Effect of Sanitation Procedures on Bacterial Levels in Blue Crab Processing Plants

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The seafood industry needs additional effort on the control of microorganisms. During the processing of crabmeat, there is a possibility that large numbers of bacteria may be brought into the plant on the raw product and by the workers. Also, a serious increase in bacteria can occur if adequate sanitary practices are not used throughout the plant. This laboratory has previously made studies on the level and types of microorganisms occurring in commercial crabmeat. However, a detailed study of in-plant levels needs to be accomplished. Once the levels have been established and problem areas identified, methods of control can be established.

This investigation involved the examination of the microbial level and an appraisal of the in-plant sanitation conditions at various points throughout the processing cycle. The object of this study was to establish levels of microbial organisms found in the finished product and throughout the processing operation.

MATERIALS AND METHODS

The microbiological sampling techniques involved sampling the finished product, personnel hands, equipment and utensils throughout the plant. Sterile swab tubes containing 10 ml of polypeptone diluent plus antifoam were used for collecting samples for total microbial numbers from the equipment, utensils and personnel. Each sample was taken during plant operations by swabbing the same location for each replication between the hours of 10:00 and 11:00 a.m. each sample day. Variations were held at a minimum by sampling the same areas for each trial throughout the study. Location of samples were labeled alphabetically as shown in Figure 1. Swab samples represented an area of approximately 8 in^2 with the exception of areas F (hand samples), N (faucet handle) and Q (knife). The hand samples were taken on a 4 in^2 area using the palm of the worker. The faucet handle samples were taken on a 4 in^2 area covering the four prongs, top and bottom. The knife samples were taken on a 4 in^2 area of the blade and were taken from the same worker whose palm was swabbed.

Enumeration of total bacterial numbers was made by removing 10 ml of swab tube diluent and placing into 90 ml of polypeptone diluent (1:10 dilution). Standard plate counts were determined using plate count agar according to standard methods of the American Public Health Association (1967). Incubation was for 48 hours at 35-37C.

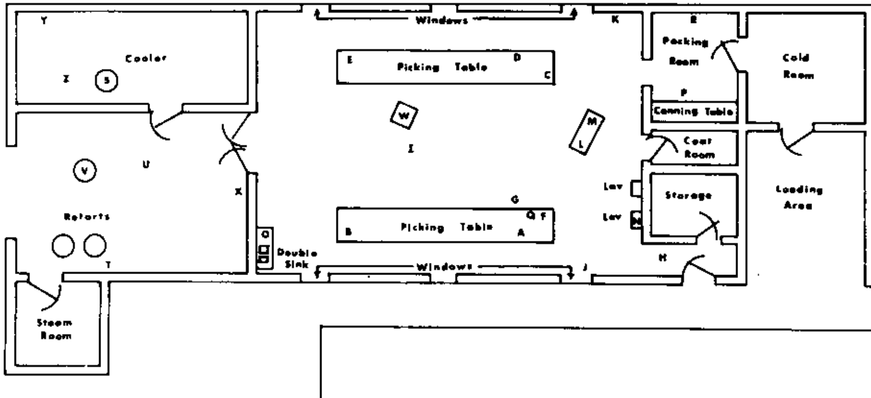

Fig. 1. Schematic design of sampling locations in a blue crab processing plant.

Sampling procedures varied for whole crabs, crab claws and "special" and claw crabmeat. Samples were taken of whole raw crabs upon arrival at the plant and whole cooked crabs after an overnight chill (approximately 18 hours). Whole crabs were placed separately in sterile "whirl-pak" bags using sterile tongs, packed in ice and delivered to the laboratory within 2 hours. One hundred ml of sterile polypeptone diluent was added for each crab, and the bag shaken 25 times. A 25 ml aliquot was removed and mixed with 225 ml of diluent (1:10 dilution).

Samples of whole cooked claws were taken after removal from the crab during the picking operation. Claw samples consisted of 10 average sized whole claws selected from the production container. Each sample was placed in a "whirl-pak" bag packed in ice and delivered to the laboratory within 2 hours. One hundred ml of polypeptone diluent was added, and the bag shaken 25 times. A 25 ml aliquot was taken and mixed with 225 ml of diluent. Total bacterial numbers were determined as described above.

The samples of blended claws were handled as above, except upon arrival at the laboratory 200 ml of diluent were added to the claws and homogenized in a Sunbeam blender for 2 minutes.

Samples of "special" crabmeat and clawmeat were taken at three points in the process: (1) meat as it was being picked, (2) meat that had been picked 30 minutes and (3) meat which had been chilled for 4 hours. Each of these samples

Table 1. Total Bacterial Numbers for Equipment in Blue Crab Processing Plant[a]

Sample Area	Code	Sample Date[b]											Range
		Nov. 19	Dec. 7	Feb. 23	May 1	May 3	June 7	June 13	June 14	June 20	June 21	June 27	
Table Picking	A	850	150	46	120	32	1,200	100	7	170	100	190	7 - 1,200
Table Picking	B	1,200	38	570	160	250	150	210	50	130,000	120	2,500	38 - 130,000
Table Picking	C	940	95	170	140	820	80	120	65	1,300	3,100	1,500	65 - 3,100
Table Picking	D	920	350	310	500	190	60	3,700	20	120	11,000	16	16 - 11,000
Table Picking	E	12,000	470	560	150	650	28	170	37	110	1,100	64	28 - 1,200
Hands Pickers	F	720	57	900	520	47	2,000	1	1,700	3,200	190,000	1,100	1 - 190,000
Cart, Weighing	L	550	92	190	270	7	430	600	140	30,000	5,300	2,200	7 - 30,000
Scale	M	1,200	600	920	3,000	120,000	1,300	500	800	22,000	3,200	4,600	500 - 120,000
Table, Packing	P	11,000	3	260	12,000	2	750	40	1,400	280	110	75	2 - 12,000
Knife, Picking	Q	930	2	230	75	2	870	2,200	400	1,600	33,000	3,000	2 - 33,000
Crab Cook Basket	S	18	140	0	5,200	0	12,000	0	330	110	1,300	480	0 - 12,000
Live Crab Basket	V	220,000	600	-	-	-	-	-	-	-	-	-	600 - 220,000
Crab Cook Hopper	W	250	210	3,600	-	3,200	0	3,000	43	17,000	-	2,600	0 - 17,000
Shovel, Cook Crab	X	160	620	250	670	1,500	960	140	1,500	1,700	-	41	41 - 1,700

[a]Numbers are organisms per in^2

[b]Nov. and Dec. were in 1971 and remaining dates were in 1972

was taken from the same can. Samples were removed aseptically from the center of the can for each examination.

To prepare the meat for bacteriological examination, one part of the meat was blended with nine parts of diluent for 2 minutes and analyzed as previously stated (American Public Health Association, 1967).

A routine cleaning procedure for the plant was conducted at the end of each working day. The procedure was to remove all debris from the area, and the floor was swept. A clean crab cart was filled with a mixture of water and detergent, and used to wash the tables and equipment. After cleaning, the small equipment was dipped in a 200 parts per million (ppm) chlorine solution. The remaining detergent mixture was placed on the floor. The floor was scrubbed and the tables and floor rinsed with cold water. At the beginning of each day, the picking tables were rinsed with a 200 ppm chlorine solution.

Table 2. Total Bacterial Numbers for Facilities in Blue Crab Processing Plant[a]

Sample Area	Code	Sample Date[b]											Range
		Nov. 19	Dec. 7	Feb. 23	May 1	May 3	June 7	June 13	June 14	June 20	June 21	June 27	
Ceiling, Picking Room	G	-	12	0	45	12	0	1	0	0	10	0	0 - 45
Floor, Picking Room	H	>370,000	11,000	>370,000	>370,000	>370,000	17,000	17,000	8,000	>370,000	>370,000	>370,000	8,000 - >370,000
Floor, Picking Room	I	300,000	87,000	21,000	300,000	190,000	300,000	>370,000	>370,000	>370,000	>370,000	>370,000	21,000 - >370,000
Window, Picking Room	J	17	410	5	8	2	1	1	0	3	0	0	0 - 410
Wall, Picking Room	K	62	1	25	2	61	30	2	0	0	0	2	0 - 62
Faucet Handle	N	30,000	>750,000	13,000	-	>750,000	>750,000	>750,000	>750,000	>750,000	>750,000	>750,000	13,000 - >750,000
Sink, Picking Room	O	11	8	4	9	0	11	20	0	10	76	2	0 - 76
Floor, Packing Room	R	19,000	47,000	1,700	1,400	41,000	10,000	110,000	12,000	>370,000	140,000	310,000	1,700 - >370,000
Wall, Cook Area	T	21	20	8,400	14	5	0	1,100	180	6,300	810	140	0 - 8,400
Floor, Cook Area	U	10,000	>370,000	31,000	270,000	>370,000	200,000	>370,000	210,000	>370,000	-	>370,000	10,000 - >370,000
Wall, Cooler	Y	0	0	3	3	0	0	0	0	0	-	1	0 - 3
Floor, Cooler	Z	-	140,000	>370,000	22,000	91,000	1,700	200,000	2,000	22,000	-	15,000	2 - >370,000

[a]Numbers are organisms per in^2

[b]Nov. and Dec. were in 1971 and remaining dates were in 1972

For comparative purposes, two additional studies were conducted.

In the second experiment, total bacterial numbers were taken on commercially harvested live whole crabs after transfer to the pilot processing laboratory. Crabs from the same lots were cooked and counts taken on the cooked whole crabs and the meat from selected samples of the same cook lots. Bacterial samples on the whole crabs were taken by rinsing each crab in 100 ml of sterile polypeptone diluent as described previously. Also, samples from crabmeat were prepared and analyzed as described previously. Total bacterial numbers were expressed as count/g.

In addition, a third experiment was conducted to determine the types of bacteria in commercially processed fresh and frozen crabmeat. The fresh crabmeat was stored for 2 days at 0C. Crabmeat stored for 1 day at 0C was frozen and stored at -29 ± 2C for 77 days. This sample was then thawed at 0C and stored for 1 day prior to analysis. All samples were analyzed for total bacterial counts, psychrophiles, coliforms, anaerobes, yeasts and molds by the technique of American Public Health Association (1967).

RESULTS AND DISCUSSION

The data shown in Tables 1 and 2 indicated that most areas sampled had extremely large variations in total bacterial numbers during the sampling period. These variations can be attributed to several factors. First, there was a seasonal variation which may have been temperature or simply day-to-day variation in sanitation practices. Second, there were major differences among the areas sampled. In general, the ceiling, walls and windows were relatively low in total bacteria. However, the floors were extremely high relative to other areas of the plant. The equipment and personnel hands were moderately high when compared to the previously mentioned areas.

It is evident from the data presented in Table 3 that a large variation in total number of bacteria was present for each sample. Numbers of bacteria present on

Table 3. Total bacterial numbers for blue crabs from various stages of processing

		Sample Date (1972)											
Sample Description	Code	May 10	May 15	May 16	May 17	May 27	May 23	June 7	June 13	June 14	June 20	June 27	Range
Whole Raw Crab Surface[a]	27		230,000						1,800,000				230,000 - 1,800,000
Whole Cooked Crab Surface (overnight chill)[a]	28	270	980	1,200	3,800	9,600	8,500	395	750	4,000	470,000	70,000	270 - 470,000
Special Meat Picking Area[b]	29		19,000	230,000	140,000	64,000	88,000	9,700		6,050	14,000	37,000	16,000 - 230,000
Special Meat Packed, 0 hrs Chill[b]	30	190,000	7,700	26,000			11,000	6,800		56,000	14,000	14,000	7,700 - 190,000
Special Meat Packed, 4 hrs Chill[b]	31	120,000	41,000	130,000	4,400		12,000	4,400		3,250	10,000	14,000	3,250 - 130,000
Whole Cooked Claw Surface[c]	32	15,000	180,000	50,000	340,000	250,000	180,000	150,000		420,000	760,000	160,000	15,000 - 760,000
Whole Cooked Claw Blended[b]	33		1,600,000	28,000	150,000		560,000	120,000	124,000	350,000	600,000	710,000	28,000 - 1,600,000
Claw Meat Packed[b]	34	8,800	97,000	62,000	120,000	12,000	9,500	26,000	12,800	31,000		38,000	8,800 - 120,000
Claw Meat 4 hr Chill[b]	35	750,000	18,000				44,000	19,000	21,000	46,000	51,000	10,000	18,000 - 250,000

[a]Numbers per crab

[b]Number per gram

[c]Numbers per ten claws

the whole raw crab were high when compared to the cooked product. This indicates the importance of maintaining restricted areas for separating raw from cooked products. The reason for a higher number of bacteria occurring in the special meat from the picking area than that from the packing area is not evident. Since this situation was found in 9 of the 11 trials, it was attributed to either the type of sampling or a bacterial injury condition. Further research is needed to clarify this point. It is evident that the whole cooked claws are a potential source of contamination and special procedures are needed to reduce the surface contamination.

Data in Table 4 indicated that numbers of bacteria from live whole crabs, cooked whole crabs and fresh picked crabmeat were relatively high for laboratory processing conditions when compared to the results in Table 3. These data suggest that the ability to routinely reduce the level of fresh picked crabmeat below 50,000/g would be extremely difficult.

The results for types of bacteria in fresh and frozen commercially processed crabmeat are presented in Table 5. In this particular study, all types enumerated were at a relatively high level, with psychrophiles and coliforms being especially prevalent. As would be expected, the freezing effect reduced numbers except for anaerobes. It is possible that conditions developed during the thawing of the frozen sample, and the 1-day storage afterward, resulted in the growth of some anaerobes.

It is beyond the scope of this study to establish that the results were high or low for crab processing operations. However, the results indicate those areas requiring greater sanitary treatment. In most cases, the variation was extremely high among sampling dates for a specific sample area. This too would indicate that there is need for increased emphasis on sanitation, since there is the potential, under commercial operating conditions, for reducing the bacterial numbers to a level near the low reported for each sample area. Also, the data indicated that extreme cross-contamination occurred and the segregation of processing operations would probably improve this condition.

Table 4. Total bacterial numbers for live and cooked crabs and crabmeat processed under pilot laboratory conditions.

	$\bar{x}$	r
Live whole crabs	4.5×10^8	(1.6 - 7.4)
Cooked whole crabs	1.8×10^4	(.09 - 5.7)
Crabmeat, fresh picked	4.1×10^4	(2.5 - 5.8)

Table 5. Distribution of bacterial types in fresh and frozen commercial crabmeat.[a]

Type	Fresh[b]	Frozen[c]
Total bacteria count	1.9×10^4	1.2×10^4
Psychrophiles	9.6×10^3	9.2×10^3
Coliforms	3.5×10^2	3.1×10^1
Anaerobes	7.2×10^2	3.6×10^3
Yeasts and molds	2.5×10^1	5.4×10^1

[a]Each mean represents 6 samples analyzed in duplicate. All samples were taken from uniformly mixed lot.

[b]Crabmeat stored 2 days in iced condition ($\sim 0^\circ C$).

[c]Crabmeat frozen after 1 day in iced condition and stored 77 days at $-29 \pm 2^\circ C$; thawed and stored 1 day in iced condition ($\sim 0^\circ C$).

ACKNOWLEDGEMENTS

This research was supported in part by a contract under Public Law 88-309 from the National Marine Fisheries Service, Department of Commerce and a grant from the National Oceanic and Atmospheric Administration's Office of Sea Grant, Department of Commerce under Grant No. 2-35178 and the North Carolina Department of Administration. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

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