h values by around 40%. This indicates that, while using frozen abalone stock, the processing time at constant temperatures required to achieve a target F_o of 2.8 min can be reduced by approximately 30%, (cf 62 min at 115.6°C for fresh abalone and 42 min at 115.6°C, for frozen abalone; when j is constant at 1.3 and initial product temperature=20°C). However this must be balanced against the disadvantages of extreme textural softening combined with increased weight losses.

Table 2. Comparison of f_h values for fresh and frozen abalone.

Number of abalone/can		Drained fill weight (g)	Range of weight for abalone in which thermocouple located (g)	Maximum f_h value (min)
Fresh	2	260-325	120-180	36.0
Frozen	2	285-329	136-176	21.0
Fresh	3	279-321	72-120	31.0
Frozen	3	291-312	85-140	18.8

Shown in Table 3 are the results of experiments evaluating the effect of retorting time at 115.6^{o}C on the weight loss of canned frozen abalone. Given this evidence, there seems little in favour of manufacturing canned abalone from frozen stock, other than the benefits that arise from achieving continuity of supply. Therefore, while maintenance of safety is of paramount importance during manufacture of canned fresh and canned frozen abalone, protectiom of yields cannot be neglected. While fetching around $23/kg drained weight for the canned product, it is not difficult to understand why this is so.

Table 3. Effect of retorting time at 115.6°C on weight loss for canned frozen abalone

Retort conditions (minutes at 115.6°C)	Abalone/can	Number of cans processed	Average loss on thermal processing	Minimum [a] F_o value (min)
45	2	4	36.5 (2)[b]]	3.5
45	3	7	37.7 (4)]	
50	2+	9	40.1 (9)]	4.7
50	2	1	40.0 (1)]	
60	3	5	41.5 (5)	7.4

a. Calculations based on $j = 2.0$
$f_h = 21$ min (Maximum individual abalone weight = 180g)
Initial product temperature = 20°C
Retort come-up time = 10 min.

b. Figures in parentheses show number of cans used in calculating average loss.

2.3.2 Product safety. Thermal processing schedules for canned abalone were evaluated in commercial canneries and the Food Technology Unit pilot plant. In all cases the minimum target F_o vaule was taken as one that would be sufficient to reduce to an acceptably low level, the probality of survival of heat resistant spores of the pathogenic bacterium Clostridium botulinum. According to good manufacturing practice this corresponds to a target F_o value of between 2.4 and 2.8 min.

Shown in Table 4 are the recommended minimum processing times, at various retort temperatures, required to deliver F_o values of 2.8 min for fresh abalone packed two, three or four per 74 X 118.5 mm can in which fill weights range from 260 to 332g and initial product temperature is 20°C.

The abalone used in generating the data shown in Table 4 were Blacklip (Haliotis ruber) taken from Victorian waters and processed at RMIT. Trials conducted in a commercial cannery using two Greenlip abalone (Haliotis laevigata) per can (seven replicate cans; maximum fill weight 320g) also yielded a maximum f_h of 36 mins, while the corresponding j value was 1.3. The similarity of results from pilot scale trials at RMIT and from commercial trials, reinforces the validity of these data, and the conclusion that abalone size must be considered a critical factor when calculating thermal processing conditions.

2.3.3 Sensory quality. Texture of canned abalone was shown to be influenced by thermal processing severity. Objective and sensory measurements of toughness revealed that following prolonged thermal processing, the flesh

Table 4. Recommended processing times required to deliver a least F_o value of 2.8 mins for abalone processed at various retort temperatures in 74 X 118.55mm cans.

Number of abalone per can	Maximum individual abalone weight (g)	Processing time at retort temperature				
		110°C (min)	113°C (min)	115.6°C (min)	118°C (min)	121.1°C (min)
2[1]	180	93	73	62	55	49
3[2]	120	88	68	59	52	46
4[3]	90	76	57	47	41	35

All calculations made by the modified Gillespy method described by Board and Steel (1978) and assume an initial product temperature of 20°C.

Note 1. Slowest heating replicate of 24 cans; j=1.3 and f_h=36 mins.

Slowest heating replicate of 24 cans; j=1.6 and f_h=31 mins.

Slowest heating replicate of 24 cans; j=1.4 and f_h=24 mins.

toughening, initially observed after a mild retorting cycle, was reversed, and that once this softening commenced, it became significantly greater as thermal processing seventy increased. Taste panel exercises demonstrated that based on the results provided by 90 Asian panelists, the texture of canned abalone was perceived to soften significantly ($P < .001$) as the process increased from 40 min at 118^{o}C to 60 min at 121.1^{o}C. The corresponding decrease in an objective measure of toughness (measured on an Instron 1140 food testing machine) was also significant ($P < .001$). The methodology for evaluating texture is described in Appendices 4,5 and 6. Selected results from these papers have been extracted and are shown in Tables 5 and 6.

Table 5. Effect of thermal processing conditions on mean force required to puncture slices of canned abalone 10mm thick.

Process conditions			
Time (min)	Retort Temperature (^{o}C)	Number of Measurements	Puncture force kg
40	115.6	54	2.13[a]
40	118.0	65	2.17[a]
40	121.1	32	2.11[a]
60	121.1	32	1.76[b]

Puncture forces designated with superscripts a and b are significantly different. ($P < .01$)

Table 6. Effect of thermal process treatment on objective (Instron) and sensory* assessment of the texture of abalone.

Thermal process treatment	Number of Instron measurements	Instron force Mean (kg)	Instron force S.E. (kg)	Sensory score Mean	Sensory score S.E.
None(uncooked)	58	0.38#	0.01	-	-
40 min at 118°C	147	2.30#	0.07	2.80¶	0.13
60min at 121.1°C	238	1.55#	0.03	1.81¶	0.08

* 90 Asian panelists' rating on 7 point category scale: extremely tender = 1, extremely tough = 7.

Hardness values significantly different (Kruskal-Wallis, $p < .001$)

¶ Sensory scores significantly different (Sign test, $p < .001$)

From these data (Tables 5 and 6), and those from a survey (see Appendix 4) which indicated that consumers prefer some residual flesh toughness, it can be concluded that abalone canners, while processing in order to achieve commercial sterility, ought not overprocess otherwise textural softening will become excessive. Thus the ideal thermal process will be one that delivers an adequate F_o value, without inducing extreme softening, while minimising the weight loss caused through retorting. It can be concluded therefore that abalone canners face a dilemma; they must balance the conflicting requirements of product safety against those for maximum yields and residual flesh toughness.

2.4 Processing canned scallops.

Following a request from a manufacturer, thermal processing procedures for the production of 180 g (drained weight) packs of canned scallops were investigated. The report of this investigation is presented in Appendix 1, which contains, in addition to results of an evaluation of F_o values, information on quality assurance, desirable seaming and an assessment of processing equipment. The canner's query arose following discovery of blown cans in exported stock; this gave rise to suspicion that either the thermal process may have been inadequate or cans had undergone post-processing contamination. There were no spoiled cans available for diagnosis, however heat penetration studies conducted in the cannery revealed that the scheduled process (30 minutes at 110°C) was insufficient to deliver an F_o value generally recognized as sufficient for low-acid canned foods (ie $\geqslant$ 2.8 min).

The results of two trials measuring the F_o value of the scheduled process are summarised in Table 7. The discrepancy in F_o values obtained via the General and Ball's methods are not considered significant, however, as the former is regarded as the reference method it is considered to be the more accurate.

A further trial was conducted in which thermal processing conditions were altered to 60 min at 111 °C. As shown by the results in Table 8, the modified process was sufficient to deliver a minimum F_o value of 2.8 min, the minimum acceptable for a pack of this nature.

It was found, however, that the subtle sensory qualities of scallops were destroyed by the severity of the modified process. Flesh colour, texture and flavour all became unacceptable, while drained weight losses were in the range of 35 to 40%. Acceptable sensory quality was only possible by reducing the target F_o value to 0.4 min, but were this process to be adopted the probability to *Clostridium botulinum* spores surviving would be, of the order of, ten thousand million times that generally recognized as acceptable for low-acid canned foods preserved by heat alone. It is because this risk is unacceptable that future development of a thermal process for scallops should concentrate on using acidified packs where the low pH of the medium precludes the growth of *Clostridium botulinum*.

Table 7. Summary of F_o values obtained when processing 180 g (nominal, drained fill weight) of scallops packed in 84 x 46.5 mm cans.

CAN NUMBER	RETORTING CONDITIONS (min)	RETORTING CONDITIONS (°C)	FILL WEIGHT (g)	INITIAL TEMPERATURE (°C)	F_o value: GENERAL METHOD (min)	F_o value: BULL's METHOD (min)
1	34	109	179	18	0.7	0.8
2	"	"	179	18	0.9	1.0
3	"	"	181	18	0.9	1.0
4	33	110	179	24	1.5	1.4
5	"	"	180	24	1.0	1.0
6	"	"	179	24	1.1	1.5

1. For all processes the scheduled thermal process was 30 min at 110°C with 10 min retort come-up time; variations due to errors in retort control.

Table 8. Summary of F_o values obtained when processing 180 g (nominal, drained fill weight) of scallops packed in 84 x 46.5 mm cans for 60 min at 111°C.

CAN NUMBER	FILL WEIGHT (g)	INITIAL TEMPERATURE (°C)	F_o value	
			GENERAL METHOD (min)	BULL's METHOD (min)
1	180	26	3.6	3.1
2	180	24	3.5	3.6
3	196	24.5	2.8	3.0

2.5 Processing of canned tuna.

It is well known that pack style (ie flake, chunk or solid) and pack weight affect the processing time, at constant temperature, required to deliver the target F_o value for a process; which is why strict control of fill weight is regarded as critical. The trials reported here consider the influence of fill weight for tuna packed in 425 g (99 x 68.5 mm) and 185 g (84 x 46.5 mm) containers.

2.5.1 Processes for 99 x 68.5 mm cans.

In July 1982 heat penetration studies were conducted, in one cannery, during production of 425 g cans of chunk style tuna in brine, packed in 99 x 68.5 mm containers. As F_o values delivered by the thermal process had not been determined since the commissioning of new retorts the manufacturer was anxious to confirm the adequacy of his processes.

During commercial production the following conditions were observed:

* The retort was brought to 102-103°C within 5 min and held at this temperature for a further 15 min, after which time it was brought to operating temperature within 5 min.

* Maximum product fill weight was 280 g.

* Minimum initial product temperature was 20°C; however at the completion of 15 min venting at 102-103°C this increased to a minimum of 47°C.

* After completion of the heating phase of the process, cooling was delayed for five to seven minutes.

Process F_o values were calculated (via the General method) over three retorting cycles in which heat penetration data were collected for a total of 12 cans. The results of these trials, which are summarized in Table 9, show that F_o values were far in excess of those required for tuna packed under conditions of good manufacturing practice. While it would not be unreasonable to select a target F_o value of 6 to 7 min , in order to be conservative a modified target F_o value of 10 min was recommended. Semi-log plots of the difference between retort and product temperature versus time for each of the twelve cans revealed that the maximum f_h value obtained was 38 min, and the corresponding j value was 1.3. Rounding the former to 40 min, the process time required to deliver a target F_o of 10min was calculated (via the modified Gillespy method) to be 63 min, when initial product temperature was taken as the minimum recorded at the end of 20 minutes venting - ie. 47°C. This means that even on an extremely conservative basis a 30% reduction in processing time was possible, without there being any significant risk to the commercial sterility of the canned product.

Early in 1983, the same manufacturer requested that RMIT complete heat penetration studies on their 425 g tuna packs in which maximum fill in weights had been increased to 310 g. Sample cans were packed and transported, unprocessed, to the pilot plant where f_h and j values were determined during processing at 115°C for 100 min. The range of values are shown in Table 10.

Table 9. Summary of F_o values[1] obtained for 425 g cans of tuna (chunk style in brine) packed[2] in 99 x 68.5 mm cans processed for 95 minutes at 121.1°C.

Process	Can Number	F_o value for each stage of processing			Total F_o Value	Amended[4] F_o value
		Heating (min)	Delay[3] (min)	Cooling (min)	(min)	(min)
1	1	70.3	7.5	0.2	78.0	70.5
1	2	58.4	7.5	2.9	68.8	61.3
1	3	64.3	7.5	3.1	74.9	67.4
1	4	60.2	7.5	3.0	70.7	63.2
1	5	65.4	7.5	3.1	76.0	68.5
2	1	64.9	5.0	3.1	73.0	68.0
2	2	69.8	5.0	4.5	79.3	74.3
2	3	64.0	5.0	4.5	73.5	68.5
3	1	59.9	7.5	4.6	72.0	64.5
3	2	65.0	7.5	3.0	75.5	68.0
3	3	75.9	7.5	2.0	85.4	77.9
3	4	70.6	7.5	5.0	83.1	75.6

1. F_o values calculated by the General method.
2. Maximum specified fill weight = 280 g.
3. Delay prior to cooling, after completion of heating phase.
4. Amended F_o value reduced by component arising from delay prior to cooling.

Table 10. Summary of f_h and j values obtained for chunk style tuna, packed 310 g/can in 99 x 68.5 mm containers.

Can Number	f_h (min)	j
1	44	1.7
2	42	1.4
3	42	1.7
4	29	2.0
5	29	1.8
6	45	1.7
7	47	1.8
8	37	1.7

Previous trials (at the cannery), when maximum fill weight was 280 g, indicated a maximum f_h of 38 min (which it will be recalled was rounded to 40 min for the purpose of calculating a conservative recommended process time required to deliver an F_o of 10 min). Thus it is apparent that the increase in maximum fill weight from 280 to 310 g, caused under worst-case conditions f_h to increase from 38 to 47 min. The effect of this change on processing time at various retort temperatures, given a constant target F_o of 10 min, is shown in Table 11. These data demonstrate that in order to deliver a constant target F_o value of 10 min,a 30 g increase in pack weight (from 280 to 310 g) must be compensated for by increases of 22% 24% and 27% in processing time at 116°, 118° and 121.1°C, respectively.

While these data were derived for conditions which may be peculiar to one manufacturer, the magnitude of the change in f_h value caused by alteration to filling weight, clearly demonstrates why all tuna canners must control this facet of production.

Table 11. Summary of processing conditions required to deliver an F_o value of 10 min for chunk style tuna packed in 99 x 68.5 mm cans.

Retort temperature (°C)	Process time: Fill weight 280 g[1] (min)	Process time: Fill weight 310 g[2] (min)
116	93	113
118	80	99
121.1	66	84

All calculations made by the modified Gillespy method described by Board and Steele (1978). No corrections made for retort come-up time.

Note: 1. Slowest heating of 12 replicate cans.
f_h = 38 min; j = 1.3; T_o = 20°C.

2. Slowest heating of 8 replicate cans.
f_h = 47 min; j = 1.8; T_o = 20°C.

2.5.2 Processes for 84 x 46.5 mm cans.

Preliminary studies at RMIT have quantified the relationship between fill weight and processing time for solid style tuna packed in 84 x 46.5 mm cans. Nine cans were hand filled to weights ranging from 140 to 180 g, filled with water to an 11 mm headspace, vacuum sealed (-80 kPa) using a Heine series D sealing machine and retorted. Shown in Table 12 are the f_h and j values for each of the nine packs and the processing times required at 116° and 121.1°C to deliver a target F_o value of 10 min.

Shown in Figure 1 are graphical representations of the relationship between pack weight and processing time calculated to deliver a target F_o value of 10 min. The graphs shown are the lines of best fit and the correlation coefficients are 0.901 and 0.904, respectively, for the 116° and 121.1°C processes.

These graphs make quite clear the dangers of overfilling. For example based on a specified maximum fill weight of 170 g, a 30 g overfill would make necessary increases of 26% and 28% for processing times at 116° and 121.1°C, respectively. Failure to compensate for over filling would not significantly affect risks to public health while the target F_o value was of the order of 10 min; however the risks increase as manufacturers select as their target, an F_o value closer to the recommended minimum for low-acid canned foods (F = 2.8 min).

As the graphs shown in Figure 1 are based on laboratory trials they ought not be used to determine processing times for

Table 12. Effect of fill weight on f_h and j values and processing times at 116° and 121.1°C required to deliver target F_o values of 10 min, for solid style tuna packed in 84 x 46.5 mm cans.

Drained fill weight (g)	j value	f_h value (min)	Process time* At 116°C (min)	Process time* At 121.1°C (min)
140	1.30	15.0	56.8	33.9
144	1.85	14.8	58.7	35.9
150	1.35	18.8	63.2	39.8
153	1.81	14.5	58.0	35.2
154	1.31	18.0	61.7	38.4
163	1.67	16.8	61.5	38.4
166	1.77	19.3	66.3	42.8
170	1.67	24.0	73.8	49.6
180	1.53	26.3	76.7	52.0

* Processing times calculated by the modified Gillespy method described by Board and Steele (1978). No corrections for retort come-up time (< 3 min); initial product temperature = 20°C.

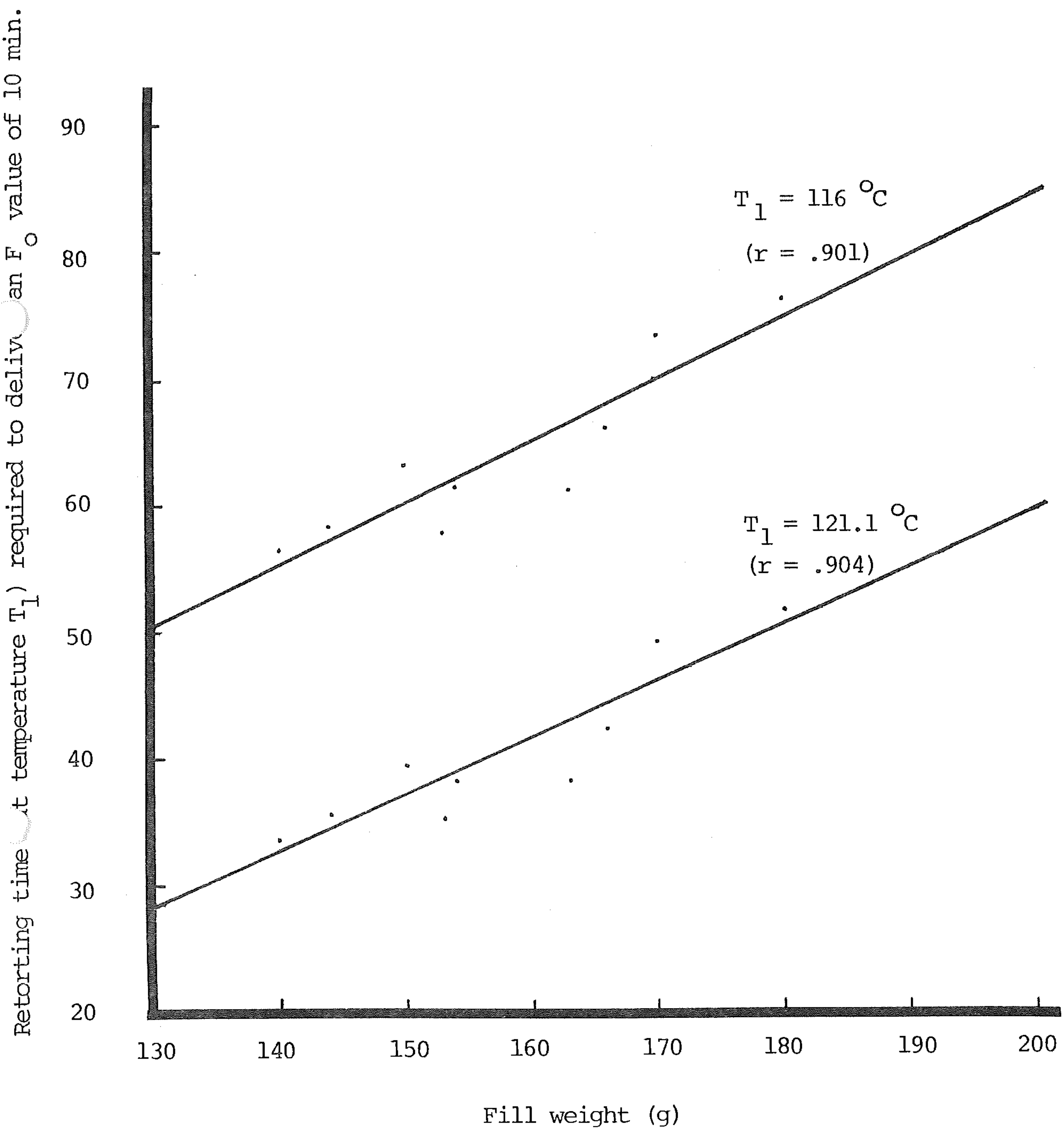

Fig 1. Effect of fill weight on retorting time required to deliver an F_o value of 10 min for solid style tuna packed in 84 x 46.5 mm cans. (Graphs represent lines of best fit drawn for heat penetration data shown in Table 12).

commercially packed tuna; however given the appropriate heat penetration data it would be a simple matter to prepare similar graphs for the conditions applying in individual canneries.

2.6 Heat resistance of FRRB *Bacillus stearothermophilus* FS1518. Procedures for evaluating the effect of sub-lethal processes on bacterial spores were developed. The project research assistant spent three days at C.S.I.R.O. Food Research Laboratories, North Ryde with Dr. W.G. Murrell where techniques for spore growth, harvesting and cleaning were demonstrated. Early efforts to harvest spores of *Bacillus stearothermophilus* from several sources were unsuccessful; it was only after the assistance given by Dr. Murrell that these problems were overcome.

2.6.1 Culture preparation.

A suspension of heat resistant FRRB *Bacillus stearothermophilus* FS1518 spores (culture supplied by C.S.I.R.O.) was produced in a sporulating medium consisting of yeast extract (0.5%), beef extract (0.3%), peptone (1%), $MnSO_4.4H_2)$ (10 micrograms/L), $CaCl_2$ (0.001%) and pH 8.2. The medium was incubated on an orbital shaker, operating at (240 rpm), at 55°C for 18h.

Spores were cleaned by centrifugation and washed with distilled water, after which they were treated with lyzozyme (0.3 mg/L), rewashed and stored at 4°C until required.

2.6.2 Determination of the heat resistance parameters, D value and Z value.

Survivor curves for the bacterial spores were prepared at 110°, 115° and 121.1°C and from there the corresponding D values were found to be 68, 15 and 3 min, respectively. The Z value of the test organism was 8°C.

The survivor curve determined at 121.1°C was not affected when, after exposure for 4 minutes, vials containing the spore suspension were temporarily removed from the heating medium (oil at 121.1°C), held at 100°C for 30 min and then returned to the oil bath. The rationale for introducing a delay in thermal destruction after four minutes exposure at 121.1°C, was to ascertain whether germination would occur; if so, spore numbers would be reduced and this would be reflected in a reduction in the time required to bring about their thermal destruction. Alternatively, it was considered that an interrupted heating cycle (ie. a sub-lethal process) may alter the slope of the survivor curve (ie alter the D value). These phenomena would have implications for the probability of spore survival in canned foods subjected an interrupted thermal process (as might occur should the steam supply be temporarily lost). However, in these preliminary trials, it was not possible to induce germination; and furthermore the slope of the survivor curve was not affected by interruption to the heat treatment.

To be successful, future work in this area will need to resolve difficulties of inducing spore germination after a sub-lethal process.

Appendix 1.

EVALUATION OF THE PROCESSING OF CANNED SCALLOPS

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CONTENTS

1. INTRODUCTION

1.1 To draw a process flow chart for the canning of scallops, from handling and transport at the raw scallop through to distribution of the canned product, as practiced by RUSSEL CRAYFISH.

1.2 To examine existing processing operations and to make any recommendations on current practices.

1.3 To evaluate current thermal processing equipment.

2. BACKGROUND

2.1 AIMS OF QUALITY ASSURANCE

To be able to assess the effectiveness and safety of canning operations it is necessary to establish routine checks and measurements throughout the process. These monitoring procedures are established by the company and carried out on a regular basis. This is known as QUALITY CONTROL.

QUALITY ASSURANCE is a larger concept which utilizes quality control as a tool to ensure that any possible error is minimised.

In order for a quality assurance programme to be successful it must be designed to incorporate all the areas of canning which may present a health risk to consumers. These areas of importance are known as CRITICAL POINTS and it is essential that they be controlled for a "fail/safe" operation.

3. PROCESS FLOW DIAGRAMS

3.1 Samples for process flow diagrams

Operation

Inspection

Transportation

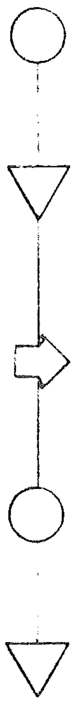
Delay or temporary storage

Permanent or controlled storage

Combined operation and inspection

3.2 Preparation of scallops

<u>DAY 1</u> <u>TASMANIA</u>



Scallops are harvested from the sea

Stored aboard the vessel. Conditions of storage unknown, duration should ideally be short ie. 1-6hrs.

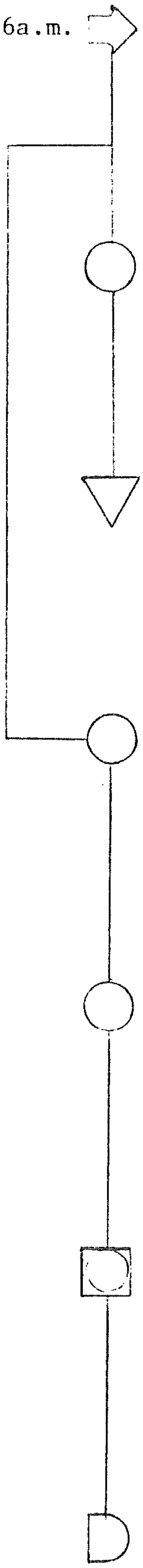
Transported to the docks

Shucked and packed into plastic bags. Weight-12kg.

Stored at 4°C overnight.

DAY 2

6a.m.



Scallops leave Tasmania and are transported to RUSSELL CRAYFISH. A process taking approximately 3 hrs.

Scallops are removed from the bags, washed and placed into plastic boxes, containing water

Boxes are stored at 4°C, ready for distribution

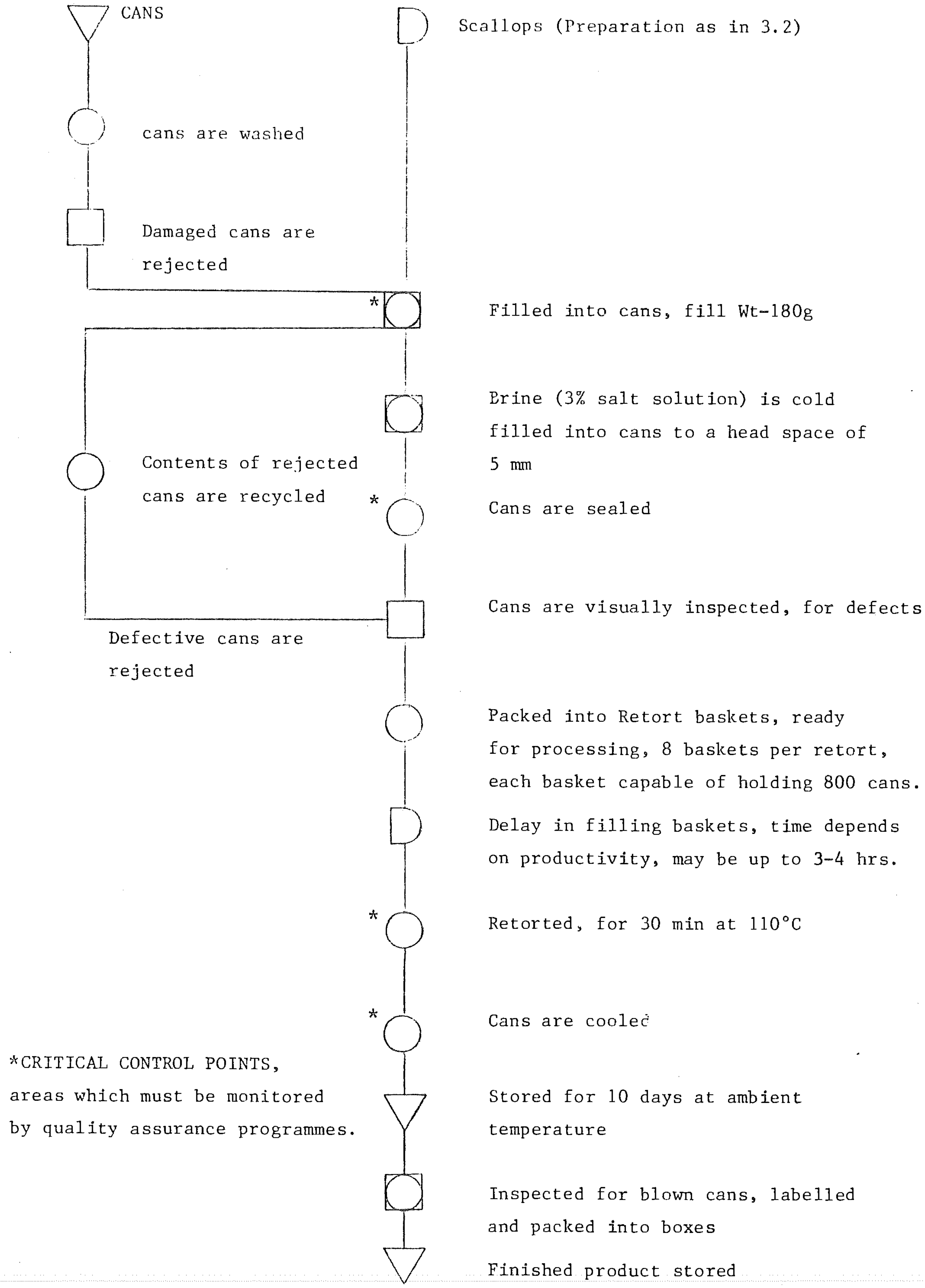
Scallops are removed from the bags, washed and allowed to drain on tables, ≈ ½ hr., ambient temperature.

Removed from the tables and placed into cool (23°C) salt water 3% for not less than 10 min.

Scallops removed from salt water and washed in cool (23°C) running water and then inspected.

Scallops ready for canning.

3.2 Canning Procedure



4: DISCUSSION

4.1 Preparation of Scallops

The procedure for the preparation of scallops used for canning was straight-forward and short. The quality of the raw scallops is expected to be good, providing that there are no major delays in preparation procedures.

4.2 Canning Operations

4.2.1 FILLING - SCALLOPS

CURRENT PRACTICE

180 g of scallops are weighed into each can to an accuracy of plus or minus 2g. This is performed manually. At no stage throughout the filling are weights checked by quality control or recorded.

COMMENTS

CRITICAL CONTROL POINT; FILL WEIGHTS MUST BE REGULARLY CHECKED AND RECORDED

Fill weights must be checked at least once every three hours during production, in order to ensure that the limits of fill, as established by management have been satisfied. These results must be recorded and kept for reference (See Appendix 4).

It is necessary to establish a lower and an upper limit of fill. Lower limits are set to satisfy labelling requirements, but this is not critical for safety, on the contrary limits of fill may become critical. This occurs as the thermal process has been based on the heat penetration for a specified fill weight. Cans which are incorrectly filled to a heavier fill weight may be underprocessed. Thus presenting a serious risk to the health of the consumer.

Upper limits of fill are not critical provided that heat penetration data are based on the heaviest pack weights.

4.2.2 FILLING - BRINE

CURRENT PRACTICE

Brine (3% salt solution) is cold filled, manually into cans to a head space of 5 mm.

COMMENTS

Providing that each can has a head space of approximately 5 mm, the filling procedure is not critical. However, it is still essential to monitor the filling procedure as overfilled cans will contain little or no vacuum. This will place stress on the seams during heat processing.

Vacuum readings should be taken on the cans after seaming at least once every three hours. These results should be recorded. Quality control must also ensure that each can is filled with brine, as no brine will influence the rate of heat penetration.

4.2.3 DOUBLE SEAMING

CURRENT PRACTICE

Cans are automatically fed to the seamer via conveyor belts. Once seamed, the cans are manually removed from the seamer and placed into retorting baskets. Cans which show visual signs of damage are rejected. Not all the cans coming from the seamer are inspected.

At no stage throughout the seaming process are tear down examinations performed. Instead a representative of a can manufacturer checks the seams twice weekly, making any adjustments necessary to the seamer.

COMMENTS

CRITICAL CONTROL POINT; CAN SEAMS MUST BE REGULARLY CHECKED AND RESULTS OF TEARDOWN AND VISUAL EXAMINATIONS MUST BE RECORDED. SEAM OVERLAP MUST EXCEED 55%.

Seam analysis of hermetically sealed containers to be used for canning scallops is critical to safe processing and requires constant surveillance. Teardown examinations must be performed as part of routine control and results must be recorded. It is unsatisfactory for the seam to be checked twice weekly, as management will not know the condition of the double seams throughout production.

The following must be performed to ensure that satisfactory double seams are maintained;

1. At least one can from each seamer is to be inspected for visual defects every 15 min. Observations are to be recorded. (See Appendix 5)
2. Teardown examinations of seams (Appendix 8) must be performed at intervals not exceeding four production hours, every time the machine is shut down and after adjustments have been made. Results of teardown examinations must be recorded. (See Appendix 6).

4.2.4 THERMAL PROCESSING

CURRENT PRACTICE

Canned scallops are processed for 30 min. at 230°F (110°C) in a static front loading retort. The retort temperature is indicated by a dial type thermometer located at the side of the retort. The process time, temperature and production date for each product is recorded in a log book.

Venting and come up times are neither specified nor recorded.

COMMENTS

CRITICAL CONTROL POINTS; MANAGEMENT MUST ENSURE THAT THE SCHEDULED PROCESS IS ADEQUATELY SPECIFIED AND CORRECTLY DELIVERED. DETAILED THERMAL PROCESSING RECORDS MUST BE KEPT.

The safety of canned scallops depends upon the adequacy of the thermal process. Processing requirements are established during product development and are based upon;

1. Container size and fill weight
2. Initial temperature
3. Expected type and level of bacterial contamination.

Heat penetration experiments were performed to establish the adequacy of the existing scheduled process. It was calculated that for a given process of 110°C for 30 min. the minimum Fo value obtained was .95. (see Appendix 1) The lethality of this process is in the order of 2.5 times UNDER that required for a 'botulinum cook' (Fo > 2.4). Hence the existing scheduled process is UNSAFE and must be amended in order to establish a safe process.

Heat penetration work was subsequently performed on a recommended process for scallops. (packed in 210g containers). This process, (111°C for 60 min.) was shown to be adequate with lethality values exceeding that required for a 'botulinum cook' (See Appendix 2).

It is essential that the severity of the existing thermal process be increased to a safe level. A scheduled process of 60 min. at 111°C has been shown to be adequate. A process of similar lethality MUST BE EMPLOYED FOR FUTURE PROCESSING.

Management must also ensure that the scheduled process is correctly delivered and that thermal processing records are kept. These records will demonstrate that past and present processing operations have been correctly performed. (See Appendix 7).

4.2.5 COOLING

CURRENT PRACTICE

Processed cans are cooled according to the following schedule;

1. the pressure in the retort is released,
2. after complete release of pressure the door is opened.
3. chlorinated cooling water is turned on. The water is sprayed from the top of the retort over the hot cans.
4. Cooling continues for approximately ½-1 hr.
5. Cans are removed from the retort and allowed to cool at room temperature. If the retort is not required, they are left to cool in the retort.

COMMENTS

CRITICAL CONTROL POINT: CANS MUST BE PROMPTLY PRESSURE COOLED TO AN INTERNAL TEMPERATURE BELOW 40°C.

Although the above method of cooling did not peak the cans, the ends were severely swollen and therefore strained after releasing the retort pressure. Upon cooling, the cans resumed their normal shape. This distortion may lead to post-processing leakage. It is recommended that cans be cooled under pressure to an internal temperature of below 40°C. Under no circumstance should cans be allowed to cool in the retort after being processed.

5. EVALUATION OF EXISTING THERMAL PROCESSING EQUIPMENT

Upon inspection of the retort and its instrumentation it was found that it did not comply with the Department of primary Industry's code of practice for canneries registered under the fish export Regulations Circular 157. (Appendix 9).

The equipment did not comply with regulations in a number of instances;

(1) Absence of a mercury in glass type thermometer (section 5.1 Circular 157)

(2) Absence of a temperature recording device (section 5.7 Circular 157)

(3) Absence of a steam controller valve (section 5.10 Circulat 157)

(4) Inability of the retort to pressure cool. (section 6.1.2 Circular 157)

COMMENTS

Due to the lack of automatic process control devices, it is not possible to maintain a steady retort temperature during processing. The retort operator controlled the retort temperature by manipulating the steam inlet and retort vent values until the desired temperature was reached. Unattended the retort temperature increased and/or decreased by as much 3°C.

The existing temperature measuring devices were evaluated to determine their accuracy. It was found that the thermometers (Dial type) were incorrect. (See appendix 3).

In order to be confident that a scheduled process can be accurately delivered processing equipment and control systems must be modernised and calibrated. The inadequacies in retort instrumentation mentioned above must be rectified before 'Department of Primary Industry' requirements for export fish canners can be fulfilled.

6. APPENDIX

APPENDIX 1: Fo values obtained for the existing scheduled process of 30 min. at 110°C.

CAN NUMBER	FILL WEIGHT (g)	INITIAL TEMP.(°C)	Fo VALUE (min. at 121.1°C)		
			HEATING	COOLING	TOTAL
1	179	24	.93	.55	1.48
2	180	24	.67	.28	.95
3	179	24	.73	.39	1.12

APPENDIX 2: Fo values obtained for the recommended process of 60 min. at 111°C.

CAN NUMBER	FILL WEIGHT (g)	INITIAL TEMP. (°C)	Fo VALUE (min. at 121.1°C)		
			HEATING	COOLING	TOTAL
1	180	26	3.16	.43	3.59
2	180	24	3.21	.32	3.53
3	196	24.5	2.46	.31	2.77

APPENDIX 3: Evaluation of existing retort thermometers

RETORT NUMBER 1

RETORT TEMP °C	110	113	114	115.5	116.5	118.5
RECORDED RETORT TEMP. °C	115.8	116.9	117.9	119.1	120.4	121.0
DIFFERENCE °C	+ 5.8	+ 3.9	+ 3.9	+ 3.6	+ 3.9	+ 2.5

RETORT NUMBER 2

RETORT TEMP. °C	115.5	117.0	119.0	120.0	121.5	122.0
RECORDED RETORT TEMP. °C	116.1	117.4	118.9	119.9	121.1	121.8
DIFFERENCE °C	+ .6	+ .4	- .1	- .1	- .4	- .2

RETORT TEMP. °C	Retort temperature as indicated by a 'dial type' thermometer located on the retort.
RECORDED RETORT TEMP. °C	Average temperature, of the retort as measured by three temperature probes placed at different positions inside the retort. Temperature difference between the probes ranged from .1-.4°C.
DIFFERENCE	Difference between Retort temperature and Recorded retort temperature.

APPENDIX 4: Example of a fill weight record form.

FILL WEIGHT (g)

OVER	IDEAL	UNDER
	180	

TIME

DATE

Can size

Product

APPENDIX 5: Visual seam inspection record form.

Date. ______________ Can size. ____________ Can code. ___________ Product. ______________

Time	Seamer No	Decision on seams		REMARKS
		Reject	Accept	

APPENDIX 6: Example of a form for recording double seam measurements

DATE. ____________ CAN SIZE. ____________ CAN CODE ____________

End Thickness (E.T) ________ Body Thickness (B.T) ________ 2(E.T)+B.T= ________ E.T+B.T= ________

TIME	Seamer No	Seam Length			Body Hook B.H			End Hook E.H			B.H+E.H min	% Overlap	Accept ✓ Reject ✗	Signed by

APPENDIX 7: Example of a daily process or production record form

DATE	PRODUCT	CODE	Container		Min I.T	R No	PROCESS		TIME				Actual process time	Thermometers		Signed by
			Size	No/R			TIME	TEMP	Steam On	Vent Closed	Temp UP	Steam Off		Mercury in Glass	Recorder chart	

APPENDIX 9: Department of Primary Industry's Codes of practice for canneries registered under the fish export Regulations. Circular 157.

Exports (Fish) Regulations

DPI CODE OF PRACTICE FOR THE THERMAL PROCESSING OF LOW-ACID CANNED SEAFOODS

The need to have codes of practice dealing especially with areas of food processing which may involve hazards to consumers is now widely accepted. One such area concerns the thermal processing of low-acid canned foods since failure to properly process these products may result in unsafe foods reaching consumers.

The Codex Alimentarius Commission has responded to the need to establish safe processing procedures by preparing a Draft Code of Hygienic Practice for Low-Acid and Acidified Low-Acid Canned Foods. (The latest draft of this Code was prepared in July 1979.) An Australian Standard for Equipment for Thermal Processing of Low-Acid Foods in Hermetically Sealed Containers is also being prepared by the Standards Association of Australia.

This Code of Practice was prepared specifically to satisfy the requirements of the Australian regulatory authorities and the canning industry and to ensure that safe low-acid canned foods are produced in this country. This Code of Practice is technically consistent with the Draft Codex Alimentarius Code and the draft Australian Standard on processing equipment.

1. SCOPE

This code of practice deals with the equipment and procedures used for thermal processing low-acid canned foods. The code is applicable to low-acid foods packaged in hermetically sealed rigid, flexible or semi-rigid containers and deals with the following types of processing equipment:

(a) batch retorts heated with saturated steam
(b) batch retorts heated with water under pressure
(c) continuous retorts
(d) hydrostatic cookers
(e) retorts heated with air steam mixtures
(f) aseptic systems
(g) flame sterilizers

2. DEFINITIONS

For the purpose of this code, the following definitions apply:

Bleeders (bleeds). Small valve-controlled orifices through which steam and other gases escape during the entire thermal process. Their purpose is to remove air which accumulates in the retort during the process and to promote circulation of the heating medium especially in the proximity of indicator/ controller probes.

Canned food. A food which is commercially sterile and packaged in an hermetically sealed container.

Code lot. Product produced during a period of time identified by a specific container code mark.

Come-up-time. The time, including venting time, which elapses between the introduction of the heating medium into the closed retort and the time when the temperature in the retort reaches the required processing temperature.

Commercially sterile. The term used to describe foods that are free of microorganisms which are capable of growing under the conditions the product is likely to encounter during storage and distribution.

When applied to processing equipment, the term means the equipment is free of microorganisms which are capable of growing in the food being processed in that equipment under the conditions the food is likely to encounter during storage and distribution.

Flame sterilizer. Thermal processing equipment in which cans are preheated to a uniform temperature and then passed over gas flames which heat the contents to the required processing temperature. The cans then move to a holding zone and are finally cooled. The cans rotate during heating and cooling and in some flame sterilizers special devices are also used to mechanically agitate the cans at those stages.

Headspace. The volume in a container not occupied by the food.

Hermetically sealed. The term used to describe containers which are closed so that the contents are protected against the entry of microorganisms and other materials.

Hydrostatic retort. A retort in which the pressure of the steam is maintained in the processing chamber by means of hydrostatic water legs. The hydrostatic legs also act as inlets and outlets to the steam dome to allow continuous throughput of containers.

Initial temperature. The temperature of the contents of the coldest container to be processed at the time the thermal process starts.

Low-acid foods. Foods with a pH of 4.6 or higher.

Retort. A pressure vessel in which containers of food are processed under pressure in steam or a steam/air mixture or water.

Scheduled process. The thermal process required to achieve at least commercial sterility in a given product in a given container.

Thermal process (heat sterilization process). The process in which a container of food is exposed to a defined heating medium at a specified temperature for a specified time so that the food is made commercially sterile.

Vent. A large valve-controlled opening in the retort installed in such a way as to allow thorough removal of air from the retort before timing of the process is started.

Venting. The operation whereby steam is used to purge the closed retort thoroughly of air before the thermal process is started.

3. PURPOSE OF THE THERMAL PROCESS

Thermal processes are primarily intended to render the food and the inside of the container commercially sterile.

The equipment and procedures used to apply thermal processe should be designed to ensure that each unit in the batch receives the same sterilizing treatment. The heating medium must therefore be delivered uniformly to all units in the batch and its composition and temperature must be known and controlled. Safe processing depends on the equipment and instrumentation being properly built, installed, maintained and operated to produce the conditions referred to above.

4. ESTABLISHMENT OF SCHEDULED PROCESSES

4.1 Scheduled processes for low-acid canned foods should be established only by competent persons having expert knowledge of thermal processing and having adequate facilities for making the appropriate measurements and calculations. Details of safe scheduled processes for a wide range of canned foods are available in the literature and from laboratories associated with the canning industry.

4.2 Scheduled processes are based on the temperature history of the slowest heating point in the container, the composition of the food, the likely number and type of possible spoilage microorganisms and the conditions the product is likely to encounter during storage and distribution. Variations in any of these factors may make the scheduled process inadequate and the product may then spoil as a result of the growth of microorganisms which survive the thermal process.

4.3 Complete records concerning all aspects of the establishment of the scheduled process, including any associated incubation tests, should be permanently retained by the processing plant or by the laboratory establishing the scheduled process.

4.4 The scheduled process should take account of established critical factors; for conventionally sterilized canned products the scheduled process should include at least the following data:-

Product code
Container size
Ingoing weight of product including liquor where appropriate
Minimum initial temperature
Type and characteristics of the heat processing system
Processing temperature
Processing time
Cooling method

4.5 Scheduled processes and venting procedures to be used for each product and container should be posted in a conspicuous place near the processing equipment. Such information should be readily available to the retort or processing system operator.

4.6 Only properly determined scheduled processes should be used.

4.7 Thermal processing and associated processing should be performed and supervised only by properly trained personnel.

5. INSTRUMENTATION OF THERMAL PROCESSING EQUIPMENT

5.1 Thermal processing equipment should be fitted with at least one indicating thermometer of the mercury-in-glass type. Other types of temperature measuring instruments may be used but they should have an accuracy and reliability equal to or better than mercury-in-glass thermometers.

5.2 Mercury-in-glass thermometers should have divisions that can be easily read to 0.5C and the scale should cover not more than 5C deg per cm.

5.3 Thermometers should be tested for accuracy in steam or water as appropriate under operational conditions against a known accurate standard thermometer. The tests should be made upon installation of the thermometers and at least once a year thereafter or more frequently as may be necessary to ensure their accuracy. A thermometer which deviates more than 0.5C deg from the standard should be replaced. A daily inspection should be made to detect mercury-in-glass thermometers with divided columns or other defects and these instruments should be replaced immediately.

5.4 Where other types of thermometers are used, routine tests should be made to ensure that they perform at least as well as mercury-in-glass thermometers. Thermometers which do not meet these requirements should be replaced immediately.

5.5. Bulb sheaths of indicating thermometers and probes of temperature recording devices should be installed either within the retort shell or in external wells attached to the retort. External wells should be equipped with an adequate bleeder which gives a constant flow of steam past the length of the thermometer bulb or probe. The bleeder for external wells should emit steam continuously during the entire processing period.

5.6 If water is used as the heating medium the bulb sheaths of indicating thermometers and probes of temperature recording devices should be installed so that the instruments give accurate readings and records respectively of the temperature of the water.

5.7 Thermometers should be installed where they can be accurately and easily read.

5.8 Heat processing equipment should be fitted with at least one temperature recording device. This recorder may be combined with a temperature controlling instrument. It is important that the correct chart is used for each device. Each chart should have a working scale of not more than 12C deg per cm within a range of 10C deg of the sterilizing temperature. The recording accuracy should be equal to or better than ±1.0C deg at the sterilizing temperature. The recorder should agree within 1.0C deg with the indicating thermometer at the sterilizing temperature. A means of preventing unauthorized changes in the adjustment should be provided. The chart timing device should be accurate.

5.9 Each retort should be equipped with a pressure gauge. The gauge should be checked for accuracy on installation and at least once a year. The gauge should have a range from zero such that the safe working pressure of the retort is about 66% of the full scale and the gauge should be graduated in divisions not greater than 10 kPa. The gauge dial should not be less than 100 mm in diameter. The instrument should be connected to the retort in a manner that does not impair its accuracy or sensitivity.

5.10 Each retort should be equipped with a steam controller to maintain the retort temperature. This may be a recording-controlling instrument when combined with a recording thermometer. The controller should be capable of maintaining the retort temperature within 1.0°C of the scheduled processing temperature.

6. SERVICES AND FITTINGS FOR HEAT PROCESSING EQUIPMENT

6.1 Batch retorts, steam heated.

6.1.1 The steam supply should be of sufficient capacity to bring the loaded retort to operating temperature in less than 15 min and to maintain a steady temperature throughout the process.

6.1.2 The retort should be supplied with water and compressed air at sufficient capacity to allow efficient cooling, whenever necessary under a super-imposed pressure of air.

6.1.3 The services should have efficient valves to prevent air and water entering the retort during the process.

6.1.4 The spreader should be designed to give as even a flow of steam and cooling water as possible throughout the retort. Usually the spreader and vent should be situated as far apart as practicable to aid in removing air during venting.

Perforated steam spreaders, if used, should be checked regularly to ensure they are not blocked or otherwise inoperative. Horizontal still retorts should be equipped with steam spreaders that extend along the length of the retort. The perforations in the spreaders should be directed so that they give uniform distribution of steam. In vertical still retorts the steam spreaders should be in the form of a cross or coil and again the perforation should be directed so that they give uniform distribution of steam.

The number and size of perforations in spreaders for both horizontal and vertical still retorts should be such that the total cross-sectional area of the perforations is equal to 1.5 - 2 times the cross-sectional area of the smallest part of the steam inlet line.

6.1.5 Bleeders should be of suitable size, e.g. 3 mm and properly located and should be wide open during the entire process, including the coming-up-time. All bleeders should be installed so that the operator can observe that they are functioning properly.

6.1.6 Vents should be designed, installed and operated so that air may be efficiently removed from the retort before timing of the heat process is started. Vents should not be connected to a closed drain system without an atmospheric break in the line.

6.1.7 Bleeders or steam traps should be fitted to remove condensate in steam-heated processing equipment. The outlets should be placed so that the operator can observe that the bleeders and steam traps are functioning properly.

6.1.8 Crates, trays, gondolas and divider plates for holding containers of product should be so constructed that steam can be circulated adequately among the containers during the venting, come-up and thermal process.

6.1.9 Crate supports in retorts should not substantially affect venting or distribution of steam.

6.1.10 An adjustable pressure relief valve of a capacity sufficient to prevent undesired increases in retort pressure and approved by the official agency responsible for inspecting pressure vessels should be fitted.

6.1.11 Retorts in which the containers are rotated or agitated should be fitted with a recording tachometer to provide a continuous record of the speed of the mechanism moving the cans. A means of preventing unauthorised speed changes on retorts should be ovided.

6.2 Batch retorts - water filled.

6.2.1 The appropriate requirements in 5 and 6.1 apply to this type of equipment.

6.2.2 The steam supply should be of sufficient capacity to bring the loaded water-filled retort to operating temperature within 20 min and to maintain the temperature during the process.

6.2.3 The retort should be supplied with sufficient compressed air for circulating the water in the retort to ensure even heating of all parts of the load. Alternatively an external pumping system should be used to circulate the water. The pump and associated pipe work should be protected against blockage by containers of product or extraneous material.

6.2.4 A pressure recording device should be fitted and may be combined with a pressure controller.

6.2.5 There should be a means e.g. a water gauge glass or petcocks, for determining the water level in the retort. The water level should be at least 15 cm above the top layer of containers in the retort during the come-up, thermal processing and cooling periods.

6.2.6 Retorts for pressure processing in water should be fitted with means for introducing compressed air to ensure that the required pressure is maintained in the retort during the process. The retort pressure should be controlled by an automatic pressure control unit. A non-return valve should be provided in the air supply line to prevent water from entering the air line.

6.3 Continuous retorts.

6.3.1 The appropriate requirements given in 5.6.1 and 6.2 apply.

6.3.2 The speed of the carrier mechanism should be adjustable and a device should be fitted to control and record the speed of the carrier. The speed of the carrier mechanism should be checked at least once a year and more frequently if necessary. An automatic device should be used to stop the carrier mechanism and provide a warning if the temperature of the heating medium drops below that specified in the scheduled process. A means of preventing unauthorized speed changes shall be provided.

6.4 Hydrostatic cookers.

6.4.1 The appropriate requirements given in 5, 6.1, 6.2 and 6.3.2 apply.

6.4.2 Thermometers should be located in the steam dome near the steam-water interface. Where the scheduled process specifies maintenance of particular temperatures or water levels in the hydrostatic water legs, at least one indicating thermometer should be located in each hydrostatic water leg so that it can be accurately and easily read.

6.4.3 The temperature recorder probe should be installed in the steam dome. Additional temperature recorder probes should be installed in the hydrostatic water legs if the scheduled process specifies maintenance of particular temperatures at these points.

6.4.4 The control of the container conveyor chain should be calibrated with an accurate stop watch and the calibration should be checked at least once a year and more frequently if necessary. The speed of the conveyor chain should also be continuously recorded. An automatic device should be used to stop the chain and provide warning if the temperature of the steam dome drops below that specified in the scheduled process. A means of preventing unauthorized speed changes should be provided.

6.5 Retorts heated with a mixture of air and steam.

6.5.1 The appropriate requirements given in 5 and 6.1 apply to this type of equipment.

6.5.2 The temperature, composition and the rate of circulation of the air/steam mixture are critically important in the operation of retorts heated with this medium.

6.5.3 There should be means of circulating the steam-air mixture to prevent formation of low temperature pockets. The circulating system used should provide acceptable heat distribution as established by adequate tests. A recording pressure controller should control the air inlet or the steam-air outlet. The temperature of the steam-air mixture should be controlled by a recording temperature controller fitted to the steam supply.

6.6 Aseptic systems.

6.6.1 Aseptic systems vary in construction and method of operation to a marked extent so each type should be operated according to the manufacturer's instructions. Essentially the equipment should be such that:-

(a) The product can be heat sterilized, cooled and where necessary homogenised, and held ready for filling under aseptic conditions;

(b) the container and closure can be sterilized before filling.

(c) the sterile product can be filled into the sterile container which can then be sealed under aseptic conditions.

The features of the equipment which are essential to ensure that a safe product is produced will depend on the construction and operation of the particular system. The period of exposure of the product, the package and the closure to the sterilizing agents should be controlled so accurate speed controls are needed. The concentration of chemical sterilizing agents should be controlled as should the temperature of heat sterilizing agents, e.g. saturated steam, superheated steam or hot gases. In addition the conditions required to sterilize the equipment before production is started, and to maintain sterility during production should be controlled.

6.6.2 The appropriate requirements given in 5 apply. The sensing element of the temperature measuring device should be installed in the product at the outlet of the holding section.

6.6.3 The sensor for the temperature recording device should be located in the product at the outlet of the holding section.

6.6.4 The sensor for the temperature controller should be located in the product at the outlet of the final heating section.

6.6.5 Where a product-to-product regenerator is used to heat the cold unsterilized product entering the sterilizer, the regenerator should be designed, operated and controlled so that the pressure of the sterilized product in the regenerator is greater than the pressure of the unsterilized product.

An accurate differential pressure recorder-controller should be installed on the regenerator. The scale divisions should be easy to read and should not exceed 10 kPa per cm on a working scale of not more than 140 kPa. The controller should be tested for accuracy against a known accurate standard pressure indicator upon installation and at least once every three months of operation thereafter or more frequently as may be necessary to ensure its accuracy. One pressure sensor should be installed where sterilized product leaves the regenerator and the other pressure sensor should be installed where unsterilized product enters the regenerator.

6.6.6 A metering pump should be located upstream from the holding section and should be operated so as to maintain the required rate of product flow. A means of preventing unauthorized speed changes should be provided. The product flow rate, which determines the sterilization holding time, should be checked at sufficient frequency to ensure that it is as specified in the schedule process.

6.6.7 The holding tube in the sterilizer should be designed to hold the product, including particulates, for at least the minimum holding time specified in the scheduled process; it should be sloped upward at least 20mm per metre. The holding section should be designed so that no portion between the product inlet and the product outlet can be heated.

6.6.8 The systems for container and closure sterilization, filling and closing should be fitted with appropriate instruments to ensure that all the scheduled conditions are achieved and maintained during presterilization and production. Automatic devices should be used to record, where applicable, the rates of flow and for the temperature of the sterilizing media. Where a batch system is used for container sterilization, the conditions of sterilization should be recorded. Automatic devices should be used to control the sterilization cycle at the rate specified in the scheduled process. A means of preventing unauthorized speed changes should be provided.

6.7 Flame sterilization.

6.7.1 The essential control factors in operating a flame sterilizer are:-

(a) the initial temperature of the product

(b) the period of heating and holding the cans before cooling

(c) the rate of agitation of the cans

(d) the position of the cans in relation to the flames

(e) the condition of the flames

(f) the temperature of the product as the cans leave the flames and enter the holding section.

Provision should be made to measure or observe each of these factors at sufficiently frequent intervals to ensure that all cans receive the scheduled process.

7. APPLICATION OF THERMAL PROCESSES

7.1 In addition to ensuring that the product has at least the minimum initial temperature specified in the scheduled process it is important to determine by frequent examination that those characteristics of the product that may influence the temperature history of the slowest heating point in the can are within the limits specified in the scheduled process. Such critical factors may include:-

Maximum net or drained weight.
Minimum headspace.
Consistency of the product.
The style of the product in instances where layering or stratification of components in the containers affects the rate of heat penetration during thermal processing.
Minimum closing vacuum (in vacuum-packed products).

7.2 Thermal processing should be started as soon as possible after closing to avoid microbial growth or changes in the heat transfer characteristics of the product.

7.3 In batch operations, all retort baskets or crates containing unretorted food product, or at least one of the containers on the top of each basket or crate should be plainly and conspicuously marked with a heat sensitive indicator.

7.4 The initial temperature of the contents of the coldest containers to be processed should be determined and recorded with sufficient frequency to ensure that the temperature of the product is no lower than the minimum initial temperature specified in the scheduled process.

7.5 Vents should be fully opened to permit rapid and total removal of air from steam-heated processing equipment before the pressure vessels are brought to operating temperature.

7.6 Air or water circulation in water-filled retorts should be continuous during the come-up, processing, and cooling periods. If air is used to promote circulation it should be introduced into the steam line at a point between the retort and the steam control valve at the bottom of the retort. All water circulation systems should be checked for correct operation during each processing cycle.

7.8 An accurate, clearly visible clock or other suitable timing device should be installed in the thermal processing room and times should be read from this instrument and not from wrist watches. Where two or more clocks are used in a thermal processing room they should be synchronised.

7.9 Before starting aseptic processing operations, the product sterilizer, the container and closure sterilizing systems, and the product filling and closing systems should be brought to a condition of commercial sterility.

7.10 In the event of a suspected loss of sterility in aseptic systems, production should be stopped and the system should be returned to a condition of commercial sterility before operations are resumed.

7.11 When the product temperature in the holding section of an aseptic system drops below the temperature specified in the scheduled process, the product in the holding section and any downstream portions affected should be diverted to recirculation or waste and the system returned to a condition of commercial sterility before flow is resumed to the filler.

7.12 When a regenerator is used in an aseptic system the product may lose sterility whenever the pressure of sterilized product in the regenerator is less than 7 kPa greater than the pressure of unsterilized product. If this condition occurs the product should be directed either to waste or recirculated until the cause of the improper pressure relationship has been corrected and the affected system has been returned to a condition of commercial sterility.

7.13 Containers of processed product should be cooled as rapidly as possible through the range of 60°C to 40°C to avoid the growth of thermophilic organisms. Unless otherwise indicated, extra pressure should be applied during cooling to compensate for the internal pressure inside the can at the beginning of cooling and to minimise the risk of deformation and leakage of containers.

7.14 In retorts processing glass jars, the cooling water should be introduced in a manner which avoids direct impingement on the jars to prevent breakage by thermal shock.

7.15 Cooling water should be of suitable microbiological quality, and should be chlorinated and maintained at a measureable level of residual chlorine, or be otherwise suitably treated.

7.16 Records should be kept of tests showing either that cooling water treatment was maintained or that the microbiological quality was suitable. Checks should be made on the water after cooling to ensure the presence of free residual chlorine.

7.17 If cooling water is chlorinated in the plant, there should be a sufficient contact time to reduce the microbial content of the water to a level which will minimize the risk of contamination of the can contents during cooling.

7.18 Where cooling water is recirculated insoluble matter should be separated and the water should be rechlorinated.

8. <u>POST-PROCESSING OPERATIONS</u>

8.1 Cooling and drying procedures should be conducted in a manner to protect against post-process contamination.

8.2 Heat processed products should not be handled while the seams and seals are wet. Manual handling should be avoided and the containers should be protected from mechanical shocks.

8.3 Conveyors and other equipment for handling processed containers should be kept clean, disinfected and dry. Where it is not possible to maintain such equipment in a dry condition, the equipment should be sprayed with an appropriate disinfectant on a continuous or semi-continuous basis during production.

8.4 Heat sensitive indicators attached to baskets or crates should be removed at the same time as the cans.

9. QUALITY ASSURANCE

9.1 Thermal processes should be properly established, correctly applied and sufficiently supervised and documented to provide positive assurance that the requirements of the scheduled process have been met.

9.2 Permanent dated records of time, temperature, code mark, and other pertinent details should be kept concerning each load.

These records should be made by the retort or processing system operator or other designated person, on a form which should include: product name and style, the code lot number, the retort or processing system and recorder chart identification, the container size, the approximate number of containers per code lot, the minimum initial temperature, the scheduled and actual processing time and temperature, the indicator and recorder thermometer readings and other appropriate processing data. Closing vacuum (in vacuum-packed products), fill-in weights or other critical factors specified in the scheduled process should also be recorded.

9.3 Prior to shipment or release for distribution, but not later than one working day after processing, an appropriate trained representative of plant management should review and ensure that all processing and production records are complete and that the product received the scheduled process. The records, including the recorder thermometer chart, should then be signed or initialled by the person conducting the review.

9.4 The records specified in 9.1 should be retained for not less then three years.

9.6 Whenever a process for a low-acid food is found to be less than the scheduled process, the processor of such low-acid food should either fully reprocess to commercial sterility that portion of the production involved, or segregate and retain that portion of the production involved for further evaluation of the processing records. Such evaluation should be made by competent processing experts in accordance with procedures recognized as being adequate to detect any potential hazard to public health. If this evaluation of the processing records demonstrates that the product has not been given a safe thermal process the segregated and retained product should either be fully reprocessed to render it commercially sterile or be destroyed under adequate and proper supervision. A record should be made of the evaluation procedures used, the results obtained and the actions taken on the product involved.

APPENDIX 8: CRITERIA FOR DOUBLE SEAM EAVLUATION

CRITERIA FOR DOUBLE SEAMS FOR TINPLATE CANS FOR HEAT PROCESSED FOODS*

PREFACE

Cans for heat processed foods must be hermetically sealed to protect the food from contamination by micro-organisms or other external agents. Therefore, to minimise the risk of the food being contaminated, the double seams of the cans must be properly constructed.

Every can manufacturer and every processor of canned foods shall have available appropriately trained and experienced technical personnel who know the characteristics required in a double seam and are competent in the techniques of measuring, inspecting and evaluating double seams. The training of personnel for the foregoing tasks shall include extensive detailed supervision and counselling as well as practice in seam appraisal standards and values over many weeks by a very experienced tutor. The trained personnel shall be assigned to perform a predetermined schedule of double seam evaluations and to ensure that necessary adjustments of closing machines are made to maintain double seams within acceptable limits.

This Appendix describes the characteristics required for an acceptable double seam and the permissible limits for the important double seam attributes. These limits take account of the accepted variations in the raw materials and methods used in can manufacture, and the capabilities of closing machines.

As canners and can manufacturers must aim to obtain a hermetic seal with every double seam they produce, they must try to form seams with attributes well within the recommended limits. This approach minimises the risk of non-hermetic seals being formed on the occasional can which may have unusual characteristics and it extends the time before drifts in closer settings make the seams unacceptable.

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* The preparation of these criteria was made possible by the co-operation of representatives of the following Companies and Organisations -

Containers Limited
J. Gadsden Pty. Ltd.
The National Meat Canners Association
CSIRO Division of Food Research
Bureau of Animal Health.

SECTION 1. SCOPE

These criteria define the characteristics of double seams on tinplate cans for heat processed foods, the methods used for assessing these characteristics, and the frequency with which the assessments shall be made by canners.

SECTION 2. DEFINITIONS

Body hook. The body hook is that portion of the double seam formed from the turned-back flange of the can body (Fig. 1). Optical methods shall be the reference methods in determining this attribute in instances of dispute, referred to a mutually recognised expert, as under section 3(2).

Compound. Compound is the sealing material, either latex or synthetic rubber, placed in the curl and on the seaming panel of the end. It serves to fill spaces within the double seam, and to assist in the formation of an hermetic seal.

Countersink depth. Countersink depth is the distance from the top of the double seam to the base of the chuck wall radius (Fig. 2).

Cut over. A cut over is a sharp projection at the inside top edge of the seam which may be associated with fracturing of the end plate (Fig. 6). See also 'sharp seam'.

Note: 1. The presence of fractures can only be determined by microscopic examination of properly prepared sections of the seam.

2. Cut overs and sharp seams are not in themselves evidence of an unsatisfactory double seam but do provide a first indication of incorrect adjustment of the closer heads, necessitating re-adjustment. Batches of cans showing either defect require very careful examination for evidence of fracture, with release only when the absence of fractures has been confirmed.

Cut seam. See 'fracture'.

Double seam. A double seam consists of five thicknesses of tinplate (seven thicknesses at the side seam juncture) interlocked or folded and pressed firmly together (Fig. 1). The double seam is produced by two operations; in the first operation the curled edge of the end is rolled under the flange of the can body to create an interlocked overlap of metal. The rolled body flange embeds in sealing compound contained within the end curl, so initiating the primary seal of the seam. During the first seaming operation, the curled edge of the end forms wrinkles around the circumference of the partially formed double seam because the diameter of the end flange is reduced. In the second operation, the five thicknesses of metal (seven at the side seam juncture) are pressed tightly together. This compression tends to flatten the wrinkles in the end hook and causes the sealing compound to flow around the edge of the end hook to complete the hermetic seal.

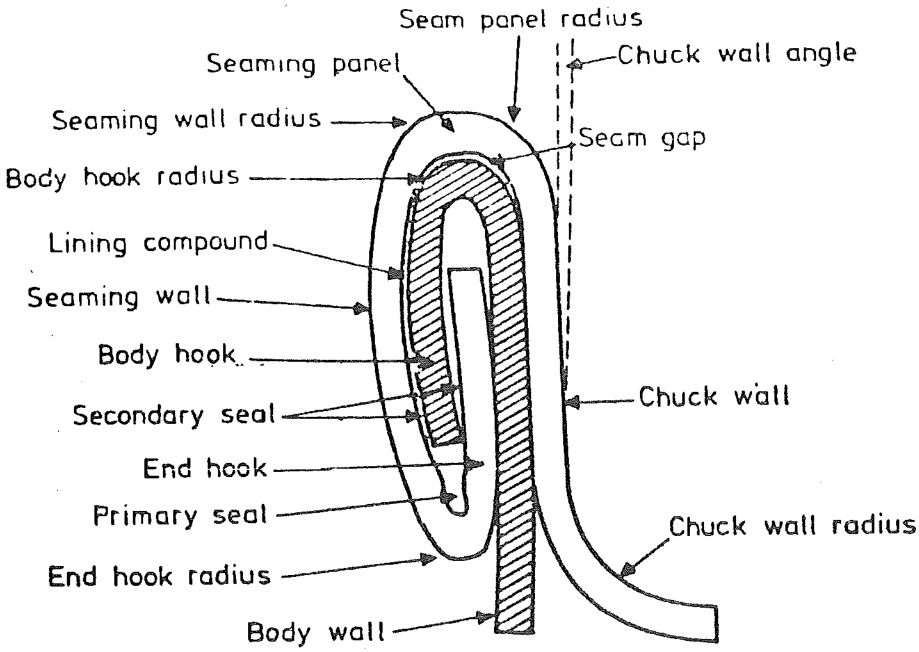


Fig 1. Typical structure of a double seam

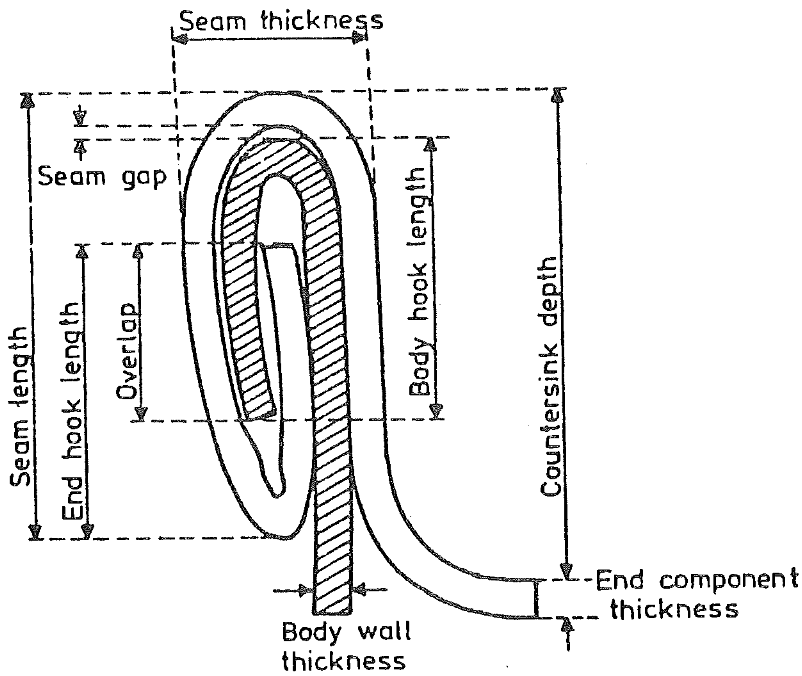


Fig 2. Standard names for the double seam components

Droop. See 'spur'.

Droop at juncture. The extra thicknesses of metal at the side seam may result in an external droop of the end hook and hence a local increase in seam length at the juncture (Fig. 3).

End hook. The end hook is that portion of the end which is turned back between the body and the body hook for the formation of the double seam (Fig. 2).

False seam. A false seam is a seam or portion of a seam where the end hook has failed to engage (ie. lock under) the body hook. If the folded body hook does not project below the seam, the false seam may only be detected on careful examination or sectioning. False seams may also be caused by bent ends or flanges on the cans.

Fracture or cut seam. A fracture or cut seam is a double seam in which the outer tinplate is split through, usually near the end hook radius.

Free space. Free space is the difference between the measured thickness of the seam and the sum of the thicknesses of the five layers of plate present in the double seam; it is calculated by using the formula:

Free space = Seam thickness - (2 (tb) + 3 (te))
where, (tb) is the measured body plate thickness and
(te) is the measured end plate thickness of the test can.

Note:

1. Single measurements of body plate thickness and end plate thickness are made on each test can and the results of these measurements are used with the results of the three or four measurements of seam thickness to calculate free space at the specified points on the double seam.

2. Where assessment is required by an importing destination, the free space shall not exceed 0.25mm. For non-round cans, a maximum free space of 0.33mm at any point of a corner may be permited. See also Section 6 b.

Hermetic seal. An hermetic seal is one which prevents micro-organisms and other materials entering a can.

Juncture. The region of the double seam which coincides with the side seam is called the juncture and is approximately 10mm wide (Fig. 3).

Juncture thickness. Juncture thickness is the dimension at the juncture of the side seam and the end double seam measured at right angles to the chuck wall.

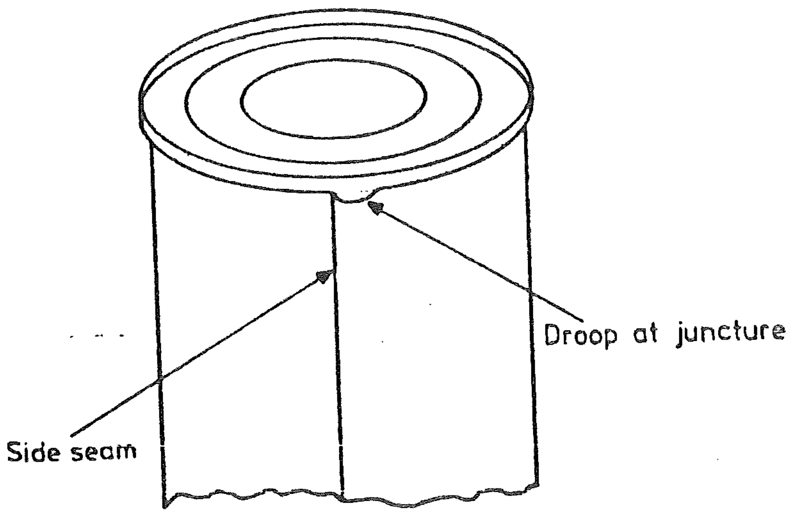


Fig 3. A droop at the juncture

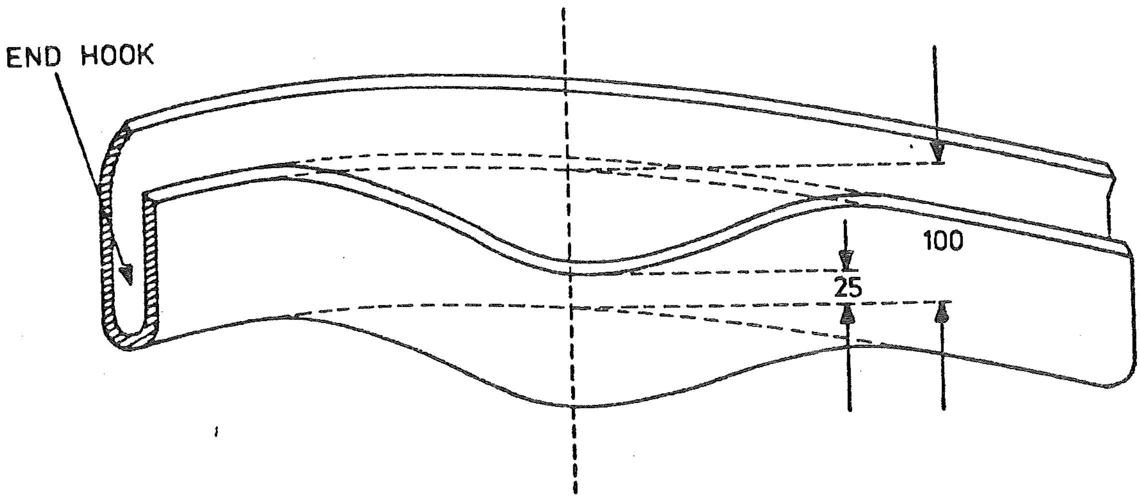


Fig 4. Assessment of juncture rating.

Lap. The lap occurs where two thicknesses of body plate are bonded together at the extremities of the side seam.

Percentage body hook butting. Percentage body hook butting is the distance occupied by the body hook expressed as a percentage of the total distance from the inside radius of the body hook to the inside radius of the end hook. Optical methods shall be the reference methods in determining this attribute in instances of dispute, referred to a mutually recognised expert, as under Section 3(2).

(i) Percentage body hook butting is calculated from measurements made on sections of the seam with a microscope or seam projector (Section 6.c) using the following formula:

$$\text{Percentage body hook butting} = \frac{b}{c} \times 100$$

where, b and c are shown in Fig. 5.

(ii) Percentage body hook butting may also be calculated from measurements of the components of the seam made with a micrometer using the following formula:

$$\text{Percentage body hook butting} = \frac{BH - 1.1tb}{SL - 1.1(2te + tb)} \times 100$$

where,
BH = body hook length
tb = body plate thickness
SL = seam length
te = end plate thickness

Percentage body hook butting may also be calculated using Table 1.

Note: Percentage body hook butting must be calculated only from the measurements taken at the same specified points.

Percentage juncture rating. Percentage juncture rating is a measure of the shortening of the end hook at the juncture, caused by the two additional thicknesses of bodyplate and solder at the side seam in three piece cans (Fig. 4). This extra metal prevents the end hook from being rolled under the body hook to the same extent as points away from the side seam.

Percentage overlap. Percentage overlap is the degree to which the body hook overlaps the end hook, expressed as a percentage of the total internal length of the seam (Figs. 2 and 5). Optical methods shall be the reference methods in determining this attribute in instances of dispute, referred to a mutually recognised expert, as under Section 3(2).

TABLE 1. PERCENTAGE BODY HOOK BUTTING

SEAM LENGTH (mm)

													SUM OF TWO END THICKNESSES AND ONE BODY THICKNESS (mm)
3.16	3.21	3.26	3.31	3.36	3.41	3.46	3.51	3.56	3.61	3.66	3.71	3.76	1.05
3.11	3.16	3.21	3.26	3.31	3.36	3.41	3.46	3.51	3.56	3.61	3.66	3.71	1.00
3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50	3.55	3.60	3.65	0.95
3.00	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50	3.55	3.60	0.90
2.95	2.99	3.04	3.09	3.14	3.19	3.24	3.29	3.34	3.39	3.44	3.49	3.54	0.85
2.89	2.94	2.99	3.04	3.09	3.14	3.19	3.24	3.29	3.34	3.39	3.44	3.49	0.80
2.83	2.88	2.93	2.98	3.03	3.08	3.13	3.18	3.23	3.28	3.33	3.38	3.43	0.75
2.78	2.83	2.88	2.93	2.98	3.03	3.08	3.13	3.18	3.23	3.28	3.33	3.38	0.70
2.72	2.77	2.82	2.87	2.92	2.97	3.02	3.07	3.12	3.17	3.22	3.27	3.32	0.65
2.67	2.72	2.77	2.82	2.87	2.92	2.97	3.02	3.07	3.12	3.17	3.22	3.27	0.60
2.61	2.66	2.71	2.76	2.81	2.86	2.91	2.96	3.01	3.06	3.11	3.16	3.21	0.55
2.56	2.61	2.66	2.71	2.76	2.81	2.86	2.91	2.96	3.01	3.06	3.11	3.16	0.50
2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85	2.90	2.95	3.00	3.05	3.10	0.45

BODY HOOK (mm) / BODY THICKNESS (mm)

0.10	0.15	0.20	0.25	0.30	0.35	0.40	0.45	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85	2.90	2.95	3.00	3.05	3.10
1.50	1.56	1.61	1.67	1.72	1.78	1.83	1.89	69	68	66	65	63	62	60	59	58	57	55	54	53
1.55	1.61	1.66	1.72	1.77	1.83	1.88	1.94	72	70	68	67	65	64	62	61	60	59	57	56	55
1.60	1.66	1.71	1.77	1.82	1.88	1.93	1.99	74	73	71	69	68	66	65	63	62	61	59	58	57
1.65	1.71	1.76	1.82	1.87	1.93	1.98	2.04	77	75	73	71	70	68	67	65	64	63	61	60	59
1.70	1.76	1.81	1.87	1.92	1.98	2.03	2.09	79	77	76	74	72	71	69	68	66	65	63	62	61
1.75	1.81	1.86	1.92	1.97	2.03	2.08	2.14	82	80	78	76	74	73	71	70	68	67	65	64	63
1.80	1.86	1.91	1.97	2.02	2.08	2.13	2.19	84	82	80	78	77	75	73	72	70	69	67	66	65
1.85	1.91	1.96	2.02	2.07	2.13	2.18	2.24	87	85	83	81	79	77	75	74	72	71	69	68	67
1.90	1.96	2.01	2.07	2.12	2.18	2.23	2.29	89	87	85	83	81	79	78	76	74	73	71	70	69
1.95	2.01	2.06	2.12	2.17	2.23	2.28	2.34	92	90	87	85	83	82	80	78	77	75	73	72	71
2.00	2.06	2.11	2.17	2.22	2.28	2.33	2.39	94	92	90	88	86	84	82	80	79	77	75	74	73
2.05	2.11	2.16	2.22	2.27	2.33	2.38	2.44	97	94	92	90	88	86	84	82	81	79	77	76	74
2.10	2.16	2.21	2.27	2.32	2.38	2.43	2.49	99	97	95	92	90	88	86	85	83	81	79	78	76
2.15	2.21	2.26	2.32	2.37	2.43	2.48	2.54	-	99	97	95	93	90	89	87	85	83	81	80	78
2.20	2.26	2.31	2.37	2.42	2.48	2.53	2.59	-	-	99	97	95	93	91	89	87	85	83	82	80
2.25	2.31	2.36	2.42	2.47	2.53	2.58	2.64	-	-	-	99	97	95	93	91	89	87	85	84	82
2.30	2.36	2.41	2.47	2.52	2.58	2.63	2.69	-	-	-	-	99	97	95	93	91	89	87	86	84
2.35	2.41	2.46	2.52	2.57	2.63	2.68	2.74	-	-	-	-	-	99	97	95	93	91	89	88	86
2.40	2.46	2.51	2.57	2.62	2.68	2.73	2.79	-	-	-	-	-	-	99	97	95	93	91	90	83
2.45	2.51	2.56	2.62	2.67	2.73	2.78	2.84	-	-	-	-	-	-	-	99	97	95	93	92	90
2.50	2.56	2.61	2.67	2.72	2.78	2.83	2.89	-	-	-	-	-	-	-	-	99	97	95	94	92

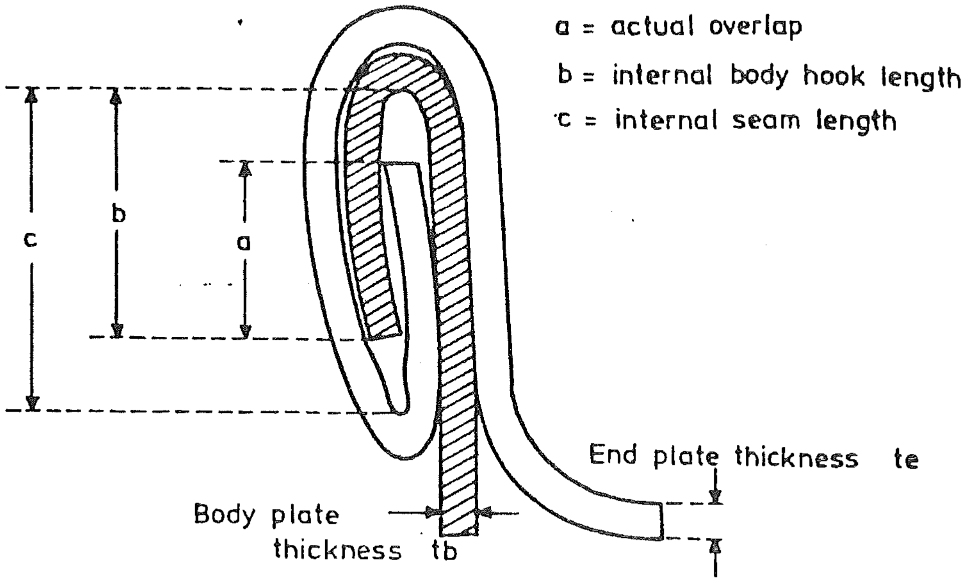


Fig 5. Double seam attributes

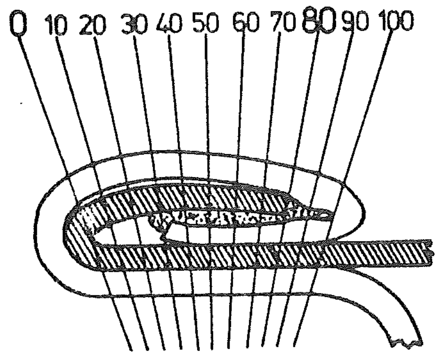


Fig 6. A typical graticule used for measuring percentage body hook butting and percentage overlap with a seam microscope

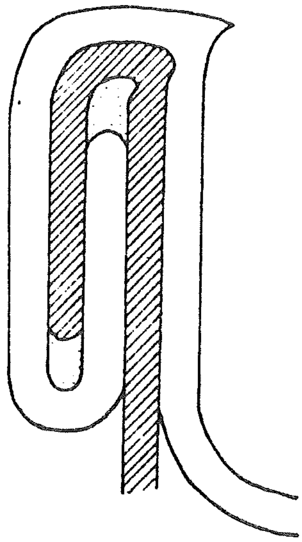


Fig. 7 Cross-section of double seam showing a 'sharp' seam. Note there is no evidence of fracture of the end plate.

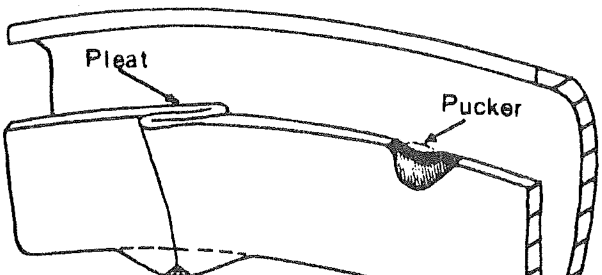


Fig. 8 End hook showing 'pleat' (with associated spur or droop) and 'pucker'.

(i) Percentage overlap is calculated from measurements made on sections of the seam with a microscope or seam projector (Section 6 c) using the following formula:

$$\text{Percentage overlap} = \frac{a}{c} \times 100$$

where, a and c are shown in Fig. 5.

(ii) Percentage overlap may also be calculated from measurements of the components of the seam made with a micrometer using the following formula:

$$\text{Percentage overlap} = \frac{EH + BH + 1.1te - SL}{SL - 1.1(2te + tb)} \times 100$$

where,
EH = end hook length
BH = body hook length
te = end plate thickness
SL = seam length
tb = body plate thickness

Percentage overlap may also be calculated using Table 2.

Note: Percentage overlap must only be calculated from the measurements taken at the same specified points on the double seam.

Percentage tightness rating. The compressive tightness of the double seam is measured by the extent of residual wrinkle in the end hook (Fig. 9). The tightness rating of a double seam is determined by the unwrinkled length of end hook expressed as a percentage of its total length. It is assessed at the point showing the lowest tightness rating on the end hook.

Pleat. A pleat is a fold in the metal of the end hook; it extends from the cut edge downwards towards the end hook radius and sometimes below this radius in a sharp droop or spur (Fig. 8).

Pressure ridge. The pressure ridge is a ridge formed on the internal surface of the can body adjacent to the bottom of the double seam. It is an impression of the chuck resulting from the pressure of the seaming rolls during seam formation (Fig. 10).

Pucker. A pucker is a condition which is intermediate between a wrinkle and a pleat; the end hook at the cut edge is locally distorted downwards without folding to form a pleat (Fig. 8).

TABLE 2. PERCENTAGE OVERLAP

SUM OF END + BODY THICKNESS (mm)								SEAM LENGTH (mm)													SUM OF TWO END THICKNESSES AND ONE BODY THICKNESS (mm)
								3.16	3.21	3.26	3.31	3.36	3.41	3.46	3.51	3.56	3.61	3.66	3.71	3.76	1.05
								3.11	3.16	3.21	3.26	3.31	3.36	3.41	3.46	3.51	3.56	3.61	3.66	3.71	1.00
								3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50	3.55	3.60	3.65	0.95
								3.00	3.05	3.10	3.15	3.20	3.25	3.30	3.35	3.40	3.45	3.50	3.55	3.60	0.90
								2.95	2.99	3.04	3.09	3.14	3.19	3.24	3.29	3.34	3.39	3.44	3.49	3.54	0.85
								2.89	2.94	2.99	3.04	3.09	3.14	3.19	3.24	3.29	3.34	3.39	3.44	3.49	0.80
								2.83	2.88	2.93	2.98	3.03	3.08	3.13	3.18	3.23	3.28	3.33	3.38	3.43	0.75
								2.78	2.83	2.88	2.93	2.98	3.03	3.08	3.13	3.18	3.23	3.28	3.33	3.38	0.70
								2.72	2.77	2.82	2.87	2.92	2.97	3.02	3.07	3.12	3.17	3.22	3.27	3.32	0.65
								2.67	2.72	2.77	2.82	2.87	2.92	2.97	3.02	3.07	3.12	3.17	3.22	3.27	0.60
								2.61	2.66	2.71	2.76	2.81	2.86	2.91	2.96	3.01	3.06	3.11	3.16	3.21	0.55
								2.56	2.61	2.66	2.71	2.76	2.81	2.86	2.91	2.96	3.01	3.06	3.11	3.16	0.50
0.30	0.35	0.40	0.45	0.50	0.55	0.60	0.65	2.50	2.55	2.60	2.65	2.70	2.75	2.80	2.85	2.90	2.95	3.00	3.05	3.10	0.45
SUM OF BODY AND END HOOKS (mm)																					
3.45	3.51	3.56	3.62	3.67	3.73	3.78	3.84	56	52	48	45	41	38	35	32	30	27	25	22	20	
3.50	3.56	3.61	3.67	3.72	3.78	3.83	3.89	58	54	51	47	44	41	38	35	32	29	27	24	22	
3.55	3.61	3.66	3.72	3.77	3.83	3.88	3.94	61	57	53	49	46	43	40	37	34	31	29	26	24	
3.60	3.66	3.71	3.77	3.82	3.88	3.93	3.99	63	59	55	52	48	45	42	39	36	33	31	28	26	
3.65	3.71	3.76	3.82	3.87	3.93	3.98	4.04	66	62	58	54	51	47	44	41	38	35	33	30	27	
3.70	3.76	3.81	3.87	3.92	3.98	4.03	4.09	68	64	60	56	53	49	46	43	40	37	35	32	29	
3.75	3.81	3.86	3.92	3.97	4.03	4.08	4.14	71	66	62	59	55	52	48	45	42	39	37	34	31	
3.80	3.86	3.91	3.97	4.02	4.08	4.13	4.19	73	69	65	61	57	54	51	47	44	41	39	36	33	
3.85	3.91	3.96	4.02	4.07	4.13	4.18	4.24	76	71	67	63	60	56	53	49	46	43	41	38	35	
3.90	3.96	4.01	4.07	4.12	4.18	4.23	4.29	78	74	70	66	62	58	55	52	48	45	43	40	37	
3.95	4.01	4.06	4.12	4.17	4.23	4.28	4.34	81	76	72	68	64	61	57	54	51	47	45	42	39	
4.00	4.06	4.11	4.17	4.22	4.28	4.33	4.39	83	79	74	70	66	63	59	56	53	49	47	44	41	
4.05	4.11	4.16	4.22	4.27	4.33	4.38	4.44	86	81	77	73	69	65	61	58	55	52	49	46	43	
4.10	4.16	4.21	4.27	4.32	4.38	4.43	4.49	88	83	79	75	71	67	64	60	57	54	50	48	45	
4.15	4.21	4.26	4.32	4.37	4.43	4.48	4.54	91	86	81	77	73	69	66	62	59	56	52	50	47	
4.20	4.26	4.31	4.37	4.42	4.48	4.53	4.59	93	88	84	80	76	72	68	64	61	58	54	51	49	
4.25	4.31	4.36	4.42	4.47	4.53	4.58	4.64	96	91	86	82	78	74	70	66	63	60	56	53	50	
4.30	4.36	4.41	4.47	4.52	4.58	4.63	4.69	98	93	89	84	80	76	72	69	65	62	58	55	52	
4.35	4.41	4.46	4.52	4.57	4.63	4.68	4.74	-	96	91	87	82	78	74	71	67	64	60	57	54	
4.40	4.46	4.51	4.57	4.62	4.68	4.73	4.79	-	98	93	89	85	80	77	73	69	66	62	59	56	
4.45	4.51	4.56	4.62	4.67	4.73	4.78	4.84	-	-	96	91	87	83	79	75	71	68	64	61	58	
4.50	4.56	4.61	4.67	4.72	4.78	4.83	4.89	-	-	98	94	89	85	81	77	73	70	66	63	60	
4.55	4.61	4.66	4.72	4.77	4.83	4.88	4.94	-	-	-	96	91	87	83	79	75	72	68	65	62	
4.60	4.66	4.71	4.77	4.82	4.88	4.93	4.99	-	-	-	98	94	89	85	81	78	74	70	67	64	

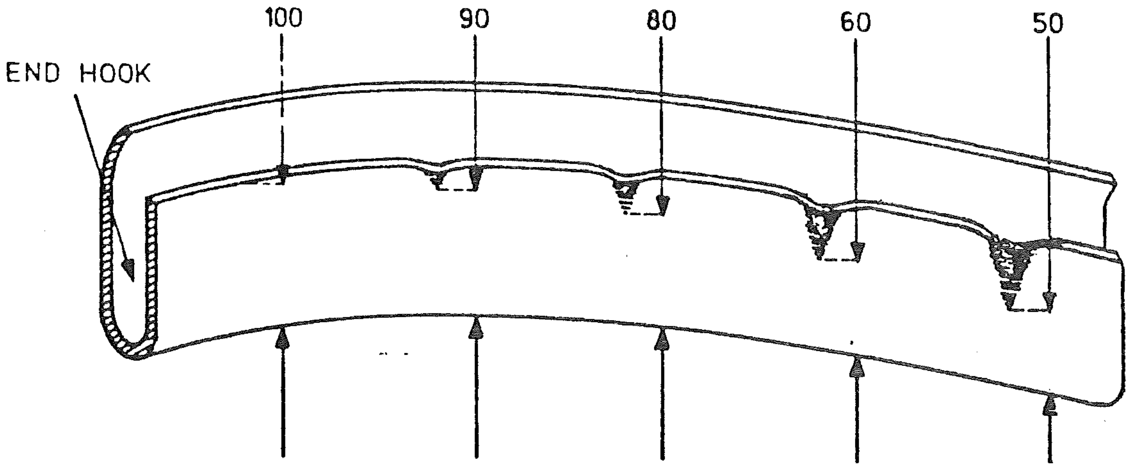


Fig 9. The percentage tightness rating is determined by examining the inside surface of the disengaged end hook for wrinkles. The tightness rating given to a double seam is determined by the unwrinkled length of end hook expressed as a percentage of its total length and is assessed at the point showing the lowest tightness rating on the end hook.

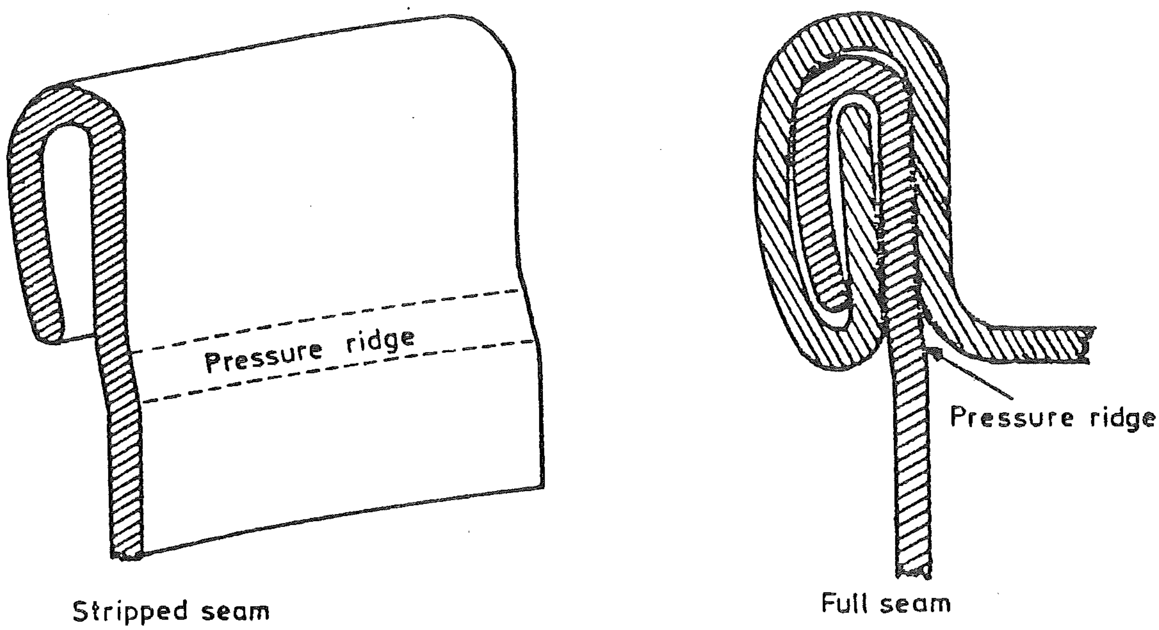


Fig 10. Pressure ridge at a stripped and complete seam

Seam length. Seam length is the maximum dimension of a seam measured parallel to the axis of the can (Fig. 2).

Seam thickness. Seam thickness is the maximum dimension of the seam measured at right angles to the chuck wall (Fig. 2).

Sharp seam. A sharp seam is a small sharp projection formed at the inner top edge of the double seam which may or may not be associated with fracture of the end plate (Fig. 7); see also 'cut over'.

Side seam. The side seam is the seam formed along the length of the can body usually by butting or hooking the edges of the body blank, and then welding or soldering.

Skidder. A skidder is characterised by a thickening of the double seam caused by incomplete operation of the double seaming rolls.

Spurs and Droops. Spurs and droops are projections of metal below the double seam at points away from the juncture (Fig. 8).

Wrinkles. During double seaming the diameter of the can end is reduced and the tinplate in the end hook develops waves or wrinkles which extend from the cut edge of the end hook towards the end hook radius (Fig. 9).

SECTION 3. ACCEPTABILITY OF DOUBLE SEAMS

3.1 A double seam is acceptable if it meets all of the following criteria:

a. it is free of defects which are likely to impair the barrier properties of the seam such as fractures and fractured cut overs, or spurs, droops, skidders, false seams, etc., which are readily visible to the eye;

b. the attributes:-
   body hook length,
   percentage overlap,
   percentage body hook butting,
   percentage tightness rating, and
   percentage juncture rating,
comply with the specifications supplied by the can manufacturer;

c. the pressure ridge shall be visible to the eye and continuous in round cans. In non-round cans the pressure ridge shall be visible at the corners and nose of the can but may be light elsewhere at the seam; and

d. The compound shall appear to be present in sufficient amount and properly distributed to ensure the seam constitutes an hermetic seal.

Note: The assessment of the compound depends to a large extent on judgement and experience. In assessing the compound it must be remembered that it will be grossly disturbed if the seam is dismantled. However the compound should be clearly visible in properly prepared cross-sections of seams.

3.2 If the seam does not meet these criteria it is assumed to be unsatisfactory. However, when a can seam does not meet these criteria the canner shall have the option (with the agreement of the Veterinary Officer-in-Charge of the State/Territory) of submitting samples for an independent assessment of the seam by a mutually recognised expert. Such samples shall be selected and submitted in consultation with inspection staff. The final decision as to the disposition of such product shall rest with the Central Office of the Bureau of Animal Health.

3.3 Can manufacturers may also supply specifications for other attributes of double seams to assist, for instance, in adjusting closing equipment. Certain overseas countries may require the assessment of other can seam attributes in which case the can manufacturer shall provide the required additional specifications.

SECTION 4. SPECIFICATIONS TO BE SUPPLIED BY THE CAN MANUFACTURER

Can manufacturers shall provide specifications for the double seam attributes listed above for each type of can. The specifications may be different for the canner's and can manufacturer's double seam on the one can.

The following specifications are appropriate for most types of can but can manufacturers may specify different limits if, in their opinion, the seams complying with these limits are hermetic. It must be emphasised that the following specifications should be regarded as the limits for safe seams under usual commercial conditions. Can manufacturers and canners should therefore aim to produce seams with attributes well within these specifications to minimise the risk of any can in a batch not being hermetically sealed.

Percentage overlap.

Round and non-round cans: 45% min.

Percentage body hook butting.

Round and non-round cans: 70% min.

Percentage tightness rating.

a. Tightness rating

Round cans	70% min.
Non-round cans	60% min.

For non-round cans which have corner radii less than 20mm the percentage tightness rating for the corners will be set by the canmaker.

b. Free space
Limits to be set by the canmaker.

Percentage juncture rating.

All types of can	50% min.

Body hook.

All types of can	Nominal value - 0.20 mm min.

SECTION 5. FREQUENCY OF INSPECTION OF DOUBLE SEAMS

a. On receipt of consignments of cans and ends from the can manufacturer.

The canner shall examine each consignment of cans and ends to determine that they are suitable for use. One of the sampling plans described in Australian Standard AS 1199-1972, "Sampling Procedures and Tables for Inspection by Attributes", should be used to sample each consignment.

Alternatively an arbitrary number of cans or ends, say fifty, could be randomly selected from each consignment.

- The ends should be assessed visually for defects and to determine that the compound is continuous and properly placed. The consignment shall be retained for re-inspection, or rejected, if one or more of the ends is defective.

- The cans should be assessed visually for defects of the types listed in Section 3 a, and the side seam and lap should also be inspected, especially for solder or welding faults. The consignment shall be retained for re-inspection, or rejected, if one or more of the cans is defective.

Five randomly selected dry cans should be tested for gross leaks by applying internally an air pressure of 20 kPa. The consignment shall be retained for retest, or rejected, if any can leaks.

The can manufacturer's seam should be examined (Section 3 b, c and d) on five randomly selected cans. If the attributes of the seams on any of the cans are outside specification, the consignment shall be retained for re-inspection, or rejected.

If a consignment is retained as a result of any of the three assessments (visual examination, pressure test and seam structure) the consignment may be re-inspected/retested. For re-inspection or retesting, the sample sizes shall be doubled and the acceptance tolerances shall remain unaltered.

b. During production runs.

At least one can from each closer head should be inspected for visual defects (see Section 3 a) every 15 minutes of operation and immediately after jams and blockages are cleared from the closer. A detailed examination of seams shall be made if visual inspection suggests that the seams may be unacceptable.

Cans for detailed examination of the seams (see Section 3 b and c) shall be taken from each closer head at the start of each production shift; after adjustment of the closer head; and at intervals not to exceed four production hours thereafter. If the dimensions of the seam are to be determined using a micrometer one can will be required from each head at each examination. However, two consecutive cans will be required if the dimensions are to be measured using optical instruments; the second can is required to assess percentage tightness, percentage juncture rating and the pressure ridge.

If a can is found to be unacceptable, additional cans from the same head should be examined to verify the result. If any of the additional cans have attributes which fall outside the specified values, corrective action must be taken at once. If they are within specification production may be continued.

Canners may examine both the canner's and can manufacturer's seams on the cans sampled from their closers during production runs. Notwithstanding this, canners shall routinely assess the can manufacturer's seam when consignments of cans are received at the cannery as in 5 a.

SECTION 6. MEASUREMENT OF SEAM DIMENSIONS

a) Location of measurements.

Round cans. Measurements shall be made:

(i) about 15mm to the left of the side seam;
(ii) about 15mm to the right of the side seam; and
(iii) opposite the side seam.

Rectangular and square cans. Four measurements shall be taken on the seam about 10mm from the tangent points (Fig. 11). The corners of rectangular and square cans shall be inspected to determine that they have a satisfactory structure because it is often impossible to make meaningful measurements at these points. When measurement of countersink is required, it shall be made at the mid-point of each corner.

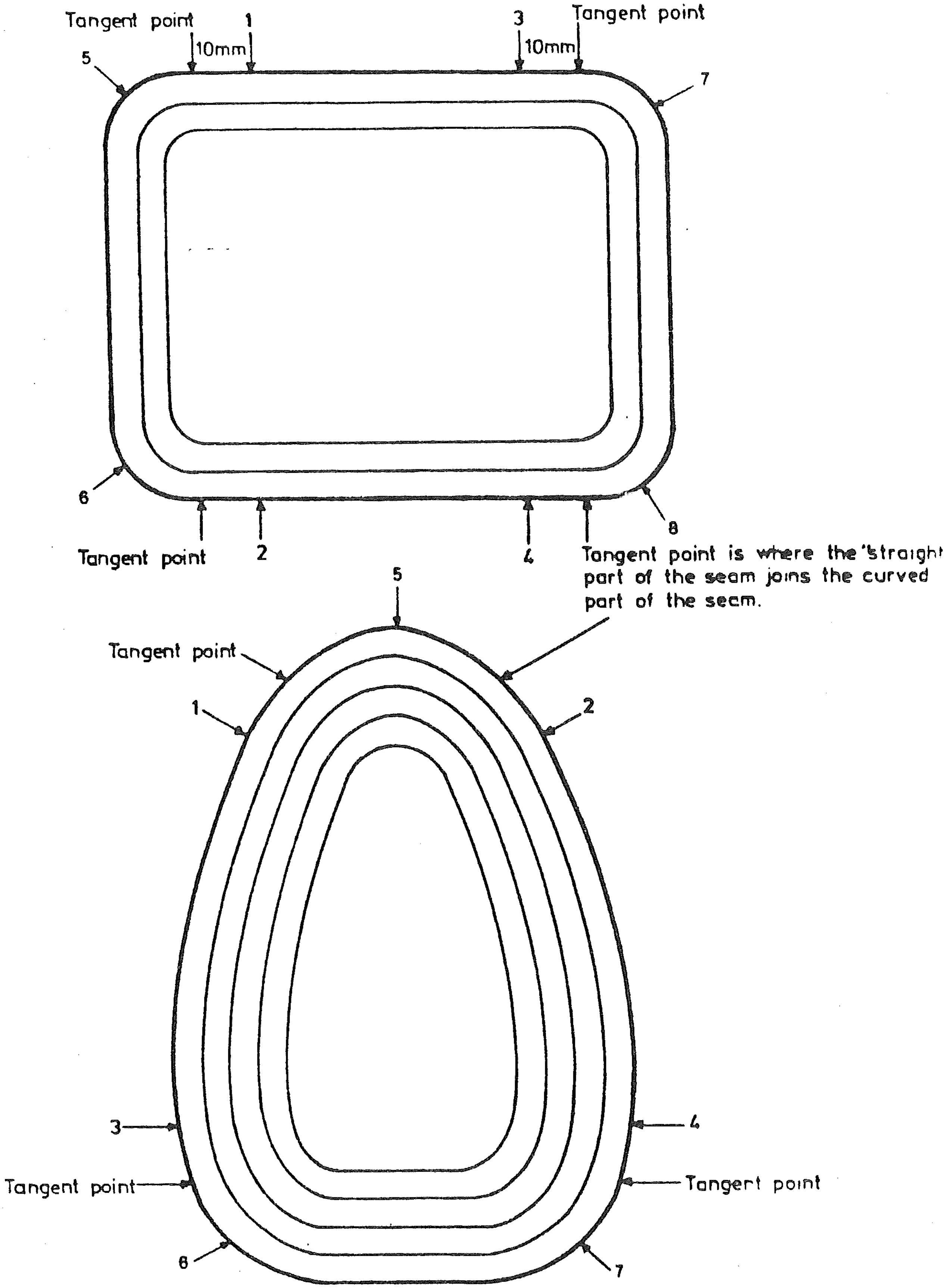


Fig. 11 Typical points for assessing the double seam are 1, 2, 3, and 4 and at the side seam juncture, and 5, 6, 7 and 8 for countersink.

Pear shaped cans. Measurements shall be made about 10mm from the tangent points on the long side away from each corner (Fig. 11). The corners of these cans shall be inspected to determine that they have a satisfactory structure. When measurement of countersink is required, it shall be made at the mid-point of the nose and each corner.

b) Measuring instruments.

Can seam micrometers shall be in good condition, properly adjusted to zero and shall have an accuracy of at least ± 0.01mm. Optical instruments shall allow measurements of the seam components to be made to at least ± 0.01mm.

When free space is to be determined the thickness of the body plate and end plate shall be measured at a point at least 10mm from a cut edge. A dial gauge or a micrometer (ball anvil or pointed anvil) having an accuracy of ± 0.001mm shall be used as the reference instrument in measuring free space.

c) Sectioning of Double Seams for Measurement by Optical Methods.

The following steps should be observed in preparing a double seam section:

1. Fix the can on its side so that the saw will pass through the five layers of tinplate in the seam simultaneously.

2. Use a high quality seam saw blade having at least one tooth per mm. Replace the blade when the cross section shows evidence of galling or butting; these indicate that the blade is beginning to dull.

3. Ensure the cut is made at right angles to the seam.

4. The cut surface may be cleaned by any of several methods, eg. by rubbing with a coarse eraser, by applying solvent with a stiff, short-bristled brush or by immersion in 5% nitric acid for about 20 seconds followed by rinsing in water and drying. Additional cleaning or polishing of the cut surface should not be required unless the blade of the seam saw has lost its edge.

5. Extreme care must be taken if additional polishing of the cross-section is done because the edges of the seam components may become radiused and may not reflect the true image of the seam for measurement using a microscope or seam projector.

Appendix 2.

PROCESSING OF CANNED ABALONE

BY

DARIAN WARNE & DANIEL CAPAUL

FOOD TECHNOLOGY UNIT

R.M.I.T.

MAY '82

CONTENTS

1. OBJECTIVES

1.1 To outline the critical control points for the processing of canned abalone and to describe the basic function of quality assurance programmes.

1.2 To calculate thermal processing schedules for canned abalone.

1.3 To outline the procedures for the correct operation of retorts.

1.4 To examine the accuracy of thermal processing instrumentation.

2. INTRODUCTION

The most important compositional factor determining the minimum thermal process required to be given a canned product is pH. Foods which fall into the low acid category (i.e. pH > 4.5) can support the growth of a variety of microorganisms *Clostridium botulinum*, one such microorganism is of great importance to fish canners because of its ability to produce a lethal neuro toxin when growing in low acid canned foods.

As *Clostridium botulinum* may be present in a highly heat resistant spore form it is necessary to process all low acid canned foods at high temperatures. Simultaneously, other less heat resistant microorganisms are destroyed, thus rendering the food and the inside of the container commercially sterile.

A thermal process capable of reducing to a safe level the probability of there being viable *C. botulinum* spores in canned foods is referred to as a 'botulinum cook'.

The occurrence of *C. botulinum* in abalone as part of its natural microflora is highly unlikely. However, the probability that abalone may become contaminated with spores of *C. botulinum* from a common source, e.g. the soil, cannot be disregarded. Since prevention of this cross contamination can never be safely assured, thermal processes for canned abalone must be adequate to destroy spores of *C. botulinum*.

2.1 Fo VALUE

F values are a measure of the severity of a thermal process. It is defined as "the equivalent in minute of some given reference temperature of all heat considered with respect to its capacity to destroy spores or vegetative cells of a particular organism.

Low acid foods such as abalone (pH 6-7) must be processed to an Fo value of at least 2.4 min. to ensure adequate sterility. In order to satisfy this condition, the heat received by the coldest point of the pack must be equivalent in sterilising effect to 2.4 minutes at 121.1°C (Fo = 2.4 min).

Equivalent processes can be achieved by selecting the most appropriate time-temperature combination compatible with safety, yield and product quality.

It is important to realise that canned abalone cannot be heated and cooled instantaneously, therefore it is necessary to calculate the lethal effect of every temperature and time combination for the process. To do this temperature measurements must be made at the slowest heating point in the container. With solid products heating is by conduction and the slowest heating point is located at the geometric centre of the container. With abalone the slowest heating point will be in the centre of the largest abalone. If the abalone are packed into the cans tightly, then the slowest heating point of the can may be at the interface between two abalone.

When determining process lethality, calculations are based upon the heating characteristics of the slowest heating can. This will ensure that the contents of every container in the retort receive adequate heat during the thermal process.

3. QUALITY ASSURANCE

3.1 Aims of Quality Assurance

To guarantee the safety of canning operations it is necessary to establish routine checks throughout the process. These monitoring procedures are established by the company and are carried out on a regular basis. This is known as QUALITY CONTROL.

QUALITY ASSURANCE, on the other hand is a larger operation which utilizes quality control as a tool to ensure that any possible error involved in canning operations is minimized.

In order for a quality assurance programme to be successful it must be designed to incorporate all the areas of canning which may present a health risk to the consumer. These areas of importance are known as CRITICAL POINTS and it is essential that they be controlled for a "fail/safe" operation.

4. CRITICAL CONTROL POINTS

The critical control points of concern in the canning of abalone include the following:-

(1) FACTORY SANITATION
(2) QUALITY OF THE RAW ABALONE
(3) FILL WEIGHT AND TEMPERATURE OF FILL
(4) CONTAINER SIZE
(5) THERMAL PROCESSING
(6) CORRECT FORMATION OF THE DOUBLE SEAM
(7) QUALITY OF THE CAN COOLING WATER
(8) TREATMENT OF THE CANS AFTER PROCESSING.

5. THERMAL PROCESSING

5.1 Process Evaluation

Heat penetration experiments were performed to establish the adequacy of a scheduled process of 115.6°C for 60 min. It was calculated that for this process the Fo value obtained for the slowest heating can was 3.3 min.(See Appendix 1).

A theoretical worst case example was calculated using the heating characteristics of the slowest heating cans. This theoretical can was found to have an Fo value of 2.6 min. Although this value is in excess of a 'botulinum cook' (Fo > 2.4 min.) any small reductions in processing temperature and/or time could lead to underprocessing.

Board (1966) recommended a processing schedule of 75 min. at 115.6°C for the processing of canned abalone. (two abalones per can). Using the heat penetration characteristics obtained above the severity of Board's recommended process was eavluated. It was calculated that his process was unnecessarily excessive, Fo values > 6.3 min(See Appendix 1).

It is recommended that a schedule of 60 min. at 115.6°C, or one of equivalent lethality (See Appendix 2) be employed for the processing of canned abalone. This is a conservative process, and has been based upon the heating characteristics under worst case conditions.

In doing this the safety of the final product can be assured and the risks of product failure minimised.

It is well documented that yields can be increased by reducing process severity, however, it is bad commercial practice and dangerous to protect yields by underprocessing. The financial incentive for marginally higher yields does not justify product safety being compromised.

5.2 Factors Affecting the Adequacy of a Thermal Process.

The recommended thermal process has been based upon;

- the use of good quality abalone.
- initial product temperature greater than 22°C.
- fill weight less than 320 g.
- 74 mm x 118.5 mm container.

It is important that the abalone used for canning be of good commercial quality, as thermal processes have been based upon the assumption that raw materials contain only an acceptable number of spoilers.

Fill weights and fill temperatures must be monitored by quality control personnel, keeping each within the specified limits set by management. (See Appendix 4). This is necessary since both factors will affect the rate of heat transfer to the centre of the product.

5.3 Process Delivery and Records.

It is the responsibility of the manufacturer to ensure that the scheduled thermal process is correctly applied and sufficiently supervised.

Under no circumstances should the thermal process schedule be altered in any detail without re-evaluation of the adequacy of new process by approved personnel. Even slight reductions in time and/or temperature of the scheduled process may endanger the safety of the consumer.

Documentation must be maintained by management to assure that the requirements of the scheduled process have been met. These records must be accurate and kept for every retort load processed (See Appendix 5).

These records will include

- date
- product
- product code
- container size
- number of containers per retort load
- minimum initial temperature
- retort identification
- specified processing time and temperature.
- actual processing time.
- actual processing temperature, mercury in glass thermometer, recorder chart.

Thermal processing records must be evaluated no later than a day after production by suitably trained staff.

6. RETORT OPERATION

The correct delivery of a scheduled thermal process ultimately depends upon the retort operator. He must be acquainted with the retorts function and competent in its operation. If the product is to be exported to the United States of America, the Food and Drug Administration require that the operator be certified as having satisfactorily completed a Retort Supervisors Course, such as those run by Food Technology Unit, Royal Melbourne Institute of Technology.

There are three stages in a retort cycle.

1. Come up time
2. Processing stage
3. Cooling stage.

1. COME UP TIME

The time taken for the retort to reach the desired processing temperature is known as the 'come up time'. The come up time of a retort should be no greater than 15 minutes. This time also includes a venting period. Venting is one of the most important operations in the retort cycle. During this period the vent valves permit the rapid and total removal of air from the retort. (On the retorts examined, automatic venting devices were fitted).

2. PROCESSING STAGE

Once the retort reaches processing temperature, timing of the process commences. An accurate and clearly visible clock should be installed near the retort area. Process times should be read from this instrument and not from a wrist watch. All relevant times must be recorded in the thermal processing records.

3. COOLING STAGE

After delivery at the scheduled process the cans are promptly cooled to a temperature of 40°C. In order to minimize the risk of deformed or stressed cans, the cans are cooled under pressure.

RETORT OPERATIONS

Operation of batch retorts heating with steam.

1. Load containers close and tighten the doors at the retort.
2. Open bleeders and drain valves.
3. Set the temperature controlling instrument to the specified processing temperature.
4. When the air in the retort has been replaced by steam during the venting period shut the drain valve and bring the retort to operating temperature and pressure. Venting must be continued until the mercury in glass thermometer reads at least 100°C.

5. Once the mercury in glass thermometer reaches the specified operating temperature, timing is commenced.

6. After delivery at the scheduled process set the temperature controlling instrument to zero and turn the steam off.

7. Open the compressed air line to the retort to maintain the processing pressure during the early stages of cooling.

8. Open the vent or drain valve to a small extent to allow the compressed air to blow the residual steam out of the retort.

9. When steam can no longer be seen leaving the retort through the drain valve or bleeders the cooling water is turned on, slowly at first to ensure that the pressure in the retort does not drop. If the pressure is stable the cooling water is turned on fully.

10. When the retort is almost full, partly close the water valve so that the retort does not suddenly fill with water and develop an excessively high pressure.

11. Discharge used cooling water through the vent/drain and at the same time replace with new cooling water.

12. Once the pressure in the cans have been reduced to the point where it can no longer cause peaking or distortion of the cans the pressure in the retort is released. For 74x118.5 mm cans retort pressure should be maintained for approximately 10 minutes.

NOTE: - Pressure in the retort during the cooling stage is controlled by manipulating the water inlet valve and the vent valve.

13. Continue cooling until centre can temperatures are less than 40°C.

Upon examination of the retort it was discovered that there were no vent valves present. If cooling is to be performed under pressure, it is recommended that a vent valve be fitted to the retort. This can be simply done by changing the water inlet line so that it enters from the bottom of the retort via the drain line. (See Appendix 6).

A vent valve should be fitted to the retort for the following reasons:

1. it will permit the rapid removal of steam after the processing cycle.
2. it can be partially opened as water is introduced into the retort - i.e. useful in balancing pressure.
3. it will permit the removal of used cooling water.

7. CALIBRATION OF RETORT TEMPERATURE MEASURING DEVICES.

Located on the retort are three different means of measuring the retort temperature during processing. They are:-

1. Mercury in glass thermometer (°F)
   (Except on Retort Number 3)
2. Dial type thermometer (°C)
3. Temperature recording device (Taylor °F)

The accuracy of these temperature measuring devices were tested at three different temperatures, 220°F (104.4°C), 230°F (110°C) and 240°F (115.6°C) against a known accurate thermometer. On each occasion the test temperature was set by the temperature controlling instrument.

COMMENTS

The most accurate and reliable means of measuring the retort temperature is by the use of the mercury in glass thermometer. (See Appendix 3). This thermometer must be kept in good condition and tested for accuracy at least once every year.

It was found necessary to recalibrate the temperature controlling instruments, as these instruments were recording high (See Appendix 3).

It is advisable not to use the dial type thermometers as these were shown to be inaccurate.

8: APPENDIX

Appendix 1. F_o values obtained for processes of 60 and 75 min (P_t) at 115.6°C.

CAN	CAN WEIGHT gm.	INITIAL TEMP. °C	j	f_h (min.)	F_o value	
					P_t = 60 min. (min)	P_t = 75 min. (min)
1	318	22.4	1.63	33.5	3.4	6.6
2	310	23.6	1.29	35.8	3.3	6.7
3	304	25.6	1.51	34.8	3.2	6.5
4	307	25.8	1.45	24.0	7.1	11.2
5	301	24.4	1.39	34	3.6	7.1
6	287	26.7	1.32	36	3.3	6.6
7	284	24.4	1.37	25.3	6.6	10.7

*Retort come-up time, constant 10 minutes.

APPENDIX 2

Thermal processing schedules required to give an Fo value of 2.6 minutes.

(Based upon the theoretical slowest heating can).

PROCESS	TIME (min.)	TEMPERATURE
1	60	115.6°C
2	57	118.0°C
3	50	121.1°C

APPENDIX 3

Calibration of Retort Instrumentation.

RETORT No. 1	TEST TEMPERATURE °F		
	220	230	240
Temperature recorder	222	232	242
Dial type thermometer	212	228.2	241.2
Mercury in glass thermometer	219	229	238
STANDARD	219.4	228.7	237.9

NOTE: Retorts numbered from left to right.

RETORT No. 2	TEST TEMPERATURE °F		
	220	230	240
Temperature recorder	224	234	244
Dial type thermometer	220.6	233.6	242.4
Mercury in glass thermometer	221	230	240
Standard	221	230.4	240

RETORT No. 3	TEST TEMPERATURE °F		
	220	230	240
Temperature recorder	220	231	242
Dial type	222.5	233.6	243.5
Mercury in glass thermometer (Absent)	-	-	-
STANDARD	219.6	229.3	239

APPENDIX 4

Example of a fill weight record form.

FILL WEIGHT (g)

OVER	IDEAL	UNDER	TIME	DATE	Can size	Product

180

APPENDIX 5

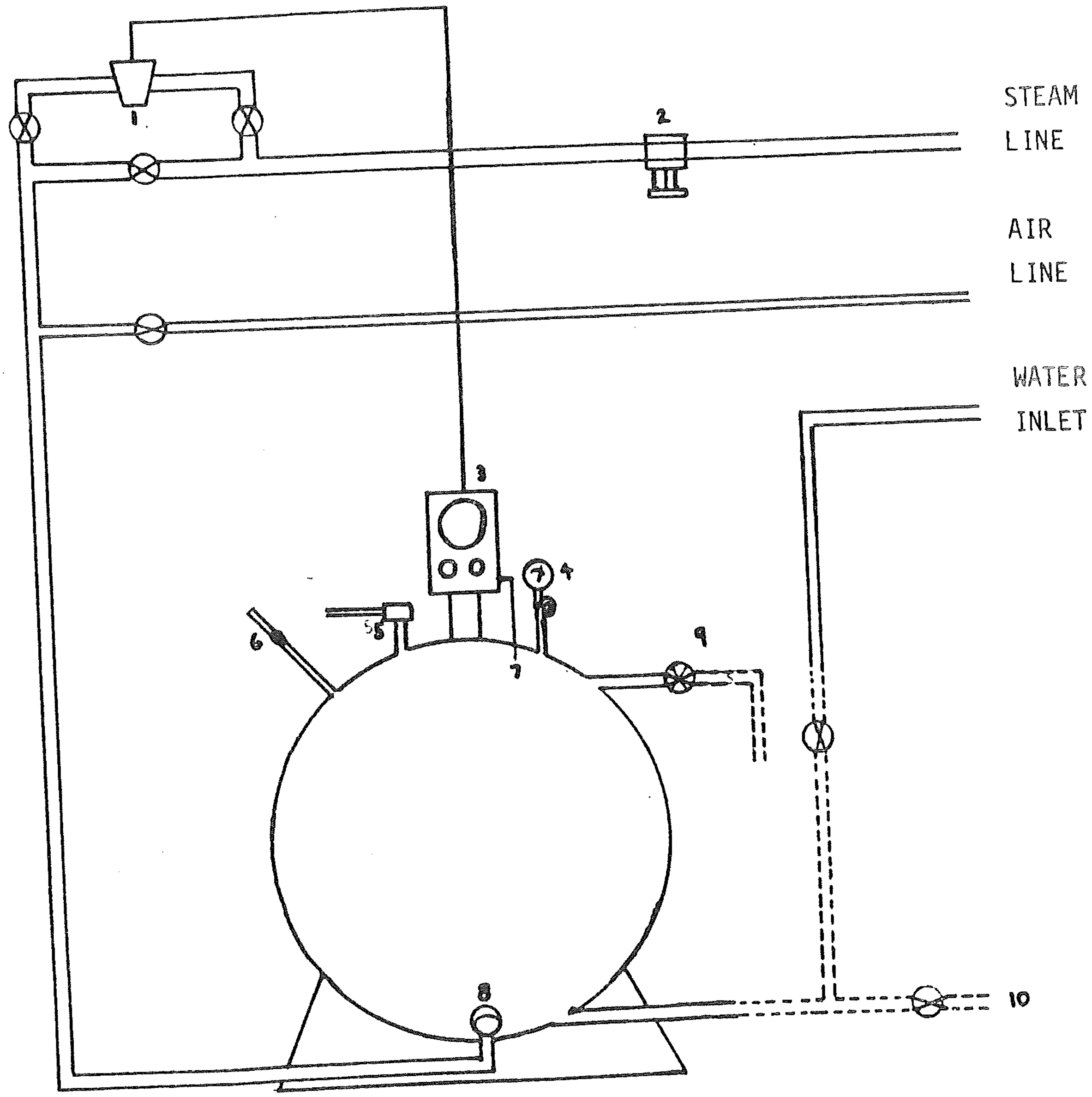
Example of a daily process or production record form.

DATE	PRODUCT	CODE	Container		Min I.T	R No	PROCESS		TIME				Actual process time	Thermometers		Signed by
			Size	No/R			TIME	TEMP	Steam On	Vent Closed	Temp UP	Steam Off		Mercury in Glass	Recorder chart	

APPENDIX 6

Diagram of Retort Number 3

with proposed modifications



KEY:

1. Control valve
2. Reduction valve
3. Recorder-Controller
4. Pressure Gauge
5. Automatic vent
6. Bleeders
7. Temperature probe
8. Spreader
9. Proposed Vent/overflow
10. Proposed Drain

APPENDIX 7

Extract from 'ABALONE - AN ESOTERIC FOOD"

by June Olley and S.J. Thrower

C. CANNING

After brining the abalone are usually tumbled in a rotary washer fitted with warm-water sprays. Some processors then precook because this helps to remove mucin from improperly cleaned material and makes the drained weight easier to predict. Other processors can directly after washing. Abalone are canned either in water or in brine up to 4% strength, depending on the previous brining treatment. The retorting conditions needed to sterilize the contents are shown in Table X.

It is usually accepted that a one-pound can must contain at least 8 ounces of abalone. The highly priced Mexican and Californian products usually contain one large animal weighing as much as 11 ounces, whereas Japanese abalone, being extremely small, are often packed six or seven to a can. These small abalone are frequently more tender than the Australian and Mexican products, possibly because of the shorter retorting time required; in general they have a higher pH, but it is not known if this is because they are fresher or because they have been chemically treated.

In the canning of abalone the drained weight of the contents is the yield of most importance to the processor. He often has difficulty, therefore, in understanding that a large loss in drained weight after canning may still in fact indicate a high yield in terms of the original weight of raw material. An abalone with a

TABLE X

RETORT CONDITIONS FOR 301 × 411 CANS OF ABALONE[a,b]

Mollusk size	Mollusks per can	Initial temperature (°F)	Time at 240°F (min)
Large	2	100	75
Large	2	160	65
Medium	3	100	65
Medium	3	160	55
Small	5	100	55
Small	5	160	50

[a] The retort processes were specified to give commercial sterility. Where abalone are of mixed sizes in a production batch, the largest retorting time would have to be used.

[b] Board (1966).

high pH or one that has been put in weak brine, or not brined at all, contains more water than one of low pH or one that has been put in strong brine before canning. The former abalone lose more water on canning because they have more to lose. The yield from such material in relation to the original weight of raw material is greater, however, than that from the latter material (Young and Olley, 1974).

Sometimes a deterioration occurs in the flesh in the center of the abalone, reminiscent of "honey-combing" in tuna that is stale when canned. The center or core of the muscle is oversoft and is like mince in appearance, while the exterior is "blown up" and the epidermis may show splitting. Tanikawa (1971) claims that honey-combing in tuna is caused by gases generated in the center of the muscle escaping through the soft but not yet coagulated collagen in the outer parts. In stale abalone the pedal arteries and vein, which are lined with collagen, are notably dilated, and bacterial action starts in these areas, presumably with production of volatile compounds. Swelling of the foot with splitting of the epidermis has been produced in the authors' laboratory by brining in 9% salt + 1% sodium carbonate which would release bubbles of CO_2 in the flesh. Hypochlorite sometimes used by the fishermen at sea as a preservative could also cause release of gas, and similar problems with the core of the foot have been encountered.

Appendix 3.

EVALUATION OF THE PROCESSING OF 'PECK ANCHOVETTE PASTE (50g)' AT LAKES ENTRANCE FISH PROCESSORS

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CONTENTS

7. continued ...

5. Temperature print-out.

References.

1. OBJECTIVES.

1.1 To calculate the total sterilising value delivered to Pecks Anchovette Paste (50g) during thermal processing.

1.2 To examine the accuracy of retort instrumentation.

2. THERMAL PROCESS EVALUATION.

2.1 Introduction.

The heat treatment of hermetically sealed low-acid food products (pH > 4.5) must be sufficient to;

1 - assure an acceptably remote probability of survival of *Clostridium botulinum*.

2 - assure reasonably minor economic losses from spoilage due to spore-forming bacteria more heat resistant than *C.botulinum*.

Good commercial practice dictates that an acceptably remote survival probability of spores of *C.botulinum* in heat processed low acid foods should be no greater than 1 viable spore per 10^{12} containers. Another way of expressing this is to say that the chances of a single spore of *C.botulinum* surviving a given process is one in a million, million.

The chances of survival of spore forming bacteria more heat resistant than *C.botulinum* is tolerated at higher levels. An acceptable probability of survival is in the order of 1 viable spore per 10^3 - 10^4 containers.

2.2 Sterilising value.

In order to assess the severity of a thermal process it is necessary to express the cumulative lethal effects of temperature and time in standard units. The F value is taken as the standard unit. It is defined as the equivalent in minutes at some given reference temperature, with its respect to its capacity to destroy spores or vegetative cells of a particular organism. In the processing of low acid foods, where C.botulinum may be present, F values are based on a reference temperature of 121.1°C. One F value is equal to holding the product at 121.1°C for one minute, or equivalent to some other suitable time - temperature combination.

In heat penetration experiments the temperature history of the slowest heating point (thermal centre) of a product is measured. From this data the F ct value of a product can be calculated. The severity of heating, as measured by the F value, for conduction-heating packs during processing varies from the wall of the container to the geometrical centre. Thus the Fc value represents the minimum lethality in a container, whilst the remainder of the contents are subjected to a higher but undefined lethality.

The severity of a thermal process may be expressed in terms of Fs values. The Fs value is obtained by integrating the lethal effects at time-temperature combinations throughout the entire container contents. Therefore the Fs is the equivalence in minutes at 121.1°C for the entire product volume, wheras Fc is the equivalence in minutes at 121.1°C for a single point in the container.

2.3 CALCULATING STERILISATION VALUES.

There are several methods which can be used for calculating F values. In this report the data from heat penetration tests was analysed by the following methods;

2.3 continued ...

2.3.1 General Method.

The General method is a procedure for summing or integrating the lethality values over the whole of the process to give the F value. It is an absolute measure of the sterilising value as it takes into consideration the exact temperature history of the product.

2.3.2 Formula Method.

Ball's method is a mathematical representation of the temperature history of the product. In order to calculate F values by this method, heat penetration parameters derived from a semi-logarithmic heat penetration curve are required.

2.4 Rate of bacterial destruction.

The amount of heating required to produce a state of commercial sterility in low acid foods will depend upon;

1 - the resistance of potential spoilage microorganisms to inactivation by heat, at different temperatures,

2 - the rate of heat penetration into the contents of the can.

The time required to reduce a bacterial population of spores when subjected to heat at lethal temperatures can be expressed by the following equation;

$t = D (\log No - \log Ns)$ (Equation 1)

where; D is a measure of the resistance of spores to heat. It is defined as the time required to destroy 90% of the spores or vegetative cells of a given organism at a specified temperature. If the specified temperature is equal to the reference temperature, ie. D value is measured at 121.1^{o}c, then the time required for bacterial reduction is equivalent to the F value.

$$\text{i.e. } t = F = D_{(121.1^{o}c)} (\log No - \log Ns).$$

- No initial population. Number of spores of a specific organism, per unit volume prior to heat treatment.

- Ns final population. Number of spores per unit volume after processing.

3. PROCEDURE FOR DETERMINING THE RATE OF HEAT PENETRATION

Copper-constantan thermocouples were made using (.35mm diameter) wire and inserted into the jars through a small hole drilled in the cap. The thermocouples were positioned so that the point of temperature measurement was approximately .5 - 1cm below the geometric center of the product. The opening through which the thermocouple wires entered the jar was sealed using an epoxy resin. (Araldite, 5 minute set). Using a clamping device the caps were secured onto the jars.

The thermocouple jars were then placed at various positions in the retort (Appendix 1). The thermocouple wires were led through a 3/4 inch British Standard Piping opening, located on the top of the retort. A packing assembly was used to seal the wires into position.

A Leeds and Northrup multipoint recorder (speedomax) was used to record the product temperature throughout the retorting process.

4. DISCUSSION OF THE METHODS USED FOR DETERMINING STERILISATION VALUES

Pecks Anchovette Paste (50g) was packed into glass jars and processed in a horizontal batch retort heated with water under superimposed air pressure. The specified scheduled process was 30 minutes at a retort temperature of 115.6 °C (240°F) The come up time of the retort was approximately 50 minutes.

Appendix 2, shows the sterilisation values received by the product. It can be observed that there are some discrepancies between the F values calculated by the general method and those calculated by Ball's formula method.

Calculation of sterilisation values by the general method gives absolute values, hence these values can be taken as representing the 'true' lethality of thermal processes. Discrepancies between the two sets of Fct values quoted in Appendix 2, tables 1 and 2 are due to the limitations associated with the formula method.

To make possible the mathematical treatment of thermal processes, Ball (1923), had to make several assumptions. This method is directly applicable only in so far as the assumptions are in reasonable accord with the actual test conditions.

The following assumptions were made by Ball (1923);

- .42 of the come up time (C.U.T) is considered as time at processing temperature, i.e. 42% of the CUT is lethal.

  The accuracy of this assumption is questionable with retort come up times over 10 minutes.

- fc = fh.

  Appendix 2, table 1 shows that the fc value was larger than the fh value.

- Jcc = 1.41

  Stumbos (1973) modification of Ball's formula method permits the Jcc value to be variable.

The total sterilisation value calculated by the formula method was generally underestimated. For all but two of the seven heat penetration calculations did the difference between the general and formula method exceed .7 minutes, which for practical purposes is negligible. Hence, although conservative the use of Ball's formula method for calculating sterilisation values received by Peck's Anchovette Paste is satisfactory under the observed processing conditions.

5. EVALUATION OF THE MAGNITUDE OF THE STERILISING VALUE

The adequacy of a thermal process for shelf-stable low acid foods in hermetically sealed containers is measured by the reduction of the initial load of microorganisms present in the food. The most heat-resistant organism of public health concern, due to its ability to produce spores, is C.botulinum. Thermal processes for low-acid foods used in the canning industry must be adequate to assure an acceptably remote probability of survival of C.botulinum.

5.1 DISCUSSION

The theoretical survival probability of C.botulinum spores in Pecks Anchovette Paste (50g) can be calculated assuming the following points;

1 - the initial population of C.botulinum spores in a formulated food should seldom, if ever, be greater than one per gram of food. (Stumbo et al, 1975).

2 - the approximate maximum 121.1°c heat resistance of C.botulinum spores is represented by a $D121.1^{o}c = .20$ min.

3 - the lethality value (Fct) for the slowest heating and fastest cooling test container is 6.6 minutes. (Appendix 2, table 2).

Using equation 1, section 2.4;

$$F = D\ (\log No - \log Ns)$$

$$6.6 = .20\ (\log 50 - \log Ns)$$

$$Ns \approx 10^{-32}$$

This implies that the probability of a single spore of C.botulinum surviving a process is approximately 10^{-32}.

A thermal process must also be sufficient to achieve commercial sterility, which, in addition to the absence of viable forms of micro-organisms having public health significance, is that condition achieved by application of heat which renders food free of any more-heat-resistant mirco organisms of non-health significance.

Assumptions;

1 - the initial population of spores of mesophilic bacteria more heat resistant than those of C.botulinum in formulated foods should seldom be greater than one spore per gram of food, (Stumbo et al, 1975).

2 - the approximate maximum 121.1^{o}c heat resistance of these spores may be represented by D 121.1^{o}c value in the order of 1.5 min. This is characteristic of heat resistant spores of C.sporogenes (Stumbo et al, 1975).

3 - the minimum integrated lethality value (Fs) is 8.2 min (Appendix 2, table 1).

Using equation 1, Section 2.4.

$$F = D (\log No - \log Ns)$$

$$8.2 = 1.5 (\log 50 - \log Ns)$$

$$Ns \ {}^{2}\!\approx 10^{-4}$$

Hence the probability of survival of spores more heat resistant than C.botulinum is approximately 1 viable spore in 10^4 containers. This is an acceptable survival probability that will give minor economic loss. If however the lethality of current thermal processes are reduced then the probability of product failure due to the growth of non-pathogenic, heat resistant merophilic bacteria may reach unacceptable levels ($Ns > 10^{-4}$).

The sodium chloride concentration and pH factor of Pecks Ancovette fish paste may be capable of acting as bacteriostatic agents. This will give some protection and can be included as an additional product safety factor.

In Appendix 3, tables 1 and 2 the effect of altering processing time and temperature on the Fct value are shown. It can be observed that the lethality of reduced thermal processes, (30 min at 113.0°c or 20 min at 116.0°c) are still adequate to provide a 'botulinum cook' (Fct > 2.4 min). Therefore there is a considerable 'safety margin' built into current thermal processes.

6. ASSESSMENT OF RETORT INSTRUMENTATION

6.1 Introduction

The equipment and procedures used to apply the thermal process must be designed to ensure that every container in a retort load receives the same sterilising treatment. The heating medium must therefore be delivered uniformly to all containers in the retort and sterilising temperature must be known and controlled.

In this section the accuracy of retort instrumentation and heat distribution in the retort was examined.

6.2 Procedure

The temperature at different positions in the retort (Appendix 1) was measured using copper/constantan thermocouples (ELLAB, type DC67). The probes were inserted through a 3/4 inch British Standard Piping opening located on the top of the retort and secured into position by the use of a packing assembly. The thermocouple leads were connected to an ELLAB Digital thermometer, Type C.T.D with a known accuracy of $\pm .2^{o}$c, when used at ambient temperatures (10-35^{o}c).

6.3 Discussion

Shown in Appendix 4, table 3 is a summary of the temperatures observed during the monitoring of processing temperature. The measurements obtained from the Ellab Digital thermometer have been taken as the standard upon which the retort instrumentation has been assessed. Due to the small errors associated with the instrument ($\pm .2^{o}$c), the retort temperature is quoted as falling within a range of temperatures, rather than having a single average value.

Inspection of Table 1, Appendix 4 reveals the following points;

1 - the temperature controlling instrument (Taylors) on all retorts, with the exception of retort 1 are accurately calibrated and capable of maintaining retort temperature within 1.0°C of the set processing temperature.

2 - All the retorts have uniform heat distribution, (temperature fluctuations between the measured temperatures $< 1^{o}c$)

3 - Retorts 3,4 and 5 are accurately calibrated.

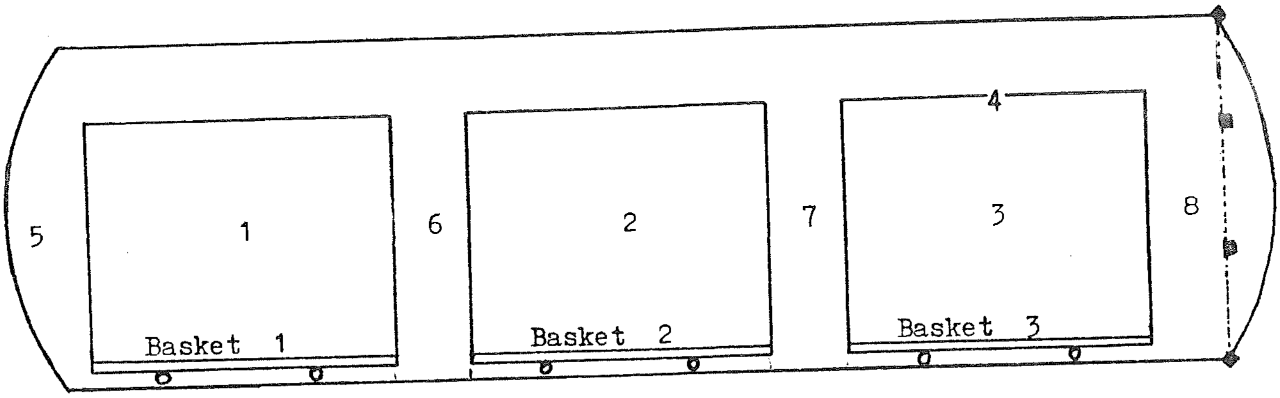
4 - The temperature recording instrument on retorts 1 and 6 requires recalibration. Accuracy should be equal to or better than $\pm$ 1.0°c at sterilizing temperatures.

5 - The Mercury in glass thermometer on retort 6 requires recalibration. The thermometer should not deviate more than .5°C from the standard.

It is recommended that the retort instrumentation on retorts 1 and 6 be recalibrated as their accuracy has been shown to be outside the tolerances set by the Department of Primary Industry (Circular 157).

Appendix 3, table 1, shows that reducing the processing temperature by as much as 2.6°c to 113.0°c does not jeopardize product safety. However it is good commercial practice to have tight controls over processing conditions. The correct delivery of a thermal process depends upon accurate retort instrumentation.

APPENDIX 1. POSITION OF THE THERMOCOUPLES IN THE RETORT.



Position of the thermocouple jar.

1 Centre of basket 1
2 Centre of basket 2
3 Centre of basket 3
4 Top of basket 3

Position of thermocouples monitoring retort temperature.

5 Back of the retort
6 Between basket 1-2
7 Between basket 2-3
8 Front of the retort

APPENDIX 2 F values received by Peck's Anchovette Paste (50 g) processed according to the following observed processing schedules.

PROCESS 1	Retort Number 1	
	Processing temperature	117°C
	Come up time	47.5 min
	Operators process time	30 min
	Cooling time	20 min
PROCESS 2	Retort Number 3	
	Processing temperature	116°C
	Come up time	50 min
	Operators process time	33.3 min
	Cooling time	17 min

Table 1 Heat penetration data and total Fs and Fct values. (Calculations performed by Ball's method using Stumbo's (1973) revised tables.)

	Position of the thermocouple jar. (See Appendix 1)	To °C [1]	jch	fh (min)	jcc	fc (min)	Sterilising value (F) min Fs [2]	Fct [3]
PROCESS 1	1	27	2.09	16.5	1.8	20	9.3	8.0
	2	27	2.12	17.5	2.0	22	8.9	7.6
	3	27	2.14	18.0	2.0	21	8.8	7.4
	4	26	1.92	17.5	1.2	25	8.7	7.2
PROCESS 2	1	23	2.00	16.8	2.0	19	9.0	7.7
	2	23	1.94	16.0	1.2	20	8.2	7.7
	3	24	2.04	17.5	2.0	19	8.7	7.4

NOTE: 1. To °C - Initial product temperature.
2. Fs - Integrated Lethal value.
3. Fct - Total lethal value at thermal centre.

TABLE 2 F values calculated by the General method.

	Position of the thermocouple jar. (See Appendix 1)	Sterilising value (F) min		
		Heating Fch	Cooling Fcc	Total Fct
PROCESS 1	1	7.5	1.4	8.9
	2	6.7	1.3	8.0
	3	6.9	2.0	8.9
	4	6.8	1.1	7.9
PROCESS 2	1	6.1	1.7	7.8
	2	7.2	.5	7.7
	3	6.2	1.6	7.8

APPENDIX 3 EFFECT OF ALTERING PROCESSING CONDITIONS ON F VALUES RECEIVED BY PECK'S ANCHOVETTE PASTE (50g).

Table 1 Effect of processing temperature on Fct value.

PROCESSING TEMPERATURE °C	STERILISING VALUE Fct
113.0	3.39
114.0	4.25
115.0	5.33
115.6	6.09
116.0	6.69
117.0	8.39

CALCULATIONS BASED UPON;

- Come Up Time 50 min
- Operator's process time 30 min
- Initial product temperature 20°C

jch = 1.94

jcc = 1.20

fh = 16.0 min

Table 2 Effect of processing time on Fct value .

OPERATOR'S PROCESS TIME min	STERILISING VALUE Fct
35	8.23
30	6.69
25	5.18
20	3.77

CALCULATIONS BASED UPON;

- Come Up Time 50 min
- Retort processing temperature 116°C
- Initial product temperature 20°C

jch = 1.94

jcc = 1.20

fh = 16.0 min

APPENDIX 4 EXAMINATION OF THE ACCURACY OF RETORT INTRUMENTATION.

Note-Retorts numbered from left to right.

Retorts 1 and 3 Batch type heated with water under pressure.

Retorts 4,5 and 6 Batch type heated with saturated steam.

TABLE 1 Temperature of retorts 1 and 3 as indicated by the Ellab thermometer and retort instrumentation. Processing temperature set by the Taylors instrument (115.6 °C).

	HEATING TIME min	Position of thermocouples [1] 5	6	7	8	Hg in glass °C	Recording Instrument °F	°C
RETORT NUMBER 1	20	70.9	72.5	71.0	71.0	70	152	(66.7)
	40	107.9	109.4	108.3	108.4	108	224	(106.7)
	55 [2]	116.4	117.2	116.1	116.5	116.5	240	(115.6)
	65 [2]	116.8	117.3	116.8	117.0	117	240	(115.6)
	75 [2]	116.9	117.1	116.9	117.2	117	240	(115.6)
RETORT NUMBER 3	15		52.8	51.7		51	125	(51.7)
	45		104.9	106.5		104	220	(104.4)
	55 [2]		115.9	117.5		116.2	242	(116.7)
	65 [2]		115.6	115.9		116	241	(116.1)
	75 [2]		116.0	116.5		116	241	(116.1)

Note : 1. See appendix 1

2. Retort at processing temperatu

'ABLE 2 Temperature of retorts 4,5 and6 as indicated by the Ellab thermometer and retort instrumentation. Processing temperature set by the Taylors instrument (115.6 °C)

	PROCESS TIME min	Position of thermocouples [1] 6	7	°C	Hg in glass °C	Recording Instrument °F	°C
RETORT NUMBER 4	0	115.6	116.0		115	240	(115.6)
	20	115.9	116.1		116	240.5	(115.8)
	40	115.7	116.0		116	240.5	(115.8)
	60	115.6	115.9		116	240.5	(115.8))
RETORT NUMBER 5	0	115.5	115.5		115.5	240	(115.6)
	20	115.7	115.6		116	240.5	(115.8)
	40	115.7	115.6		116	240.7	(115.9)
	60	115.8	115.7		116	240.7	(115.9)
RETORT NUMBER 6	0	114.5	114.6		114.5	240	(115.6)
	20	115.0	115.0		116	241	(116.1)
	40	115.0	115.1		116	241.5	(116.4)
	60	115.1	115.1		116	241.5	(116.4)

Note: 1 See appendix 1

TABLE 3 Examination of the accuracy of retort instrumentation.

RETORT NUMBER	PROCESSING TEMPERATURE SET BY THE "Taylors"	TEMPERATURE MEASURED BY THE ELLAB THERMOMETER "STANDARD" Range °C	TEMPERATURE INDICATED BY THE Hg in Glass °C	COMMENTS[1] Hg in glass-against-STANDARD.	TEMPERATURE INDICATED BY "Taylors" °C	COMMENTS[2] Taylors-against-STAND
1	115.6	116.7-117.4 (.7)	117	Negligible difference	115.6	SIGNIFICANT DIFFERENCE 1.1 - 1.8 °C LOWER
3	115.6	115.8-116.7 (.9)	116	Negligible difference	116.1	Negligible Difference
4	115.6	115.4-116.1 (.7)	116	Negligible difference	115.8	Negligible difference
5	115.6	115.5-116.0 (.5)	116	Negligible difference	115.9	Negligible difference
6	115.6	114.8-115.3 (.5)	116	SIGNIFICANT DIFFERENCE .7 - 1.2 °C HIGHER	116.4	SIGNIFICANT DIFFERENCE 1.1 - 1.6 °C HIGHER

Note 1. Comparison of temperature indicated by Hg in glass against the standard.

2. Comparison of temperature indicated by Taylors instrument against the standard.

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Appendix 4.

Factors affecting the quality and yield of canned abalone (*Notohaliotis ruber*)

D. WARNE and N. BROWN

Salt concentration and brining time affected yield after brine cleaning abalone; however, variations in yield became insignificant after thermal processing. Proteolytic enzyme treatments made flesh cleaning easier and phosphate additives did not influence yield of the canned product. While Asian panelists were found to consume abalone more frequently than their Caucasian counterparts, there was no significant differences between these groups in the results of their taste panel assessments of the canned product. Although the Instron food testing machine and taste panelists could differentiate between tough and tender abalone, the relationship between these two forms of assessment requires further investigation.

This paper is the first of a series in which parameters affecting quality and yield of canned abalone are discussed. Australian canned abalone exports for 1979-80 amounting to 1456 t were valued at $12.4m (Anon 1981). Predictions are that for the year ending June 1981 exports will exceed 1700 t ($18m) which represents 96% by value of total exports for canned marine products. Local consumption of the commodity is limited, the large markets being Japan, Hong Kong, the USA, Singapore and Malaysia in descending order. Abalone canners and research workers (James & Olley 1970, 1971a, b, Young & Olley 1974) have demonstrated that yields and texture are influenced by product freshness, solute composition and concentration in the cleaning brine and by processing severity.

The Commonwealth Department of Primary Industry (DPI) stipulates that the use of approved additives is permitted provided that their use has been justified and their inclusion declared on the label. All manufacturers use a salt brine canning liquor to which some have permission to add polyphosphate and/or metabisulphite. Although DPI has approved neither proteolytic enzymes for cleaning nor the addition of citric acid to the canning liquor, in principle there is no objection to their use.

The aims of the experiment in this paper were:

- to assess the influence of cleaning brine strength and phosphate additives on yield; and
- to assess the efficacy of enzyme preparations for cleaning.

In addition to the above, preliminary investigations to compare subjective textural evaluations with objective assessment using an Instron 1140 Food Testing Machine were carried out. Future investigations will assess the influence of thermal processing variables on yield and texture.

Methods

Fresh abalone (*Notohaliotis ruber*) was transferred in open fish boxes to the processing plant and stored overnight in air at 3-5°C. Approximately 24 h after catching, 51.9 kg of whole abalone were shucked. Flesh pH was measured by inserting the tip of the electrode of a 30 mm Metrohm Herisau E520 pH meter into the pedal sole. Shucked abalone were divided into 12 lots for processing. Experimental variables are summarised in Table 1. Each lot was immersed in approximately three times its mass of cleaning brine at 40–45°C and gently stirred. Those lots (4–12) treated with enzyme preparation (Protease FS, Halcyon Proteins Pty Ltd, Melbourne) were subsequently rinsed for 10 min in a 0.225 g/L hydrogen peroxide solution to arrest enzymic action. Abalone were lightly scrubbed with a nail brush and the ease of cleaning rated on a five point scale ranging from 1 (easy) to 5 (difficult). Cleaned, trimmed abalone were blanched for 5 min at 70°C and packed whole (200-220 g/can) into SR lacquered 74 x 112.5 mm cans. Hot (85°C) canning liquor was added to a 10 mm headspace, the cans sealed, processed in a batch retort at 115.6°C for 40 min and pressure cooled. Thermocouple probes were centrally located in three cans in each of the three batches processed so that F_0 values could be computed. Can vacuums and drained weights were measured after 34 days storage at ambient temperature (20°C). Lot weights were measured after each processing stage so that weight changes and progressive yields could be calculated.

Lots 6, 9 and 11 were selected for taste panel and objective textural evaluation because of their favourable appearance and yield. Throughout one afternoon, 47 untrained panelists (32 Asian, 15 Caucasian) were asked to rate the three samples, plus a fourth sample which was Victorian black lip abalone produced commercially, on a category scale for texture and hedonic scales for flavour and appeal. Each rating was on a 5 point scale: Texture: 1 (tender) - 5 (tough); flavour: 1 (dislike very much) - 5 (like very much); and appeal: 1 (poor) - 5 (good). Panelists were asked to indicate whether they consumed abalone often, occasionally, rarely or never, and also to rate their ideal rating for texture.

At least five cans of each variable were opened and all the abalone pooled to reduce can-to-can variations. Each panelist was given at one time four 2 mm thick vertical slices. Each slice was taken from the flesh approximately 5 mm either side of a 10 mm thick central portion which had been removed for objective textural assessment. Samples were presented on a small tray with a cup of cool water and identified with three-digit random numbers; panelists were directed to assess each sample as many times as they wished. Each sample for objective assessment was placed on a flat base plate with a central hole (15.7 mm diam.) and punctured by a flat end probe (6.3 mm diam.) moving through at 200 mm/min. Chart speed was 400 mm/min and peak height recorded as kg force. Each slice was tested five or three times depending on cross sectional

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Table 1. Experimental variables for brine cleaning time and canning [illegible]

Lot (No.)	Cleaning brine Constituents	Concn (g%)	Cleaning time (min at [illegible]°C)	[illegible]
1	NaCl	[illegible]	[illegible]	[illegible]
2	NaCl	[illegible]	[illegible]	[illegible]
3	NaCl	[illegible]	[illegible]	[illegible]
4	NaCl	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible]

Table 2. Effects of processing operations [illegible]

[illegible]

area. As noted by James and Olley (1971a) the force required to puncture the flesh reflected test position; however, for statistical analysis the mean reading for each slice was used and data pooled to give the mean reading for each lot. The rationale for this procedure was that subjective textural evaluation is a composite impression formed by chewing each slice several times in different positions.

Results and discussion

The yield after shucking was 40.3% and the average pH of the pedal sole 6.1. As live abalone in good condition have a pH range of 7.0-7.4 it can be concluded that storage in air at 3-5°C induced cold shock, anaerobic glycolysis and an attendant pH drop as a result of acid formation. This mechanism as described by Olley and Thrower (1977) would also account for the comparatively low final yields shown in Table 2 (average 57.3%) and Figure 1 (average 23.2%). It is difficult to obtain accurate figures, however, yields of 28-32% (unshucked weight) are common within the industry.

Effect of brine strength and phosphate additives

The effect of varying salt concentration in the cleaning brine was clearly demonstrated with lots 1-4. Yields were greatest with 3% NaCl as the osmotic pull causing flesh dehydration was least at this concentration, but as a result of rehydration caused by the competing osmotic pull of the salt-protein complex, increasing brining time from 30 to 60 min produced increased yields. The weight gain was less pronounced with the 6% brine as the ability to rehydrate was restricted by the relatively high solute concentration of the brining solution. While brine concentration and cleaning time affected yields after brining, the benefits attributable to one set of conditions were not sustained throughout the remainder of the process. Young and Olley (1974) also found that increased yields made on brining were not lasting. Given abalone of constant freshness the most significant factor likely to affect final yield is the severity of retorting. In this experiment thermal processing conditions were constant and there was no significant difference (analysis of variance, $P > 0.1$) in the losses caused by retorting despite the variations in pretreatment and canning liquor.

As shown in Table 3 abalone from lot 4 were rated easier-to-clean than those from lots 1-3. This demonstrates the advantage of using a high salt concentration for brining; yet, the benefits may not be realised unless cleaning time is for an hour or more. It is because of the losses associated with high salt concentrations that proteolytic enzyme preparations were added to the brine. Addition of sodium tripolyphosphate did not increase yields after brining; in all cases there was a small increase in weight after rinsing in the peroxide solution. Thus the phosphate exhibited some water-binding capacity; but the effect was not consistent after canning. Further work will evaluate the addition of other phosphate blends of higher concentrations.

Enzyme preparations for cleaning

Black melanin pigment can be removed by salt or the use of proteolytic enzyme solutions. The advantage of the latter is that they reduce brine cleaning times and avoid weight losses caused by dehydration in strong solutions. Lots 5-8 were rated easier-to-clean than lots 1-3 and compared well with lot 4; the latter was brined for 60 min., whereas the advantage of enzymic treatment (lots 5-8) was apparent after 30 min. In all instances of enzymic cleaning the canned abalone had an acceptable cream-yellow colour and generally was of better appearance than the salt cleaned product. To some extent this may have been rather a consequence of the peroxide rinse than that of enzymic action: for it was noticed that the enzyme application made cleaning easier without giving a lighter coloured product. Thus the value of enzymic cleaning is in part attributable to the bleaching effect of the peroxide rinse. In addition to enhancing the appearance of the product enzyme treatment also offers potential savings in labour.

Subjective and objective textural evaluations

Selection of panelists was biased as it was considered that Asian respondents would be familiar with the product and more representative of abalone consumers. Table 4 summarises the frequencies with which the panelists eat abalone. Although the frequency of abalone consumption for the sample populations was significantly different (Chi-square analyses, $P < 0.005$), there was no significant difference between groups in the sensory assessment of abalone samples. This observation could be interpreted as meaning that panelists could be randomly selected; we would qualify this statement as it is rational to select a trial population that reflects the preferences of the target market. Future research will survey a larger Asian population and identify textural and flavour preferences of those used to eating abalone.

Table 5 gives the mean taste panel scores for texture, flavour and appeal. Analyses by Tukey's test indicates that there was a significant ($P < 0.01$) textural difference between product C (commercial product) and product from lots 6, 9 and 11. Panelists considered that the ideal abalone texture would be close to that of sample C and significantly ($P < 0.05$) more tender than samples 6, 9 and 11. There was no significant difference in flavour; but the appeal of sample 6 was significantly ($P < 0.05$) lower than that of C. It appears that high texture ratings do not necessarily reduce overall appeal, even though a low texture score is ideal. Although texture is not the sole criterion of quality, abalone canners prefer to use fresh abalone of high pH in order to obtain a tender product. The effect of pH on texture was not studied in these experiments; but it was observed (Warne & Brown – unpublished) that raising the temperature and/or time of the thermal process increase tenderness.

The results shown in Tables 5 and 6 indicate that neither the taste panel nor the Instron instrument could differentiate between the texture of samples from lots 6, 9 and 11, since both forms of assessment recorded much lower values for commercial product. This phenomenon suggests that future research using matched samples may demonstrate significant

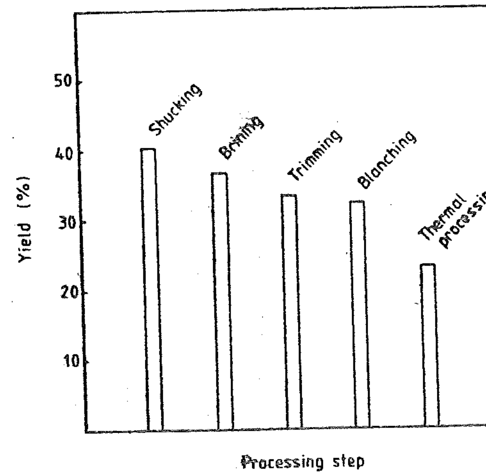

Figure 1. Effect of processing steps on yield during the canning of abalone: average values for all lots

Table 3. Summary ease of cleaning, total yields and quantities produced

Lot (No.)	Ease of cleaning* (rating)	Total yield† (%)	Cans/lot (No.)
1	3	22.5	7
2	3	22.8	5
3	3	23.5	7
4	2	23.6	5
5	2	22.6	5
6	2	23.3	5
7	2	22.6	5
8	2	22.6	5
9	3‡	24.0	10
10	3‡	22.6	5
11	3‡	23.9§	5
12	3‡		5

*Ease of cleaning: 1 (easy) – 5 (difficult)

†Total yield calculated on basis of 40.3% yield after shucking and progressive yields as shown in Table 2.

‡Lots 9–12 were the last processed and had developed a surface slime on standing.

§Results pooled. See footnotes to Table 2.

Table 4. Frequency of abalone consumption by Asian and Caucasian panelists

/	Asian (n = 32)	Caucasian (n = 14*)
Never eat abalone	1	3
Rarely eat abalone	5	10
Occasionally eat abalone	24	1
Often eat abalone	2	0

*One panelist did not answer.

Table 5. Mean taste panel scores for texture, flavour and appeal (pooled results)

	Lot 6	Lot 9	Lot 11	C	Ideal
Texture	3.70	3.61	4.00	1.60	1.90
Flavour	2.98	3.21	3.23	3.43	–
Appeal	2.62	2.81	2.66	3.32	–

Table 6. Mean Instron puncture force (pooled results)

Sample (No.)	Force (kg)	Frequency of measurements (No.)
6	3.26	42
9	3.37	12
11	3.40	22
C	2.02	17

correlation between objective and sensory measurements.

Conclusions

Brine composition and washing time were shown to affect yields after brining; but there was no significant difference between final yields after thermal processing. Enzyme preparations increased the ease of cleaning and indirectly improved the colour of the canned product. Textural evaluations indicate that flesh toughness is only one factor affecting overall appeal, as in some cases tough and tender abalone were liked equally. Preliminary investigations indicate that the relationship between rapid instrumental texture measurements and sensory assessments warrant further studies.

Acknowledgements

This investigation is funded by a grant from the Fishing Industry Research Trust Account (FIRTA) and forms part of a project in which fish canning and quality control are being investigated.

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Appendix 5.

The influence of thermal processing severity on the yield and texture of canned abalone (*Notohaliotis ruber*)

A. D. WARNE and N. BROWN

The effect of thermal processing on the yield and texture of canned Victorian black lip abalone (*Notohaliotis ruber*) was investigated. Cans of abalone were processed for 40 min at 115.6, 118.0 and 121.1°C respectively, and for 60 min at 121.1°C, after which the relationship between the process F_0 value and pack weight was studied. Significant losses on canning, based on the ratios of drained to filled weight, and softening texture, assessed objectively with an Instron 1140 Food Testing Machine, were observed as thermal processing severity increased.

This paper is the second in a series investigating the effects of processing on canned Victorian black lip abalone (*Notohaliotis ruber*). The previous paper (Warne & Brown 1982) was confined to a study of preparatory techniques, specifically cleaning brine concentrations and application times, enzymic cleaning and the use of phosphate additives in cleaning brines and canning liquor. Whilst combinations of these variables influenced total yields, the thermal process was shown to account for the greatest losses of all the processing stages (excluding shucking). Losses on retorting for 40 min at 115.6°C were shown to average 28% for 69 cans each filled with approximately 200–220 g of whole abalone. In terms of total sterilising effect this process was relatively mild for a low-acid canned product. F_c values of 2.9, 3.5 and 3.9 indicated that although the process was adequate with respect to inactivation of *Clostridium botulinum* spores, reductions in processing temperature and or time could jeopardise commercial sterility. Abalone canners must not overlook product safety in the belief that yield is the only criterion by which thermal processing severity is assessed; flesh tenderness is also influenced by processing. James and Olley (1971) have shown that canning produces a textural inversion as a result of the toughening of myofibrillar proteins at the base of the adductor muscle and a softening of the pedal sole as collagen is converted to gelatinous derivatives. The objectives in this investigation paper were: to study the relationship between thermal processing severity and weight loss during retorting canned abalone; and to study the effect of thermal processing on the texture of canned abalone.

Methods

The day after catching and overnight storage at 8°C, 18 kg of live abalone were shucked, packed in plastic bags under crushed ice in insulated boxes and transported to the processing plant. On arrival 11 molluscs were removed for measurement of the flesh pH using a Metrohm Herisau E520 pH meter. An incision was made into the pedal sole of each abalone and the electrode tip inserted to a depth of 30 mm. Abalone were cleaned for 30 min by immersion and gentle stirring in approximately three times their mass of warm (35–40°C) cleaning brine containing protease, F S (5 g/L, Halcyon Proteins Pty Ltd, Melbourne), NaCl (30 g/L, food grade), and Mera 67(30 g/L) a proprietary blend of sodium tripolyphosphate and monosodium orthophosphate (Albright and Wilson Pty Ltd, Melbourne). After removal from the brine, enzymic action was arrested by rinsing the abalone for 10 min in peroxide solution (0.225 g/L). Abalone were trimmed and any remaining melanin pigment removed by light scrubbing with nail brushes before blanching for 5 min in water at 70°C. In order to simulate commercial operations i.e. packing whole abalone to a minimum weight, three or four abalone were filled into S.R. lacquered 74x112.5 mm cans and fill weights recorded. Thermocouples were inserted into the thermal centres of seven filled cans so that F_c values for the thermal process could be calculated. Cold canning liquor containing NaCl food grade (20 g/L) sodium acid pyrophosphate (5 g/l) and sodium metabisulphite (1 g/L) was added and the cans vacuum sealed. Cans were divided into four lots for processing at time and temperature combinations chosen to simulate commercial canning procedures; these were 40 min at 115.6, 118.0 and 121.1°C and 60 min at 121.1°C. After pressure cooling and 21 days storage at ambient temperature (20°C), cans were opened and drained weights recorded. Weight losses on thermal processing were then calculated for each can.

The texture of pooled samples from each lot was assessed using an Instron 1140 Food Testing Machine. A 10 mm thick vertical slice taken through the mid-portion of the adductor muscle and underlying pedal sole of each abalone tested was placed on a flat base plate with a central hole (15.7 mm diam.) and punctured by a flat ended probe (6.3 mm diam.) moving through at a crosshead speed of 200 mm/min. Each slice was punctured between two and five times depending on cross sectional area and the maximum resistance for each measurement recorded as kg-force on the recorder chart which was synchronised to move at twice the crosshead speed. For statistical analysis, the mean reading for each slice was used and then pooled to give the mean reading for each lot.

Results and discussion

The mean flesh pH of 6.4 (SE = 0.04) indicates there had been a loss of condition since harvest when it would be expected to have been between 7.0 and 7.4. In commercial practice such a pH drop is unlikely to be avoided unless canning is commenced within hours of landing healthy specimens. The average fill weight for 24 cans was 313 g (95% confidence interval, 303 to 323 g).

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Table 1. Effect of thermal process conditions and fill weight on F_o values for canned abalone*

Process conditions				
Time (min)	Retort temperature (°C)	Can fill weight (g)	F_o value actual	F_o value (theoretical 'worst case')†
40	115.6	333	0.5	0.5
40	115.6	313	1.1	—
40	118.0	315	3.1	0.7
40	115.6	325	3.1	—
40	121.1	335	1.3	1.4
40	121.1	270	4.2	—
60	121.1	272	9.4	10.4

** From Warne (1982)*
† In cases where theoretical 'worst case' values exceed the actual values, the difference can be attributed to the difference between methods of calculation.

Influence of fill weight and processing severity on F_o values

Table 1 summarises the F_o values obtained for each process. The results indicate the extent to which processing conditions and fill weight can influence the total sterilising effect. Fill weights as high as 335 g are not uncommon, because some processors who having accepted large (30%) losses on thermal processing must pack to ensure they fulfill minimum weight requirements set down by the Department of Primary Industry. Whilst 40 min at 118°C yielded F_o values in excess of the generally accepted safe minimum of 2.4 (Stumbo 1973), the cans processed for 40 min at 115.6°C and the heavier of those processed for 40 min at 121.1°C received inadequate heat treatment. The latter was the heaviest of all packs examined, which would account for the slow heat penetration to the point of temperature measurement. Inevitably there will be some can-to-can variation in F_o values as it is not always possible to locate the tip of the thermocouple in the thermal centre of the packed can. Notwithstanding this, the data indicate that fill weight should be regulated; most important, the adequacy of the thermal process must be assessed on 'worst case' examples, that is on cans filled to the upper limit of pack weight. Theoretically, calculated 'worst case' F_o values based on the slowest heating can demonstrate the values that could be expected had all cans exhibited the same heating characteristics.

Relationship between thermal processing severity and weight loss

The influence of processing conditions on weight loss of canned abalone is demonstrated by the results in Table 2. Average losses ranged from 12.8 to 29.1% after processing for 40 min at 115.6°C and 60 min at 121.1°C, respectively. Analysis of variance indicated there was a significant difference [Kruskal-Wallis test, $p < 0.01$] between average can losses for the processes. When considered in conjunction with the results shown in Table 1, it is evident that an increase in processing severity as measured by F_o value will result in reduced yields. Thus the abalone canner must compromise between the desire for maximum profitability through high yields and the need to apply an adequate thermal process. While losses caused by retorting for 40 min at 115.6°C are relatively low, the safety from botulism of those eating the canned product is less than that required by good commercial practice.

Table 2. Effect of thermal process conditions on weight loss* of canned abalone

Process conditions			
Time (min)	Retort temperature (°C)	Cans/lot	Average loss/can (%)
40	115.6	7	12.8
40	118.0	7	17.7
40	121.1	5	19.2
60	121.1	5	29.1

** Weight loss calculated as* $100\left(1 - \frac{\text{drained weight}}{\text{filled weight}}\right)$
where filled weight and drained weights refer to the weight of abalone in each can before and after retorting.

Table 3. Effect of thermal processing conditions on mean force required to puncture slices of canned abalone 10 mm thick

Process conditions			
Time (min)	Retort temperature (°C)	Number of measurements	Force (kg)
40	115.6	54	2.13
40	118.0	65	2.17
40	121.1	32	2.11
60	121.1	32	1.76

Effect of thermal processing on texture of abalone

Amongst the changes produced by canning are the weight losses of abalone and the formation of opaque canning liquors which frequently set as a firm gel on refrigeration. These phenomena are explained in part by the conversion of collagen in the pedal sole to gelatin, some of which passes into the surrounding liquor. James and Olley (1971) concluded that this mechanism accounts for the softening of the pedal sole, albeit in contrast to the toughening of the adductor muscle myofibrillar proteins. The results in Table 3 summarise the effect of thermal processing severity on flesh texture as assessed with an Instron 1140 Food Testing Machine. The method of textural evaluation selected produces a composite profile based on the average force required to puncture each slice. Statistical analysis using pairwise multiple comparison (Dunnett 1980) indicated there was no significant difference ($p > 0.10$) between the force required to puncture samples processed for 40 min at 115.6, 118.0 and 121.1°C, respectively. However, the difference between the texture of samples processed for 60 min at 121°C and those processed for 40 min at 115.6, 118.0 and 121.1°C were significant ($p < 0.01$). This indicates that the flesh toughening produced by heating can be reduced by prolonged thermal processing.

It had previously been observed (unpublished work) that Instron values (determined as in the method for this paper) for uncooked abalone, and abalone processed for 40 min at 118°C and 60 min at 121.1°C are significantly different ($p < 0.001$). These results and those of a corresponding sensory test in which 90 Asian panelists were asked to rate texture of samples from the two processes, are given in Table 4. Throughout the series of experiments referred to, the source of, and the preparatory techniques for, the abalone were identical and all processing was conducted on the same day. We concluded that changes in Instron puncture forces have a discernible sensory correlation; on the scales chosen a change in force from 2.30 to 1.55 kg corresponds to a sensory assessment change of 0.99 units, or

Table 5. Effect of process conditions on line slopes and correlation coefficients for linear regression analysis of Instron puncture force versus abalone drained weight

Process conditions: Time (min)	Retort temperature (°C)	Number of abalone tested	Number of Instron measurements	Regression line slope	Correlation coefficient
40	115.6	18	54	0.00	0.01
40	118.0	22	65	-0.01	-0.19
40	121.1	11	32	0.01	0.14
60	121.1	12	32	0.01	0.46

from between 'extremely' and 'moderately tender' to between 'moderately' and 'slightly tender'. Applying these conclusions to the evidence in Table 3, it can be postulated that where there is a significant difference in puncture force there will also be a detectable sensory difference.

To determine whether texture after processing was a function of abalone size, linear regression analyses for mean Instron puncture force versus abalone drained weight for all processes were performed. (Table 5). Theoretical regression line slopes are close to or equal to zero and correlation is poor in all cases. The inability to demonstrate a relation between flesh texture after processing and abalone weight applies for all processes. Rather than assert there is no association between these factors, we conclude that none was detectable under the commercial filling standards adopted. Furthermore, thermal process severity remains the dominant factor determining both yield and final texture.

Thus an abalone canner is faced with the choice of increasing the severity of the thermal process and benefiting from textural softening, or accepting a tougher product and also a higher yield. The significance of freshness and high flesh pH should not be overlooked, for as James and Olley (1970) observed there is a highly significant negative and linear relationship between toughness and hydrogen ion concentration. However, given abalone of constant freshness it appears that a processor may adjust the severity of the thermal process so as to attain desirable texture. What constitutes desirable canned abalone texture for the Asian export market will be the subject of a further contribution.

Conclusions

Increasing thermal processing severity has been shown to reduce yields and soften the texture of canned abalone. Thus the attraction of high yield must be weighed against the possibility of inadequate sterilisation for no manufacturer can tolerate consumer health risks. Similarly the desire to produce a tender product must be balanced against the acceptability of high canning losses.

Acknowledgements

The work was funded by a grant from the Fishing Industry Research Trust Account and forms part of a project to investigate fish canning and quality control in Australia.

Table 4. Effect of thermal process treatment on objective (Instron) and sensory* assessment of the texture of abalone

Thermal process treatment	Number of Instron Measurements	Instron force (kg) Mean	SE	Sensory score Mean	SE
None (uncooked)	58	0.38†	0.01	—	—
40 min at 118°C	147	2.30†	0.07	2.80‡	0.13
60 min at 121.1°C	238	1.55†	0.03	1.81‡	0.08

* *90 Asian panelists' rating on 7 point category scale: extremely tender = 1, extremely tough = 7.*
† *Hardness values significantly different (Kruskal-Wallis, $p < 0.001$)*
‡ *Sensory scores significantly different (Sign test, $p < 0.001$)*

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Appendix 6.
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Consumer preferences for fishery products

J.L. SUMNER, A.D. WARNE, E. GORCZYCA and N. BROWN

Australia is both a major importer and exporter of fish and fisheries products. Mainly frozen fillets destined for the chilled, supermarket trade are imported; highly-priced crustaceans and molluscs are exported mainly to Asia and the USA. Perhaps not surprisingly, therefore, Australian consumers have little perception of the objective criteria of fish quality which has led to the definition of the 'Great Australian Fillet' as 'white, skinless, boneless and . . . tasteless'. By contrast, Asian consumers are much more expert at assessing quality as evidenced by a survey of Chinese consumers who were able to differentiate between abalone processed by two thermal processes differing in severity.

Fish quality is notoriously difficult to assess. First, there is the hunting nature of fishing which often results in empty nets or gluts, plus associated storage difficulties in bringing home the catch. Second, there is the diversity of 'fish' species ranging over several phyla such as crustaceans (prawns and crabs); molluscs (abalone and mussels); echinoderms (sea urchins and cucumbers); and the finfish, both cartilaginous fish (shark) and bony fish, which comprise the majority of finfish species. Third, consumers tend to be 'experts'. They effect to know exactly what is good quality and what they like, factors which they often consider synonymous.

Australia's export/import fish trade reflects many of the perceptions of Australian consumers. Traditionally, Australia has exported predominantly high-value crustaceans and molluscs, and imported generally low-value frozen fillets and crustaceans. In the year ending June 1981, for example, imports totalled $189 million (up 5.6% from June 1980) with a value of $2.60/kg (up 18%). Exports for the same period totalled $230 million (down 32%) at $7.70/kg (up 35%) (Anon. 1981).

Interestingly, Australia both exports and imports prawns, high-value uncooked prawns being exported at an average of $9.50/kg (1980-81 figures) while mainly small, cooked, peeled prawns are imported at an average of $5.90/kg. This great disparity in quality and price has not prevented Australian authorities from imposing microbiological standards for imported prawns more stringent than those recommended by the International Commission on Microbiological Specifications for Food (ICMSF 1974), or by any other importing country (Sumner 1982). The attitude of Australian authorities that standards for imported prawns be identical with those imposed on domestic industry fails to take into account the naturally higher bacterial levels of tropical prawns (Cann 1976). In addition, Australian prawns are typically much larger than the size categories imported which owing to their surface area/volume ratio must be expected to have a higher count on a per weight basis.

Recent trends in fish imports into Australia

A major recent trend has been increased imports of chilled and frozen fish, either whole or filleted (Table 1) particularly from New Zealand (Table 2), and particularly in the volume of frozen fillets. Imports of finfish to Australia have had a debilitating effect on the local industry which already has considerable problems stemming from catches which are often low and which may contain up to 40 species (Townsend 1981). As well, the appreciation in 1981 of the Australian dollar against other currencies in general, and the New Zealand dollar in particular, made imports even more competitive. In terms of sensory quality, fish imported frozen and marketed thawed, chilled in supermarkets and other retail outlets, has been shown to be of very poor quality (Sumner & Gorczyca 1982). For some species grade 1 ('good') quality shelf-life was expended even before the product could be marketed (Table 3) while grade 2 ('average') quality had a short shelf-life, necessitating packs being removed from supermarket cabinets each weekend. Local species, on the other hand, iced between catching and processing had much longer shelf lives in grade 1 (Table 3).

Table 1. Imports of whole and filleted fish into Australia

	Quanity (t)		Value ($A'000)	
	1979–80	1980–81	1979–80	1980–81
Fresh, chilled or frozen				
Whole	8121	10 021	9605	13 329
Fillets	20 652	22 842	34 471	43 672
Total	28 773	32 863	44 076	57 001
		(+11%)		(+13%)

Source: Aust. Fish. *40 (10): 22-7; 1981*

Table 2. Imports into Australia of fresh and frozen fish from New Zealand

	1978–79 (t)	1979–80 (t)	Change (%)
Fresh and chilled	1811	1494	−17
Frozen	5001	9543	+90
Fish fingers	35	436	+1145

Source: Aust. Fish *40(5): 14-16;* 1981

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Consumer preference for fisheries products — it is all a matter of taste

John Sumner, Darian Warne, Elizabeth Gorczhca and Nick Brown

Fish quality, as defined by the consumer, is a very difficult thing to assess. As the title of this article suggests, it depends so much on individual taste. Nevertheless, there are some objective methods of determining "consumer-defined" quality, a few of which are discussed here by the authors.

Fish quality is notoriously difficult to assess. Firstly, there is the hunting nature of fishing which often results in either empty nets or gluts, plus associated storage difficulties in bringing home the catch. A second problem is the diversity of "fish" species, ranging over several phyla: crustaceans, like prawns and crabs; molluscs, like abalone, mussels and squid; echinoderms like sea urchins and cucumbers; and finfish — both cartilage fish like sharks and bony fish which comprise the majority of finfish species. Thirdly, consumers tend to be "experts". They appear to know exactly what is good quality and to know what they like, factors which they often consider to be synonymous.

The fact that consumers know exactly what they like should be good news to fish processing companies developing new products or broaching new markets. The company, typically, will organise an evaluation of test products and hope that the great consuming public will tell them unequivocally what the product should taste like.

A matter of taste

Unfortunately, such is only rarely the case. Consider the data in Table 1, where seven consumers were asked to evaluate a pickled scallop *Pecten alba*) product. All seven consumers were experts who all worked with scallops and were used to tasting them.

At first sight the information they supplied appeared useless. Three consumers considered Sample 1 the best, though overcooked, while to the other taste panelists Sample 1 was, variously, "too acid", "too salty", "tasteless" and "horrible". Whoever said "the customer is always right" never set up a taste panel!

However, from all the information supplied, it became clear that the product had been overcooked. Every panelist had commented on the tough texture using words like "overcooked", "rubbery", "chewy" or "tough".

Another pervading comment was on saltiness and on lemon flavour from added citric acid. Eventually a success-

Table 1: Consumer reactions to test batches of pickled scallops

Consumer profile	*Sample 1*	*Sample 2*	*Sample 3*	*Sample 4*
Male, manager Scallop Association	Overcooked*	Overcooked Tasteless	Overcooked rubbery	Overcooked
Male, Director Fisheries	Overcooked*	Overcooked	Overcooked	Bitter
Male, Manager Fisherman's Co-op	Too acid	Less acid Tough	Less acid Tougher	Too lemon
Male, Fisheries Inspector	Too salty	Too acid	Extremely overcooked	Overcooked rubbery
Male, Fish processor	O.K.*	Slightly rubbery	Slightly rubbery	Slightly rubbery
Female, Fish processor	Tasteless	Chewy, salty	Better	Nice*
Female, Fish processor	Horrible	Chewy, dislike	Not bad*	Not bad*

* *Denotes some preference for one particular sample*

This article represents a summary of a paper presented at the Singapore conference in May. (See INFOFISH Marketing Digest no 4, July 1982, for a report on the conference). John Sumner is Principal Lecturer in Food Science and Technology at the Royal Melbourne Institute of Technology, and his main interest is fish quality and ensiling of fish waste. Darian Warne is fish canning expert, currently surveying quality control in Australian fish canneries. Elizabeth Gorczhca recently completed her Master's Degree on storage and quality of fish. Nick Browne is food technology graduate presently working on a Master's Degree in ensiling of fish waste ful product was made by boiling scallops very quickly in a relatively small quantity of water which formed the stock from which the brine was made by adding small quantities of salt, acetic acid and citric acid.

What's in a name

Sometimes consumers buy according to the name of a fish species — paying considerably more for a favoured species. But can they tell the difference from closely similar species, and if they can tell a difference, which species do they prefer in a "blind" taste panel test of unmarked fish samples?

Australian consumers in Melbourne pay considerably more for Rock Flathead, (*Platycephalus laevigatus*) ($2.50 — 4.30 per kg) compared with other flatheads, like Tiger Flathead (*Neoplatycephalus richardsoni*) ($1.60 — 2.50 per kg) and Sand Flathead (*Platycephalus bassensis*). However, consumers found it difficult to distinguish rock flathead from the other flatheads and, of those who could differentiate flatheads, only around 50% actually preferred rock flathead. Objective criteria for quality (Table 2) showed little difference between flathead according to Torrymeter reading, K-value, TMA level and bacterial levels which, coupled with taste panel data, indicates that consumers cannot distinguish a species for which they will cheerfully pay 70% more than closely similar species.

Using the Australian consumer as a marker for fish quality, however, must be balanced by the fact that Australian consumers dictate that the Great Australian Fillet be white, skinless, boneless ... and tasteless!

The fastidious Asian consumer

Much more relevant is the reaction of Asian consumers to the highly valued abalone (*Notohaliotis ruber*) which fetches A$16 kg (shucked) and A$23/kg (drained weight) for the frozen and canned products respectively. Last year this lucrative canned item earned Australian manufacturers A$20 million (about US$20 million), 81% of production going to Japan, Hong Kong and Singapore.

Canning of abalone presents advantages compared with the more traditional frozen product:

- greater returns on a $ kg basis.
- freedom from the cold chain.
- shelf-stable product.

But what do consumers want in canned abalone in terms of texture and flavour? This was the key problem facing an Australian manufacturer planning to change from frozen to canned product as he costed the plant and equipment needed for the cannery and as he considered the risks of canning, compared with freezing.

The solution — a survey in Melbourne's Chinatown involving 90 Chinese consumers who regularly ate abalone, and, like all consumers, knew what they liked. Answering a questionnaire in Mandarin and English (Fig. 1), consumers isolated texture as a major quality factor. This had immediate impact for the processor who could, by altering the temperature and time of the retorting (cooking) process, markedly alter the texture of the canned product.

But there was a further critical point — process alteration also affected the yield of abalone — for, as the process became more severe, the abalone, quite literally, lost weight. And, as any food technologist will tell you, weight loss equals financial loss.

So the manufacturer worked out two processes:

Table 2: Rock Flathead quality parameters compared with Tiger or Sand Flathead

	Rock Flathead Mean	Tiger or Sand Flathead Mean
Torry meter	12.2 (6–16)*	13.6 (10–15)
K value (%)	42.2 (15–85)	42.6 (12–97)
Trimethylamine (mg%)	0.37 (0.03–2.8)	0.58 (0.06–2.5)
Total bacteria count (/g)	50,000 (5000–140,000)	60,000 (50–200,000)
Total count of sulphide producing bacteria (/g)	2,000 (<100–20,000)	2,000 (<100–20,000)

* *values in parentheses are minima and maxima*

Table 3:— What do consumers think of canned abalone

	Mild process 118°C/40min	Severe process 121.1°C/60 min.
Very tender	40*(44%)	81 (90%)
Neither tender nor tough	49 (54%)	9 (10%)
Very tough	1 (2%)	0

* *Number of consumers who graded in each texture category.*

Table 4:— How does the experimental abalone compare with your usual brand?

	Mild process	Severe process
Better than or equal to my usual brand	60 (67%)*	54 (60%)
Worse than my usual brand	11 (12%)	14 (16%)
Don't know	19 (21%)	22 (24%)

* *Consumers who graded in each category.*

- Mild process, 118°C for 40 min, giving a relatively tough product.
- Severe process, 121.1°C for 60 min, giving a more tender product.

Each product was offered to consumers who commented on the quality (Table 3) considering the product from the mild process to be tougher and preferred (Table 4) to that of the severe process. Which supports the observation that good quality abalone has a unique "chewy" texture.

Trials involving approximately 450 measurements using the Instron Texture Tester — a highly sensitive set of mechanical jaws — confirmed the panelists' findings; abalone from the mild process was significantly tougher

I THINK THIS ABALONE IS EXTREMELY TENDER
我認為这鮑魚最柔脆

I THINK THIS ABALONE IS MODERATELY TENDER
我認為这鮑魚不过分的柔脆

I THINK THIS ABALONE IS SLIGHTLY TENDER
我認為这鮑魚有些小的柔脆

I THINK THIS ABALONE IS NEITHER TENDER NOR TOUGH
我認為这鮑魚不柔脆也不堅韌

I THINK THIS ABALONE IS SLIGHTLY TOUGH
我認為这鮑魚有些少的堅韌

I THINK THIS ABALONE IS MODERATELY TOUGH
我認為这鮑魚不过分的堅韌

I THINK THIS ABALONE IS EXTREMELY TOUGH.
我認為这鮑魚最堅韌

Figure 1: Questionnaire prompt card for evaluation of abalone texture.

than the severely processed product. The strong correlation between objective and sensory texture measurements means the manufacturer need not rely on expensive and time-consuming consumer surveys in order to find out how his valued customers rate the texture of the canned product. This important quality characteristic can be measured directly in the canning factory as part of routine quality control.

Once objective textural limits have been set, abalone can be produced to have just the right texture for the discerning Asian consumer as shown by these experiments.

All of which was good news for the canner: the mild process gives higher yields, only 21% weight loss on retorting (cooking) compared with 32% for the severe process. At A$23 000 per tonne, in the can, this represents extra revenue of A$700 per tonne (fresh weight), or on a national basis at current prices A$1.2 million for the industry as a whole.

Quality, then, for that esoteric food, abalone, can be measured by taste panel evaluation and by mechanical means with the tongue and teeth giving answers identical with the Instron Texture tester — discriminating Asian consumers and objective testing machine agreeing.

But lest the impression is gained that quality assessment is an Asian trait consider a Sri Lankan marketing ploy used in fish quality assessment: beach-seined fish are considered best quality, and, not surprisingly, fetch higher prices. And typically, beach-seined fish also have sand in the gills and scales which is why you will find a section at Colombo's St. John's Market selling little bags of sand which you can sprinkle to make all your fish beach-seined!

Appendix 8.

RMIT studies seafood canning-cooking

by A. D. Warne*

THE Royal Melbourne Institute of Technology is examining current Australian cooking methods for canned seafood products to ensure there is no risk of food poisoning.

While there has been no suggestion that there is any risk whatsoever in Australian canned seafood products, a recent outbreak of food poisoning caused by canned product in Britain and other cases overseas have emphasised the need to regularly assess thermal processing techniques for canned products, including seafood products.

The present research in this area at the Royal Melbourne Institute of Technology (RMIT) is being conducted by the Food Science and Technology Unit under a Fishing Industry Research Trust Account grant.

We aim to assess the safety of current processes and confirm that Australian canned products are safe from spoilage by the food-poisoning bacterium *Clostridium botulinum*.

This is the bacterium responsible for the type of food poisoning commonly known as botulism. It was the cause of fatal food-poisoning cases in Britain recently. That outbreak resulted in lost sales worth at least A$3 million and attracted considerable bad publicity for the nation's entire food-canning industry.

So far the RMIT work has been confined to abalone, which is the major canned seafood exported from Australia. Sales in 1980-81 totalled $20 million.

Canning abalone is lucrative but difficult. For instance product quality and high yields (drained-weight yield, that is) require a fine balance between *temperature* and *time* of cooking. Lower temperatures for shorter times produce higher yields; longer times at higher temperatures give comparatively poor yields but a succulent product (like the acclaimed Mexican canned abalone).

Although pre-canning treatments such as brining and washing can affect the final yield, the greatest improvements in yield undoubtedly come from reducing the time and temperature of thermal processing. However the danger in reducing these is that they then may not be enough to kill all contaminating bacteria, particularly the heat-resistant spores of *Clostridium botulinum*.

Should these spores survive the canning process they could produce lethal toxin without any overt signs of spoilage to alert the canner, retailer or consumer.

Good commercial practice, based on years of experience, dictates that the probability of even one spore surviving in a can must be made less than one in a million-million. These are long odds, certainly, yet realistic when public health and processor bankruptcy are at stake.

This safety level is achieved by designing a thermal process sufficient to guarantee that every part of the canned product has received the equivalent of at least 2.8 minutes' heating at 121.1°C. This time and temperature combination are referred to as giving an 'F_0 value' of 2.8 minutes, or a 'botulinum cook'.

At RMIT we have duplicated typical Australian processing schedules and have studied the influence of fill weights and processing temperatures and processing times on actual F_0 values for canned abalone.

In some instances cans were underfilled so that the final drained weights would be less than the required 225 g of abalone meat in each 450 g can. Other cans were overfilled, as

This table shows the effect of process temperature, time and fill weight (the weight of abalone meat in each can) on the so-called 'F_0 value', a measure of destruction of bacteria. A figure below 2.8 (minutes) is not acceptable.

Process temperature (°C)	*Process time (minutes)*	*Can fill weight (g)*	*Actual F_0 value (minutes)*	*Theoretical F_0 value for 'worst case' (minutes)*
115.6	40	333	0.5	0.5
115.6	40	313	1.1	—
118	40	315	3.1	0.7
118	40	325	3.1	—
121.1	40	335	1.3	1.4[a]
121.1	40	270	4.2	—
121.1	60	272	9.4	10.4[a]

a. In cases where theoretical 'worst case' values exceed the actual values, the difference can be attributed to the difference between methods of calculation.

*Darian Warne is a member of the Food Science and Technology Unit of the Department of Applied Chemistry at the Royal Melbourne Institute of Technology.

could happen in a cannery where large abalone were being used.

In the table are summarised the processing variables used and the F_0 values computed directly. Also included are theoretical F_0 values for 'worst case' conditions, based on parameters derived in these experiments.

These theoretical figures indicate the F_0 values that could be expected with high fill weights and initial temperatures of 35°C. Several points emerge:

- processing for 40 minutes at 115.6°C was not sufficient to produce the minimum F_0 value (2.8 minutes) required and canned product processed at this time and temperature would not be accepted as safe from *C. botulinum;*
- processing at 118° and 121.1°C produced the required F_0 value in all but one can, a can packed with 335 g of abalone, not an unrealistic amount given the solid packing that sometimes occurs;
- assurance of process adequacy is only possible if can fill weights are strictly controlled, and this might need size-grading and use of some abalone portions (rather than whole abalone only);
- the heating characteristics of canned abalone indicate that heat transfer is by conduction, which makes product fill temperatures critical if marginal processes are to be used; and
- theoretical 'worst case' F_0 values highlight the dangers in striving for increased yields through reductions in process severity.

It can be concluded that strict adherence to sound thermal processing schedules is essential if consumer safety is to be guaranteed. A risk-benefit analysis would surely indicate that it is more prudent to accept a small drop in yields rather than a total loss in sales through failure in the market place.

Canning abalone — background information

THE canning of abalone represents an important sector of the Australian fish-processing industry.

Currently it is based on the resources of this mollusc in coastal waters along southern New South Wales, Victoria and Tasmania. (Most of the abalone taken in South Australia is exported frozen.)

Production of canned abalone in 1980-81 was 1 800 tonnes, almost all of it sent to Asian markets (particularly Japan and Hong Kong). At present there are five abalone canneries in Australia.

A useful summary of investigations into abalone canning is provided by the paper 'Abalone — an esoteric food', written by J. Olley and S. J. Thrower and published in *Advances in Food Research*, Vol. 23, 1977. This paper draws on work on abalone canning carried out by Dr Olley at the CSIRO Division of Food Research Laboratory in Hobart.

An earlier description of abalone canning is available in the article 'Processing and canning abalone' by W. A. Montgomery in *Australian Fisheries Newsletter*, June 1966.

A description of quality requirements in canned abalone is given in the circular 'Australian Export Standard for Canned Abalone' *(Exports Fish Circular* 140, 1979), available from the Fisheries Division, Department of Primary Industry, Canberra, ACT 2600. — **Peter Davis, DPI.**

Appendix 9.

Maximising customer satisfaction and product yield — an attainable goal for abalone canners

Abalone canners can produce a safe yet slightly-processed product that will both satisfy customers and maximise yield, according to food technologists Darian Warne and Nick Brown.

SAFETY is an important consideration for abalone canners. In fact consumer safety is *the* most important factor in canning abalone, and a previous article in *Australian Fisheries* (February) examined factors affecting the safety of canned abalone and identified the minimum processing requirements.

However canners' problems are not confined to matters of safety — fluctuations in market price and increased competition also threaten the valuable export trade. (It earned $20 million in 1980-81.)

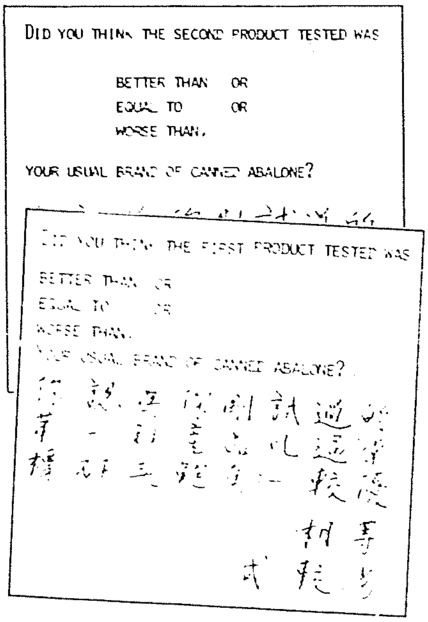
To survive, abalone canners must balance the need for safety against sensory requirements (affected by texture, flavour and colour) and satisfactory yields. At around $23 a kg (drained weight) it is important that:

- the product conforms to consumers' expectations; and
- yields are maximised.

Work in the Food Technology Unit of Royal Melbourne Institute of Technology (under a Fishing Industry Research Trust Account grant) has identified critical factors influencing consumer acceptance of Australian abalone and related these to yields of the canned product.

Rather than conduct our research in the export markets of Japan, Hong Kong and Singapore we opted for the considerably cheaper alternative of locating a target population closer to home.

We surveyed restaurants in Melbourne's Chinatown and questioned 90 Asian respondents, all chosen because they ate canned abalone at least once a month. Our selected panelists had product familiarity and would know what to expect of canned abalone,



whereas the average Caucasian would be of little help.

Respondents were asked to rate the texture of product cooked for either 40 minutes at 118 °C (mild processing) or 60 minutes at 121.1 °C (severe processing). Using a seven-point scale (extremely tender = 1; extremely tough = 7) the mildly-processed product was found significantly tougher than the severely-processed variety.

Further questioning revealed that when compared with their usual brand significantly more people preferred the tougher product.

We then related preferred textual characteristics to instrumental measurements of the same attribute and developed a scale that allows prediction of consumer response to the texture of all grades of canned abalone — without expensive and time-consuming surveys.

Of direct financial importance to canners is the yield after thermal processing. It was shown that the severe process caused a 12 per cent greater loss on cooking (retorting) than the mild process. This means mild processing not only produces a preferred texture but also offers potential savings of $700 a tonne (fresh weight) for the canned product.

Our conclusions are, that by carefully manipulating process severity:

- an abalone canner may produce to a textural specification matched to the requirements of his discerning Asian consumers; and
- substantial savings can be made if overprocessing is avoided — and this need not jeopardise consumer safety.

In the canned abalone market, where the competition is strong and the returns high, it makes good sense to identify consumer preferences. And what processor wouldn't be pleased to know that he can increase profitability while meeting those consumer preferences?

Further information is available from the authors by writing to them at the Food Technology Unit, Department of Applied Chemistry, Royal Melbourne Institute of Technology, GPO Box 2476V, Melbourne, Vic. 3001, or telephoning (03) 345 2822.

Canning quality and product safety:

The case for vigilance before and after processing

Under a research grant from the Australian Federal Government's Fishing Industry Research Trust Account (FIRTA), the Food Technology Unit at Royal Melbourne Institute of Technology (RMIT) has evaluated thermal processing and quality control procedures in a number of Australian fish export canneries.

by Darian Warne and Daniel Capaul

In each cannery reviewed, the research team studied critical functions of the canning process — from the receipt of raw materials through preparation, filling, sealing, retorting, cooling and storage. Using Critical Control Point analysis, process flow diagrams were prepared and submitted to the manufacturer. In some cases, recommendations for improvements were made while in others new canning processes were developed. Although the work is scheduled to be completed by December 1983, key findings can be summarized as follows:

Underprocessing and spoilage with canned scallops

One manufacturer, having adopted a thermal process that proved inadequate for shelf stability, isolated blown cans amongst finished stock; the problem was caused by underprocessing. It is accepted that low acid (pH > 4.5) canned foods must receive a total thermal process lethality that is at least equivalent in sterilising effect to 2.8 minutes at 121.1 °C. By convention, this is designated as $F_o > 2.8$ min. Trials in the Food Technology Unit demonstrated that the manufacturers' scheduled process produced an F_o of 1 min; for potentially lethal bacterial spores of *Clostridium botulinum*, this corresponds to a survival rate of approximately one thousand million times the maximum recommended. There being no assurance that *Clostridium botulinum* spores were not contaminating the raw material it was fortunate that the microbial spoilers did not cause an outbreak of food poisoning.

The process schedule has been amended to deliver the required F_o value, but as the increase in thermal processing severity has decreased yields and led to unacceptable softening, the manufacturer is now developing an acidified pack. With the new formulation in which the acidity of the brine prevents growth of *Clostridium botulinum*, a pasteurization process will be sufficient for commercial sterility and the mild heat will limit textural damage and weight loss.

Canned abalone

Abalone canning in Australia is an attractive proposition — at least the management of three canneries which have been recently commissioned think so; and when consumer demand pushes prices to $23/kg (drained weight), it is easy to understand their logic. Despite the rewards, the task of canning is difficult. Trials at RMIT and with several abalone canneries have demonstrated that thermal processing severity affects both the safety and the weight loss of the finished product. Table 1 summarizes our results showing the process times at different retorting temperatures required to give the contents of every can the minimum F_o value of 2.8 min. Table 2 shows the effect of increasing thermal process severity on the yield of the canned product. The dilemma facing the canner, that of sacrificing yield in order to protect consumer safety, is heightened, as shown by market surveys (see INFOFISH Marketing Digest/September 1982, No. 5-p.8). Asian consumers prefer the unique chewy characteristic of abalone that has undergone relatively mild processing. But there can be no choice in this matter — consumer safety must come first. However, by adopting a strictly regimented thermal processing schedule, safety requirements can be fulfilled while yields and textural characteristics are optimised.

Canned tuna

As those familiar with fish canneries understand, no two production lines are the same, and what makes sense in one factory may be inappropriate in another. As a registered (but small) food factory, the RMIT Food Technology Unit has been processing canned tuna for several years, and as a result has built up a substantial data base on the thermal properties of canned tuna. While working in one commercial cannery, we found that processing temperatures and times employed in the plant were significantly greater than those used elsewhere. Detailed analyses of temperature-time plots taken from cans in the commercial retorts and later replicated in our pilot plant showed that the F_o value for the scheduled process was approximately seven times the usual target for industry. Although we acknowledge that the process was more than sufficient to kill any harmful bacterial spores present, we concluded that a process reducing the probability of *Clostridium botulinum* spore survival to approximately one in 10^{60} was excessive. In this instance, there were several reasons for reducing processing severity:

— the texture of product was suffering as a result of overprocessing
— flesh browning was occurring at the surface of the pack
— throughput could be increased when processing time was reduced
— unit costs would be reduced as steam and labour requirements fell

As a result of these trials, it was possible to recommend a reduction in processing time of 32% without risk of any

Table 1: Effect of retorting temperature on processing time required to deliver a total process lethality (F0 value) of 2.8 minutes for canned abalone

[illegible]	Proc[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	5[illegible]
121.1	45

[illegible]

Table 2: Relationship between thermal process severity and weight loss during thermal processing of canned abalone

Process Conditions Time (min)	[illegible]	[illegible]
40	[illegible]	[illegible]
40	[illegible]	[illegible]
40	[illegible]	[illegible]
60	[illegible]	[illegible]

significant effect on the safety of the finished product. Work with other can sizes is proceeding and similar savings in processing times are anticipated.

Canned Alaskan pink and red salmon

Reports compiled by the Public Health Laboratory Service (PHLS) of the Communicable Disease Surveillance Centre in London attributed the recent fatal botulism case in Belgium to consumption regulatory authorities and consumers around the world. On 16 February 1982, ten days after a Belgian, Eric Mathay, died from botulism, the Department of Health and Social Security in Great Britain announced a recall of all 220g cans of US salmon. On 17 February, the manufacturer, identified by the suspect can's code, ordered a world wide recall. The following day, the United States Food and Drug Administration issued a nation wide recall of several million cans of Alaskan pink salmon. Australian authorities having initially ordered a restricted recall on 19 February, enlarged this on 12 March, to a total recall of all brands of canned salmon from the United States. As suspect stock was recalled, analytical laboratories were faced with the task of assessing the safety from botulism of approximately 50 million cans from eight Alaskan canneries. The International Commission on Microbiological Specifications for Foods (ICMFS) had previously reflected on the difficulty of such a procedure when it noted "... if present *Clostridium botulinum* would be expected to occur, at such low frequency that no conceivable sampling plan would be adequate as a direct measure of its presence."

Safety can only be assessed indirectly when criteria other than the presence of *Clostridium botulinum* are used. The following is a summary of the results of analysis of one hundred and twenty cans (220 g) of Alaskan salmon which were withdrawn from sale by the Australian Department of Health in March 1982.

Materials and methods

Sixty cans (84 × 46.5 mm) of pink salmon and sixty cans (84 × 46.5 mm) of red salmon were received from the importer and inspected externally for signs of poor seam formation, damage and leakage. Tap vacuum tests were performed and the gross weight and manufacturing code of each can recorded.

Can ends were cleaned with 70% ethanol and then flamed. Each can was opened in a laminar flow cabinet using a sterile bacti-disc cutter. After noting the appearance and odour of the product, a portion (2-3g) was removed from each can and innoculated into a tube (13mm I. D.) containing cooked meat medium (15 ml) to which had been added glucose (0.5% w/v). After incubation for 3 days at 33-37°C, the tubes were inspected for turbidity and/or gas.

The product was aseptically removed from cans and placed in a sterile stomacher bag from which samples were taken for pH determination. After removal of all product, the cans were washed in warm water and detergent, boiled for one hour in clean water, drained and then dried for one hour at 60 °C. Cleaned containers were clamped in a leak-test rig in which flat rubber metal plates were adjusted to hold the cans across the tops of their double seams without distorting the can ends. Each can was subjected to an internal pressure of 170 kPa for at least two minutes by

Table 3: Summary of manufacturing codes, numbers of cans examined, flesh pH's and gross weights of canned pink and red salmon

Manufacturing code(s)	Number of cans	Product type*	pH Mean (g)	pH Range (g)	Gross weight Mean	Gross weight Range
HD 14B Q718T	10	P	6.12	5.95–6.20	276	267–289
HK 13C P818L	10	P	6.20	6.10–6.35	279	270–293
HP 13C N818	10	P	6.18	6.10–6.25	279	270–290
HU 13A V718	10	P	6.18	6.10–6.30	279	271–286
HS 14C L818	10	P	6.14	6.00–6.25	278	270–281
PGM 3 C032	10	P	6.23	6.10–6.30	277	270–281
B 1663 R81	3	R	6.32	6.25–6.40	278	274–282
B 1705 R81	4	R	6.25	6.20–6.35	274	269–279
B 1713 R81	3	R	6.37	6.20–6.50	278	269–291
P 1854 R81K	4	R	6.38	6.15–6.60	280	275–287
P 1902 R81K	3	R	6.27	6.20–6.30	286	282–288
P 1903 R81K	3	R	6.38	6.30–6.55	283	278–287
R 1705 278	10	R	6.35	6.20–6.50	280	274–284
SD 17 B6221	2	R	6.40	6.40–	275	269–275
SD 1A H6231	3	R	6.35	6.25–6.40	277	274–281
SD 10A C6292	2	R	6.43	6.30–6.55	270	259–280
SD 10C D6292	2	R	6.32	6.15–6.50	281	279–282
SD 10C G6252	2	R	6.35	6.30–6.40	283	282–283
SD 10M G6251	2	R	6.30	6.20–6.40	279	275–282
SD 10V A7062	2	R	6.40	6.30–6.50	276	267–284
SKI 06 A6265	2	R	6.45	6.40–6.50	271	268–274
SKI 07 D6275	2	R	6.40	6.30–6.50	276	274–277
SKI H A6174	2	R	6.40	6.40–6.45	273	272–273
SKI H A6175	2	R	6.40	6.40 –	280	276–284
SKI T D6195	2	R	6.40	6.40 –	275	272–278
SKI V H6254	3	R	6.35	6.30–6.40	279	276–282
SKI V H6255	2	R	6.43	6.40–6.45	276	275–276

* Pink salmon = 0, Red salmon = R.

Table 4: Minimum double seam percentage overlaps at canner's end (CE) and can makers end (CME) for pink and red salmon cans

Product	Minimum overlap Mean %		Range		Number of cans with less than 45 % overlap	
	CE	CME	CE	CME	CE	CME
Pink salmon	58	59	[illegible]-70	45-68	0	0
Red salmon	57	54	[illegible]-70	40-73	8	[illegible]

introducing compressed air through the can end opening and an inlet in one end of the clamping apparatus. Pressurised cans were held under water and examined for the continuous emission of bubbles indicative of double seam leakage.

In order to evaluate the formation of the double seams, the canner's and the can maker's ends were stripped and the percentage overlaps calculated 15mm either side of, and diagonally opposite, the side seams.

Results

All cans examined appeared sound with satisfactory vacuums and seam formation. There was no detectable double or side seam damage and no evidence of leakage. It was observed that some cans were sufficiently scored in the sidewall to cut through the external lacquer; however, in no case was the can wall perforated.

The absence of gas turbidity in the cooked meat medium in all but one tube suggests that viable organisms were not present in these cans. The exception, in which turbidity was observed, revealed numerous cocci on staining and was presumed to have resulted from contamination during innoculation as the product showed no signs of microbial activity and the can from which it came was sound.

In Table 3 are summarised the manufacturing codes, number of cans within each code and average flesh pH's and gross weights for all cans received. The uniformity of pH and gross weight for both pink and red salmon coupled with the acceptable characteristic odour and appearance of all samples indicated there had been no microbial deterioration in, nor leakage from, any can.

Table 4 gives summaries of double seam analyses for pink and red salmon cans. These data indicate that the minimum percentage overlaps for all pink salmon can ends were within the guidelines required by good manufacturing practice (i.e. > 45%). Of the red salmon can, eight canner's ends and four can maker's ends displayed overlaps less than 45%; however, neither these cans nor any others tested leaked under pressure testing at 170 kPa.

We infer from the lack of microbial growth in the cans, the failure to isolate viable organisms and the satisfactory leak test performance that all cans examined were commercially sterile. This finding offers little comfort if it is suspected that the incidence of potentially fatal product failure is too low for detection by sampling. The Belgian outbreak is believed to have resulted from post-processing contamination in which bacterial entry was through a small sidewall defect formed during can fabrication. Evidently, the damage caused by can reforming equipment occurred more than once as the Food and Drug Administration isolated 30 defective cans in its examination of recalled stock.

Critical control point analysis for fish canning

There are two classes of risk in fish canning:

- Commercial risks — associated with poor product quality, low yields and excessive manufacturing costs arising from incorrect processing conditions.
- Public health risks — associated with under-processing or post processing contamination.

We believe the most effective way for these risks to be reduced to an acceptable level is for canning operations to be defined by process flow diagrams that identify all critical control points:

Raw material quality
Temperature
Filling weight temperature
Container size and function
Processing temperature-time (F_o values)
Cooling water chlorination
Line damage records
Transports and storage conditions

At each critical control point, the manufacturer must establish a three component system that:

- Monitors
- Records and
- Controls

Only then can end product quality be assured.

Sample testing not sufficiently reliable

These analyses have confirmed the commercial sterility of the 120 samples examined but they do not imply that all eight million cans held in Australia were safe from botulism. Product safety and consumer protection is best assured by stringent manufacturing and recording systems which monitor well designed and correctly executed thermal process schedules. Even these by themselves are insufficient — as this last botulism outbreak demonstrated, post-processing contamination must also be prevented if fatal accidents are not to be repeated. Sampling cannot be relied upon to detect accidents which in a chance sequence of events cause manufacture of an unsafe product. This is why we recommend critical control point analysis.

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Appendix 11.

Abalone canning: Factors affecting product safety, sensory quality and profitability

Sensory quality, product safety and profitability are three key requirements necessary for the successful manufacturing of canned abalone. While the interdependence of these criteria has made it somewhat difficult for manufacturers to fulfil them, the fact still remains that product safety must override all other considerations.

by Darian Warne and Nick Brown

Australia lands more abalone than any other country, and since 1978 has accounted for over 36% by weight of the total catch in major producing countries. The other major fisheries are Japan and Mexico; however, the significance of Chilean loco (*Concholepas concholepas*) as a cheaper alternative has grown so that now, in terms of in-shell tonnage, it matches total annual landings of abalone. In August 1982, Australia introduced production quotas to combat over-supply and to stabilise the market. This has had the desired effect on the catch, which over the first twelve months fell 12% by weight and 25% (A$ 7 million) by value. However, despite the diminished harvest, abalone canners appear not to have been affected as their exports rose 47% by weight, and earnings showed a healthy 34% increase. Australian canned abalone exports over the five years to 1982–83 indicated that Japan, Hong Kong and Singapore continued as major customers, accounting for about 85% of the canned abalone exports.

There are eight Australian export registered canneries sharing a market, which in 1982–83 earned A$ 22 million; in 1978–79, there were only four canneries which earned A$ 7 million. Over a period of five years, the annual tonnage exported had grown by more than 60% while earnings increased by 200%. Expansion of this magnitude indicates that Asian consumers are not deterred by price alone, provided that the following criteria are met:

- The product matches consumer expectations of quality.
- The product is safe to eat.
- The selling price is competitive.

Successful manufacturers must not only fulfil these market-oriented requirements; they must also operate profitably. Research and development have revealed the interdependence of these criteria; however, in some cases pursuit of one objective has proved detrimental to the attainment of others.

Export of canned abalone from Australia

Year	Japan		Hong Kong		USA		Singapore		Others		Total	
	Quantity (MT)	Value (A$1000)	Quantity (MT)	Value (A$1000)	Quantity (MT)	Value (A$1000)	Quantity (MT)	Value (A$1000)	Quantity (MT)	Value (A$1000)	Quantity (MT)	Value (A$1000)
1978 – 79	513	3 243	313	2 022	95	604	90	531	98	645	1 109	7 045
1979 – 80	540	4 664	451	3 833	136	1 128	201	1 730	129	1 037	1 457	12 392
1980 – 81	607	6 984	560	6 232	220	2 520	265	2 919	115	1 172	1 767	19 826
1981 – 82	502	6 755	363	4 761	65	1 109	132	2 381	88	1 161	1 220	16 197
1982 – 83	571	7 175	533	6 255	186	2 232	417	4 972	88	1 048	1 795	21 682

Consumer expectations of quality: Texture

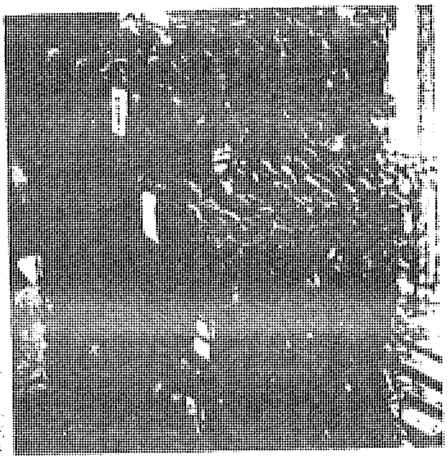
To the uninitiated, canned abalone is frequently perceived as having a "rubber-like" texture and "slightly saline" flavour — hardly the sensory attributes that might be expected to justify the selling price. Nevertheless, these are just the quality characteristics without which sales would be lost. Given the brief to develop a shelf-stable canned abalone product, we were faced with locating a target test market. Not surprisingly, we found that only Asian panelists possessed the product familiarity necessary to comment on sensory quality. The results of a preliminary survey in this table quite clearly showed the risks of asking Caucasians about the subtleties of abalone texture and flavour. It was apparent that future taste panel evaluations should be restricted to Asian consumers.

Having identified the appropriate test market, 90 panelists were asked to comment on the texture of canned abalone processed at different time–temperature conditions. The results showed that sensory assessment of toughness mirrored instrumental measurements. It was also found that consumers indicated a preference for the tougher abalone coming from the less severe process. By establishing a mechanical technique of measuring a sensory characteristic, it was possible to set objective limits defining acceptable texture. In practice, this means that manufacturers can monitor texture during production and be confident of maintaining product acceptability.

Frequency of abalone consumption by Asian and Caucasian panelists*

	Asian (%)	Caucasian (%)
Never eat abalone	3	21
Rarely eat abalone	16	71
Occasionally eat abalone	75	8
Often eat abalone	6	0

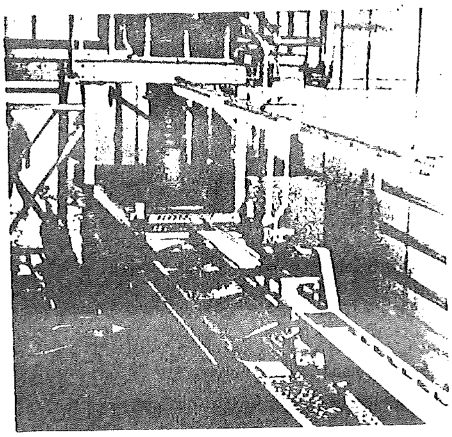
* The number of Asian and Caucasian panelists totalled 32 and 14, respectively.



Fresh abalone received at the factory, ready for shucking.

Abalone Fisherman's Cooperative

Abalone being shucked and rinsed prior to cleaning.



Abalone Fisherman's Cooperative

Modern packaging line used by Abalone Fisherman's Cooperative for handfilling — note the stainless steel surfaces for easy cleaning and excellent overhead lighting for operator comfort.

Appearance

Good quality canned abalone has a creamy yellow appearance and the surface is free of any localised discoloration. On receipt of fresh abalone, it is necessary to remove the pigment around the "lip". A simple cleaning technique involves immersing the shucked abalone for approximately 30 mins in warm (35–40°C) water containing salt (30 g/l). During this time, the molluscs are gently abraded either by a forced tumbling action, namely rotating the holding tank which is partially submerged in brine, or by stirring the brine with paddles. Usually, residual pigment can be removed by light hand-scrubbing with nail-brushes or abrasive pads.

An alternative method of cleaning is to use a proteolytic enzyme in addition to, or in place of, salt. Enzymic action is arrested by submersion in a hydrogen peroxide solution. Enzymic cleaning has been found to be marginally easier. In the trials conducted, however, its greatest benefit was that the peroxide treatment bleached the flesh, thereby improving overall appearance.

Under certain circumstances, though not well understood, a blue discoloration becomes apparent on parts of the pedal sole. This is thought to be related to formation of a metallic complex and can be controlled by addition of citric acid (about 0.2% w/v) and/or EDTA ie. ethylene diamine tetra acetic acid (<0.25%) to the cleaning brine. This discoloration is, however, not a regular phenomenon and is, therefore, not always needed. Some packers incorporate sodium metabisulphite in their canning brine as this can aid good colour formation; however, it is used with caution. Certain countries do not permit its addition (check importing country's food additive regulations), and in high concentrations an unacceptable odour is often detectable. Nonetheless, the most important factor affecting acceptability of canned abalone is selection of fresh raw material combined with visual quality grading.

Flavour

The flavour of canned abalone is subtle and not an attribute with which we have experimented in product development. Salt (20 g/l) in the canning brine has proved sufficient to enhance the complex flavour profile, whereas even the slightest overdose of sulphite was unacceptable. Of the sensory characteristics, texture and appearance have proved the most important.

Product safety

Fresh abalone flesh has a pH between 7.0 and 7.4 and after handling and canning this may fall to 6.2–6.5. Unfortunately, in this pH range and within the hermetically (air-tight) sealed can the environment is suitable for growth of the human pathogen, *Clostridium botulinum*. It is this bacterium which so devastated the canned salmon industry in 1978 and 1982 when it was responsible for the death of three unsuspecting consumers who had eaten contaminated product.

In both instances, Type E *Clostridium botulinum* had entered the container after thermal processing, multiplied and produced toxin. Type E is typically associated with marine environments. However, manufacturers are ill-adversed to ignore the possibility of contamination by the more heat resistant Types A and B *Clostridium botulinum* which, being of terrestrial origin, cannot be excluded from normal microflora likely to gain entry into the processing plant. There is little comfort in the assumption that heat resistant spores of Types A and B *Clostridium botulinum* will, if ever, only be surface contaminants of abalone and will, therefore, be rapidly killed by the temperatures in the can during sterilisation. "Worst-case" analyses project that deep tissue cuts, as might occur during shucking, may implant spores of *Clostridium botulinum* into the previously sterile flesh. Under these conditions, the spores which possess an inherent heat resistance are further protected by insulation with several centimetres of abalone. It is conceivable, therefore, that a process sufficient to effect surface sterilisation will be inadequate to provide the assurance of commercial sterility at the thermal centre of the pack. It is against this scenario that strict attention must be given to the application of a thermal process severe enough to destroy all types of *Clostridium botulinum* present in the can.

It is in response to the need for safety through commercial sterilisation that low-acid food canners have adopted a standard procedure for determining process adequacy. Thermal processing severity is expressed by summing the lethal effects of all time–temperature combinations experienced in the thermal centre of the product during processing and equating these to the time required at 121.1°C for the product to receive an equivalent sterilisation effect. The symbol used is F_0 value and the units are minutes. According to good manufacturing practice, the minimum F_0 value for low-acid canned foods preserved by heat alone is 2.5 mins. ($F_0 \geq 2.5$ mins.) When this is achieved, and given reasonable microbial raw material quality, the probability of spore survival for *Clostridium botulinum* is less than one in a billion. This means that the probability of there being a survivor is sufficiently remote as to be acceptable and this, therefore, ought to be the minimum standard for abalone canners. However, the effect of thermal processing abalone goes beyond public health issues.

During retorting, abalone undergoes a dual change:

- There is a textural inversion caused by a tenderisation of the pedal sole and a toughening of the myofibrilla proteins at the base of the adductor muscle.
- There is weight loss as collagen in the pedal sole is converted into gelatine which migrates into the canning liquor.

Effect of thermal process treatment on objective and sensory assessment of the texture of canned abalone			
Process conditions		Puncture force * (kg)	Sensory score **
Time (min.)	Retort temperature (°C)		
40	118	2.30	2.50
60	121.1	1.55	1.81

* Puncture force required to puncture 10 mm thick slice of abalone.

** Ninety Asian panelists rating on 7 point category sale: extremely tender = 1, extremely tough = 7.

Effect of thermal process conditions on F_o value, weight loss and puncture force of canned abalone				
Process conditions		F_o value*	Average weight loss can (%)	Puncture force** (kg)
Time (min.)	Retort temperature (°C)			
40	115.6	0.5	12.3	2.13
40	118.3	0.7	17.7	2.17
40	121.1	1.4	19.2	2.11
60	121.1	10.4	29.1	1.76

* F_o value calculated on "worst-case" conditions taken from slowest heating of 24 cans.

** Puncture force required to puncture 10mm thick slice of abalone.

Thus, as thermal processing severity (F_o value) is increased, the product softness and yields fall — phenomena which are undesirable to the consumer (who prefers a relatively tough product) and also to the processor (who wants to maximise drained weights).

In the table above is shown the relation between F_o value (calculated under "worst-case" conditions), yield and flesh texture (measured objectively) for abalone processed under four sets of conditions.

Factors affecting F_o values

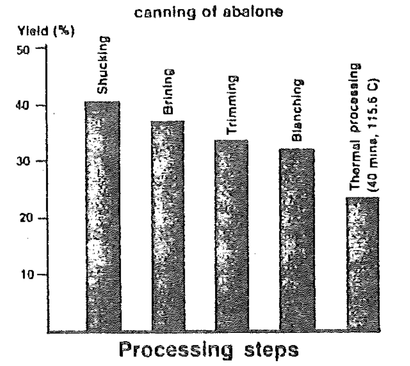
Taking the safety aspects first, the controlling factors that affect the rate of heat penetration and hence the F_o value for the process include:

- Fill weight and abalone size — tight packed cans heat more slowly than loose fills.
- Fill temperature — cold filled cans take longer to reach lethal temperatures than do hot filled cans.
- Retort temperature — the higher the retort temperatures, the more rapid the sterilisation.

F_o values were calculated using heat penetration characteristics found in the slowest heating of 24 trial packs. The values shown are, therefore, the theoretical "worst-case" values and would apply had all cans exhibited the same characteristics. In this sense, "worst-case" analysis, while pessimistic, allows for production variables that may affect the rate of heat penetration. Based on these results, it is apparent that in order to achieve the minimum recommended F_o value (2.5 mins.), manufacturers should opt for conditions more severe than 40 mins. at 121.1°C. However, against this, canners must face the disadvantages of reduced yield and greater textural softening. This is why it is not possible to simultaneously maximise product safety, consumer appeal and profitability. Instead, abalone canners are obliged to compromise their desire for maximum product acceptability and profitability, for under all conditions, safeguarding against botulism is paramount. The latter can be assured through application of an adequate thermal process. This, however, does not remove all dangers as evident in the last two botulism outbreaks when fatalities occurred because of post-processing contamination by *Clostridium botulinum*. It is because of the dangers of post-processing contamination that good manufacturing practice recommends the use of chlorinated cooling water and the prohibition of manual handling of wet containers after cooling.

Other factors important to the safety of canned seafoods have been briefly discussed in INFOFISH Marketing Digest, No. 3/83, pg 33–35.

Effect of processing steps on yield during the canning of abalone



D Warne N Brown A Mustaza

Factors affecting yields

In the table above can be seen the pronounced effect of increasing process severity on yields. As F_o values increase, so too do losses, a point which is not likely to be missed by canners who, over 1982–83, enjoyed high returns for their product. Given these high returns, all canned abalone manufacturers will be keen to minimise the losses associated with each processing step. In the figure here are shown the effects of processing stages on yields attained during trials in the pilot plant. Losses prior to retorting are difficult to avoid; however, the following techniques have been found by others to be of benefit:

- Fresh abalone should be stored at a temperature range of between 5° and 8°C. Lower temperatures induce anaerobic glycolysis and acid production which cause a drop in flesh pH and increased losses on handling.
- Inclusion of phosphates in cleaning brines, blanch waters and canning liquors have been investigated. We have found the benefits to be marginal prior to, and inconsistent after, canning. They may also be unacceptable in some markets.

The most significant factor affecting losses after shucking is the thermal processing severity, which is why manufacturers find it more profitable not to overprocess their product. However, the benefits of potentially higher yields must not be allowed to obscure the need for an adequate thermal process in which the F_o value is appropriate against the risks of botulism.

Factors affecting texture

There is a clear indication that as processing severity increases, flesh firmness decreases. The canner, therefore faces the dilemma of having to manufacture a safe product by employing an adequate thermal process, while knowing that textural degradation may not be desirable from a consumer's point of view. However, as with the association between yields and F_o values, there is *no choice* — product safety must override all other considerations.

The final analysis

The task for abalone canners is one of balancing the conflicting requirements of fulfilling consumer expectations, manufacturing a safe product and operating profitably in a highly competitive industry. The solution is not simple as it combines product formulation, canning technology and cost accounting. What is needed is a strict process control system that monitors production at the three critical facets of production, namely:

- Sensory quality — colour, flavour and texture.
- Product safety — heat penetration characteristics; F_o values.
- Profitability — yields during and after processing.

Only by effective in-process control can manufacturers be sure they have optimised their process.

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There is irony, therefore, in the importation of several thousand tonnes of frozen hake from South Africa and South America while gemfish *(Rexea solandri)* which could fill the same market niche, was not caught off the New South Wales coast during 1981, due to poor prices thus leading to the closure of the Eden Fishermens' Co-operative (Bowerman 1981).

Mislabelling of fish species

There is irony also in the importation of 'prawns', kamaboko 'crabs claws' and 'scallops' by a major Australian seafood company. The products are reformed from a finfish, pollock *(Gadus pollachius)* and flavoured according to the desired copy. The products are not of high quality compared with authentic prawns, scallops and crabs claws but have been widely marketed to an unsuspecting public. It is remarkable that during the same period scallops *(Pecten alba)* were in glut (Anon. 1982) after the Victorian Fishing Industry Council had made a large investment in promoting the authentic local product.

Not surprisingly, given the foregoing, fraudulent naming of fish species is common in Australia. One species, the orange roughy *(Hoplostethus atlanticus)* also known for marketing niceties as deep sea perch, has become a favoured import selling in Australian supermarkets at up to $6.80/kg. They are caught by Russian and NZ trawlers south of New Zealand and processed in New Zealand and Singapore before importation into Australia. The orange roughy was alleged (Anon. 1982) as being substituted in the Australian retail system for the more highly-priced john dory *(Zeus faber)*, snapper *(Chrysophrys auratus)* and barramundi *(Lates calcarifer)*. A subsequent survey of retail outlets in Melbourne revealed that of 52 samples purchased only 13 (25%) were correctly labelled and that orange roughy was, in fact, a common substitute for barramundi and john dory (Sumner & Mealy 1982).

Preferences of Australian fish consumers

An example of Australian fish consumers' perception of quality is the preference, particularly among Victorian consumers, for flathead. Over the period June 1980–August 1981 the rock flathead *(Platycephalus laevigatus)* was found to attract a much higher average price ($3.48/kg) than other flatheads such as sand flathead *(P. bassensis)* and tiger flathead *(Neoplatycephalus richardsoni)* (average $2.07/kg). Taste panels indicated that consumers could distinguish rock flathead only 50% of the time (Table 4) and of those who could distinguish it only 53% considered it preferable to other flatheads (Table 5). Since objective quality criteria (Table 6) showed little difference either in mean or range it is difficult to account for this preference (Goreczyca & Sumner 1982).

Perceptions of quality by Asian fish consumers

Asian consumers, by contrast, are fastidious regarding fish quality, particularly when judging the unique characteristics of the highly valued abalone *(Notohaliotis ruber)*. Exports of canned marine products from Australia in 1980-81 were valued at $21 million of which abalone comprised $20m, major markets being Japan, Hong Kong and Singapore. Asian consumers expect high quality canned abalone and at $23/kg (drained weight) Australian manufacturers are keen to supply. One Australian abalone processor, attracted by a potential 40% increase in earnings, contemplated changing from freezing to canning. To protect capital investment and be assured of a share in a highly competitive market the processor considered it essential to determine the quality characteristics required by Asian consumers. A preliminary survey in which 93% of Caucasian respondents indicated that they never or rarely ate abalone and 81% of Asian respondents indicated they ate abalone 'occasionally' or 'often', demonstrating that product familiarity for test marketing was possibly only with Asian respondents. A second survey of 90 Asian respondents from Melbourne's Chinatown showed that 51% of the target group ate abalone at least once a week and 76% at least once a month.

Accordingly, a taste panel comprising 90 Asian consumers who regularly ate abalone was asked to rate the texture of

Table 3. Shelf life in grade 1 ('good') quality of thawed and chilled fish fillets packaged in permeable film and held in ice

Species	Thawed, chilled fillets (days)	Chilled fillets (days)
Flathead	0*	8
Tarakihi (morwong)	0	5
Hake	0	-
Gemfish	-	8

Table 4. Taste panel evaluation of rock flathead versus sand or tiger flathead

Panelists	Number	No. of Tests	No. able to differentiate	Significance
Untrained adults	215	215	105 (49%)	$P < 0.001$
〃 children	43	43	19 (44%)	Not significant
Trained	19	88	59 (67%)	$P < 0.001$

Table 5. Preference of taste panelists for rock flathead versus sand or tiger flathead

Panelists	Preference	
	Rock flathead	Tiger flathead or sand flathead
Untrained adults	56 (53%)	49 (47%)
Trained adults	32 (54%)	27 (46%)

Table 6. Means of objective quality parameters of rock flathead versus sand or tiger flathead

Quality parameter	Rock flathead	Tiger or sand flathead
Torry meter	12.2 (6-16)*	13.6 (10-15)
K Value (%)	42.2 (15-85)	42.6 (12-97)
Trimethylamine (mg/100g)	0.37 (0.03-2.8)	0.58 (0.06-2.5)
Total Bacterial Count (No./g)	50 000 (5,000-140 000)	60 000 (50-200 000)
Total count of sulphide producing bacteria (No./g)	2000 (<100-20 000)	2000 (<100-20 000)

* *Values in parentheses are minima and maxima*

Table 7. Influence of thermal processing severity on texture of canned abalone

Thermal process	Mean sensory score	Mean Instron force (kg)
40 min. at 118°C	2.80*	2.30**
60 min. at 121.1°C	1.81*	1.55**

* *Sensory scores significantly different (P < 0.001)*
** *Instron force significantly different (P < 0.001)*

I THINK THIS ABALONE IS EXTREMELY TENDER
我認為这鲍鱼最柔脆

I THINK THIS ABALONE IS MODERATELY TENDER
我認為这鲍鱼不过分的柔脆

I THINK THIS ABALONE IS SLIGHTLY TENDER
我認為这鲍鱼有些少的柔脆

I THINK THIS ABALONE IS NEITHER TENDER NOR TOUGH
我認為这鲍鱼不柔脆也不堅靭

I THINK THIS ABALONE IS SLIGHTLY TOUGH
我認為这鲍鱼有些少的堅靭

I THINK THIS ABALONE IS MODERATELY TOUGH
我認為这鲍鱼不过分的堅靭

I THINK THIS ABALONE IS EXTREMELY TOUGH.
我認為这鲍鱼最堅靭

Figure 1. Seven-point scale of toughness — part of a sensory analysis by Asian consumers

canned abalone processed either for 40 min at 118°C or for 60 min at 121.1°C. Using a seven point category scale (Fig. 1) (extremely tender = 1, extremely tough = 7) and objective texture readings from an Instron 1140 food testing machine, it was clear that panelists and the machine could distinguish significant ($P < 0.001$) textural differences in the two samples (Table 7). Panelists rated the tougher product significantly better than that from the more severe process (60 min/121.1°C) and their usual brand ($P < 0.01$) confirming the market acceptability of the trial product. They demonstrated that Asian consumers were sensitive to changes in texture arising from different thermal processing conditions (Warne & Brown 1982).

Important from the manufacturing viewpoint was the significantly higher ($P < 0.001$) yield of 81.9% (on a drained weight basis) for the milder process compared with 70.8% for the more severe process. At 1982 prices a 10% increase in yield corresponded to potential profit of $700 per tonne (fresh weight) which for the Australian Industry as a whole would have represented profits of $1.2 million per annum.

There is paradox in much of Australian fish marketing. On the one hand a supermarket filleted fish trade is based firmly on imported raw materials of poor sensory quality in equilibrium with a consuming public with little objective perception of quality leading to a definition of the ideal fish fillet as 'white, skinless, boneless and . . . tasteless'. And on the other hand there is a successful export trade in crustaceans and molluscs to fastidious Asian consumers. Given the capability to supply both ends of the quality spectrum is it impossible to hope that an education program for local consumers might result in an upward shift in quality expectations matched by a desire by Australian fish marketers to conform?

Acknowledgements

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