FACTORS CONTROLLING STERILITY IN CANNED PRAWN

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Probable sources of contamination of raw, blanched and processed meat at various stages of handling and methods for their rectification have been described in the paper. Inter-relationship between absolute sterility and commercial sterility with particular reference to the sanitation of the factory has been discussed.

INTRODUCTION:

The process recommendations for commercial sterility of canned foods are usually based on the assumption that the products subjected to retorting are without undue contamination. But a process which has been found 'adequate' for years may turn 'inadequate' under same processing conditions due to a sudden increase in bacterial load for lack of sanitary conditions in the factory. Though retorting brings about destruction of micro-organisms the importance of sanitation in a cannery cannot be overlooked. Different methods are now available to calculate sterilizing process for packed foods. The 'formula method' of Ball & Olson (1957) is simple and easy but still easier and more recent is the computer derived tables (Herudell *et al* 1969).

Canned material subjected to thermal spoilage requires higher processing time. Usually a lethal value of the order of 6-7 (where *C. botulinum* = 1) even in the case of a good quality product prepared under strict hygienic conditions is called for according to Bashford (1947). Quality considerations, however preclude the adoption of such heat treatment. In order to get rid of unwanted contaminations it is necessary to maintain not only strict sanitary codes in the factory but also to keep a high level of personal hygiene of the workers handling the material. Each cannery is thus required to guage its standard of sanitation and level of personal hygiene so that suitable adjustments could be effected in the processing techniques to produce a bacteriologically sound product. The present communication highlights the inter-relationship between these factors, particularly between cannery hygiene and bacterial load in the finished product.

MATERIAL AND METHODS

All the studies and surveys detailed in this investigation have been carried out in the prawn canneries around Cochin. Sampling has been done for determining

the level of bacterial load on table surfaces, utensils, water and ice used in each of these canneries. Canned shrimp collected at random were also tested for their residual bacterial load. Bacteriological samples from the surfaces of the utensils were collected using sterile swab and transferred to sterile buffered water. Raw material, water and ice were collected aseptically and transferred to the laboratory under ice.

Plating was done using sea water agar as culture medium for total plate count, desoxycholate agar for coliforms, *E. coli* type I being determined by the method prescribed in ISI specifications (1962). KF agar was used for enumeration of faecal streptococci (Kenner *et al* 1960).

Results and Discussion

Probable sources of contamination and their methods of prevention are discussed below.

First Stage

i) Washing

Peeled meat soon after delivery to the canneries from peeling centres or dressed in the factory itself is first washed with water. The extent of residual bacteria in meat depends upon the bacteriological quality of the water. Careful washing of raw meat with potable water brings down the standard plate count (SPC) by about 90% ($2.4 \times 10^6 - 9.5 \times 10^5$ /g to $3.3 \times 10^5 - 2.5 \times 10^4$ / g) of surface bacteria from the meat. On the other hand washing with polluted water adds to its bacterial load. Material coming in direct or indirect contact with polluted water, ice or unclean utensils invariably show an increase in bacterial load even after washing.

Second Stage

i) Blanching

Partial destruction of bacteria is brought about during blanching (Table III)

TABLE I BACTERIAL LOAD OF UTENSILS CLEANED WITH SOME COMMON DETERGENT AS AGAINST STANDARD METHOD

Description	No. of samples examined	Bacterial load of the utensils/Sq. cm. Cleaned with common detergent SPC/ sq. cm.	Faecal Streptococci/ sq. cm.	Coli forms/ sq. cm.	E. coli Type I/ sq. cm.	No. of samples examined	Cleaned according to standard cleaning schedule SPC/ sq. cm.	Faecal Streptococci/ sq. cm.	Coli forms/sq. cm.	E. coli Type I/sq. cm.
Table surface	250	$9.9 \times 10^5 - 1.3 \times 10^6$	200–436	34–90	Nil–50	200	$1.2 \times 10^2 - 3.3 \times 10^3$	Nil	Nil	Nil
Steel basin	500	$4.1 \times 10^4 - 1.2 \times 10^6$	72–956	Nil–450	,, 90	400	$1.4 \times 10^2 - 2.1 \times 10^3$	,,	,,	,,
Polythene basin	300	$3.5 \times 10^3 - 7.5 \times 10^5$	Nil–525	,, 350	,, 20	225	$0.5 \times 10^2 - 1.9 \times 10^3$	,,	,,	,,
Aluminium Tray	225	$5.5 \times 10^4 - 6.4 \times 10^5$	,, 56	,, 430	,, 75	175	$0.2 \times 10^2 - 1.5 \times 10^3$	,,	,,	,,
Basket	75	$2.5 \times 10^5 - 5.5 \times 10^6$	300–1000	,,–750	,,–125	75	$2.6 \times 10^2 - 2.7 \times 10^3$	,,	,,	,,
Basin Perforated	50	$3.8 \times 10^5 - 9.8 \times 10^6$	250–2000	75–550	10–90	45	$1.9 \times 10^2 - 2.5 \times 10^3$	,,	,,	,,
Ice/ml	80	$62–3.2 \times 10^4$	Nil–144	0–95	Nil–20	40	0–80	,,	,,	,,
Cooling water/ml	75	$5–7.2 \times 10^4$	Nil–2.5×10^4	0–250	0–60	50	0–40	,,	,,	,,

but in most of the cases contamination takes place during subsequent stages of handling from external sources like utensils, water, ice etc. The utensils and equipments coming in contact with material if not properly cleaned as suggested by Iyer and Chaudhuri, (1965) may harbour millions of bacteria (Table I) which invariably affect the bacterial quality of the meat. Apart from this, gross under pasteurization (Nevot 1959, 1960) and subsequent growth of the residual flora at ambient temperature (Mossel, 1956) may also contribute to the bacterial load of the blanched meat. Extent of contamination is usually more in factories where strict sanitary codes are not followed.

In some canneries where cold water is used for immediate cooling of blanched meat, contamination may take place from the water. Ice prepared from water of low bacterial quality, polluted water used for cooling or water contaminated by continuous dipping (Table II) may add to the bacterial load of the material. In most of the factories where cooling is done by air blowing the chances of contamination are through unclean utensils and air. The extent of pollution of the latter however, depends entirely on the general sanitary conditions of the factory.

ii) Handling

Maximum contamination of blanched meat usually takes place during handling and grading (Table III). Personal hygiene of the workers in the factory is very important particularly when grading is carried out by hand. The survey results indicate that total plate count of the palmswab, used as an index of personal hygiene, normally does not exceed 3500

TABLE II BUILD UP OF BACTERIAL LOAD IN COOLING WATER DURING CONTINUOUS DIPPING OF BLANCHED MEAT

Factory	Description	Bact. count of cooling water: *Faecal Streptococci / ml*	SPC/ ml	*E. coli*/ ml
A	Initial cooling water	12	250	Nil
	After first dip	48	3.0×10^2	,,
	,, second ,,	45	3.2×10^2	,,
	,, fifth ,,	48	7.5×10^2	,,
	,, sixth ,,	50	8.0×10^2	,,
	,, seventh ,,	52	1.4×10^3	,,
	,, eighth ,,	65	3.8×10^3	,,
	,, nineth ,,	70	4.0×10^3	,,
B	Initial cooling water	73	1.1×10^3	,,
	After first dip	65	1.1×10^3	,,
	,, third ,,	70	1.5×10^5	1
	,, fifth ,,	70	2.0×10^3	Nil
	,,twelveth,,	80	5.0×10^3	,,

TABLE III CHANGES IN BACTERIAL LOAD OF MEAT DURING DIFFERENT STAGES OF HANDLING AND PROCESSING

Factory	Raw material before washing Count/g.	Bact. count of blanched meat/g. Before cooling	After air cooling	After grading
A	4.42×10^5	3.0×10^3	3.3×10^3	1.5×10^4
B	1.82×10^5	9.0×10^4	9.0×10^4	2.1×10^5
C	1.38×10^6	25	9.2×10^3	8.7×10^4
D	5.5×10^5	40	3.0×10^3	7.0×10^4
E	8.6×10^5	120	270	300
F	7.5×10^5	150	200	250
G	2.5×10^5	200	250	375
H	9.2×10^5	175	205	275

organisms / sq cm in good factories while in poorly maintained factories, it is always higher than 4000 organisms/sq cm which in addition contains 0-11% *E. coli* and 44-77% *Staphylococci.*

iii) Cans

Empty cans are found to be one almost unsuspected source of bacteria. Cans (301 x 206) stacked in godowns showed micro-organisms upto 3.2×10^4 / can, majority of which was found to be heat resistant spore formers. Dust adhering to the surface of the can may be responsible for harbouring the bacteria. Empty cans should be washed properly with potable water before packing the meat. Bad water on the other hand may add to the bacterial load instead of removing it (Table IV). Long (1935) found 1.0% yield toxin type A strains of *C. botulinum* in the can. Cans even washed with hot water sometimes showed micro-organisms upto 1.2×10^5 / can and incidence of 20-25% *faecal streptococci* while Forgaces (1942) observed 3000,000 organisms / 4 sq inch of surface, in some cases.

TABLE IV BACTERIAL LOAD OF EMPTY CANS (301 x 206) STORED IN THE GODOWNS

Factory	Bacterial load/can interior		
	Before washing	After washing with cold water	After washing with hot water
A	2,000	1,000	500
	*10,200	13,200	1,100
	53,000	16,000	12,000
B	1,400	*9 600	1,400
	*8,400	*10,400	*1,400
	9,000	*23,500	*1,800
C	1,500	2,000	500
	1,800	5,000	800
	4,600	12,000	1,300
	28,000	3,20,000	1,20,000
D	1,000	5,000	300
	1,100	5,200	800
	2,800	5,200	1,000
	5,000	9,000	3,800

* Indicate incidence of Enterococci in cans.

THIRD STAGE

i) Retorting and Cooling

Majority of cans which showed leaker spoilage become infected during cooling after retorting. Leakage may take place only at the moment when the seam in contact with cooling water changes its shape (Sanders, 1949) as a result of 'flipping' of the end from the convex (internal pressure) to the concave (internal vacuum) condition and the degree of contamination is more with the extent of pollution of cooling water but in the case of cans having internal pressure, infection is unlikely (Bryan and Morris, 1932). According to Gratland (1941) contamination is negligible when the bacterial count in the cooling water is less than 100/ml. Improper handling, storage and continuous use of cooling water help in building up the bacterial load, particularly in the latter case where there is ample nutrients in the form of food washed off the exterior of the can. It is therefore, necessary to chlorinate the cooling water to the level of 5 ppm. Time required for chlorine to kill the micro-organisms depends on both type of organisms and concentration of available chlorine (Table V). Though most of the organisms present in cooling water are gram negative and sensitive type, a minimum contact time of 10-15 minutes should be strictly adhered to.

For scarcity of potable water in some of the canneries the practice of addition of ice in cooling water is followed. Ice usually gets contaminated during different stages of handling, transport and storage (Iyer & Chaudhuri, 1966) which when added to water increases its bacterial load. It would therefore be advisable to wash ice with chlorinated water before adding to the reservoir and to maintain the free

chlorine level of the system which will take care of bacterial load of water. Cans seamed under enforced loose seaming conditions did not show bacterial count, when chlorinated water was used for cooling (Table VI). Although proper chlorination of cooling water is a valuable means of reducing spoilage resulting from seam leakage it cannot be always regarded as a safeguard for poor seaming.

COMMERCIAL STERILITY

Commercial sterility of a product represents the minimum bacteriological standard acceptable from the public heatth point of view. However, in processed cans in addition to spores and thermophiles other non-heat-resistant types are also present which indicate either post-process contamination or gross understerilization. Results of analyses of 1215 bacteriologically defective cans indicate the predominancy of rods (81.1%) over *cocci* (18.9%); but of the can spoiling organisms gram positive ones (78.2%) play a major part out of which only 12.9% was heat resistant spores (Table VII). The incidence of higher percentage of viable non-sporing rods (65.3%) or *cocci* (18.9%) generally indicates post-process leakage since these organisms are unable to survive the processing (Cameron & Esty, 1940).

Contamination of heat processed material by non-heat-resistant type of organisms can be easily avoided by cooling the retorted cans in chlorinated water, while the control of heat resistant thermophiles can be brought about by

i) reducing their number in the raw material by packing under strict hygienic conditions and processing at highest temperature for maximum time permitted by quality factors.

TABLE V INFLUENCE OF CONTACT TIME (5 ppm available chlorine) ON TYPE AND NATURE OF BACTERIA PRESENT IN PURE & DIRTY WATER

Contact time in minutes.	Bacterial count/ml Gram negative (Coliform) rods		Gram positive (Bacillus) rods	
	* mud 1.0%	mud 0%	mud 1.0 %	mud 0 %
0	1.6×10^7	1.6×10^7	1.4×10^6	1.5×10^6
5	4.6×10^4	10	—	—
15	—	—	7.0×10^4	5.0×10^4
30	1.1×10^4	Nil	6.5×10^4	3.0×10^4
60	7.0×10^3	,,	5.0×10^4	2.0×10^4

* Sterile mud was used as a source of organic matter

TABLE VI EFFECT OF COOLING WATER ON BACTERIAL COUNT OF CANNED MEAT UNDER DEFECTIVE SEAMING CONDITIONS

Description of cooling water	Bact. count of cooling water / ml	Bact. count of canned material Immediately after retorting		After 4 days' incubation at 30°C	
		Brine/ml	Meat/g	Brine/ml	Meat/g
Chlorinated water	Nil	Nil	Nil	Nil	Nil
Well water	100	,,	,,	,,	,,
Inoculated with *B. cereus*	7.0×10^4	3	11	4.0×10^4	3.7×10^6
-do-	3.4×10^5	8	28	6.0×10^4	4.9×10^6
-do-	3.8×10^6	25	45	8.0×10^4	7.8×10^6

TABLE VII DISTRIBUTION OF MICRO-ORGANISMS ISOLATED FROM BACTERIOLOGICALLY DEFFECTIVE CANS

Description	Gram positive organisms		Gram negative organisms		Gram positive aerobic spore
	Rod	*Cocci*	*Rod*	*Cocci*	
Distribution of organisms	775	213	249	27	
Percentage distribution	61.4	16.8	19.7	2.1	
Percentage according to gram character		78.2		21.8	
Percentage distribution of rods according to gram character.	65.65		24.35		
Percentage distribution of *Cocci* according to gram character		88.95		11.05	
Percentage of spore out of total organisms					7.7
Percentage of spore out of total gram positive rods					12.9

TABLE VIII INTER-RELATIONSHIP BETWEEN BACTERIAL COUNT, DETENTION DUE TO BACTERIOLOGICAL DEFECTS AND ABSOLUTE STERILITY OF CANNED PRAWN

Factory	Average bact. count/g.	Percentage of detention	Percentage of absolute steriliy
	Grade I Factory		
A	6	0.18	42.0
B	11	0.16	25.0
C	10	0.56	28 0
D	9	0.45	33.0
E	8	0.67	70.0
F	13	0.73	40.0
G	9	0.62	50.0
H	12	0.58	50.0
	Grade II Factory		
I	35	1.3	Nil
J	37	1.5	,,
K	31	1.1	,,
L	46	8.2	,,
M	21	2.0	,,
N	42	2.0	,,
O	40	7.7	,,

ii) storing the processed cans at a cool warehouse, maintained at a temperature of 21°C (Pearce & Wheaton, 1952).

ABSOLUTE STERILITY

There are conflicting views regarding the degree of sterility of commercial cans. According to Savage (1923) the proportion of sterile cans varied from 8% for meat to 0% for crab. An extensive survey made by Fellers (1926) on canned salmon showed 96.6% sterility while in another report (Anon, 1944) 90% of 500 sound cans of meat and meat products showed aerobic spores However, bacteriological analyses carried out on canned prawn stored upto two years at room temperature (28°C–31°C) gave on an average 10 micro-organisms/can. This total plate count is correlated with the sanitation of the canneries. 'Distribution of the survivors' and post process contamination in the cans are more in poorly maintained canneries where utensils, water, ice and cooling water contribute to

the initial baeterial load. Analyses carried out with 500 cans collected from 15 canneries situated around Cochin reveal that 55% of them may be classified as grade 1 whose products usually carry bacterial counts less than 1l/g and maintain at least 25% absolute sterility. Golden-berg *et al* (1955) proposed less than 10 micro-organisms/g in bacteriologically sound canned ham while 10–100 organisms/g for reasonably satisfactory cans. Absolute sterility, average total plate count of the canned prawn and percentage of can detained by Inspection Agencies due to bacteriological defects alone during the period March to November 1968 are shown in Table XI. None of the cans from grade II canneries are absolutely sterile although the samples are commercially sterile, Moreover percentage detention in these cases is always above 1.0% while in grade I canneries it is always below 0.8%.

Recommendations

In order to produce bacteriologically sound can the following precautions should be adopted:-

i) Washing of the raw material should be carried out in potable water and ice prepared from potable water should be used.

ii) Utensils coming in direct or indirect contact with material (raw or blanched) should be cleaned by the method suggested by Iyer and Chaudhuri *(loc. cit.)*

iii) Proper care should be taken both for maintenance of the sanitation of the factory and the personal hygiene of the workers and in handling the material.

iv Proper exhausting should be done to minimise seam strain and the cooling of the retorted cans be should carried out immediately in chlorinated water maintained at 5 ppm of available chlorine.

v) Checking of the seam should be carried out after each turn over of 200 cans.

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References

Anon 1944. *Food 13*, 232.

Bashford, T. E. 1947 *J. Roy san Inst., 67*, 519.

Bryan, J. M. & Morris T. N., 1932. *Food Invest. Bd. Dept. Sci. Ind. Res. Ann. Rep.*, p. 178.

Ball, C. O. & F. C. W. Olson, 1957. *'Sterilization in Food Tech'* published by Mc Graw Hill Book Co., New York, 1st Edition.

Cameron, E. J. & Esty, J. R. 1940. *Food Res. 5*, 549.

Fellers, C. R. 1926 *J. Bact. 12*, 181.

Forgacs, J. 1942. *Food Res., 7*, 442.

Gartland, B. J. 1941. *The Crown, 29*, 38.

Godenberg, N., Sheppey, C. G., & Robson, J. N. 1955. *Int. Sym. on Food Bacteriology*, Annale De L Institute Pasteuri De Little, *7*, 240.

Herndon, D. H, Griffin J. R., R. C., & Ball C. O. 1968. *Food Tech. 22 (4)*, 129–140.

Iyer, T. S. G. & Chaudhuri, D. R. 1966. *Fish Technol; 3 (2)*, 113-116.

Iyer, T. S. G. & Chaudhuri, D. R. 1965. *Ibid, 2 (1)*, 131–138.

ISI 1962. Indian Standards specifications for Frozen Prawns, IS: 2237.

Kenner, B. A., Clark, H. F & Kabler, F. W 1960 *Appd. Microbiology, 9*, 15.

Lang, O. W., 1935. *Univ. Calif. Pub. in Pub. Health, 2 (1)*, 1–174.

Mossel, D. A. A., 1956. *Wein tierarzfl uschr., 43*, 321, 596.

Nevot, A , Lafont, P., & Lafont, J. 1956. *Bull. Acad. Nat. Med* (Paris) 143–175.

Nevot, A., Lafont. P., & Lafont, J., 1960. *Ann. Inst. Pasteur, 98,* 306.

Pearce, W. E., & Wheaton, E. 1952. *Food Res., 17,* 487.

Savage, W. G. 1923. Canned Food in relation to Health; Cambridge University Press.

Sanders, R. K., 1949. *Chem. Ind.,* p 151

Songnefest, P. Benjamin, H. A. 1943. Processing conf. of the Nat Canners Association Quoted by Alstrand & Eckland, *Food Tech. 6,* 185.