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Influence of Mechanical Processing on the Quality and Yield of Bay Scallop Meats

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NOTE

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By

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ABSTRACT

The present commercial method of shucking bay scallops by hand is costly. A mechanical method has accordingly been developed in an effort to reduce costs while maintaining or improving the quality of the processed meats. Therefore, the mechanical method must produce meats of a quality and yield equal to or better than that presently obtained by hand processing.

The purpose of this study therefore was to compare the quality and yield of bay scallops processed by mechanical means with the corresponding values of those processed by the typical hand method. The mechanical method included heat-shocking of the shell-stock, roller-vibration removal of the meats and viscera and the subsequent separation of the viscera from the meats.

The quality of the scallops was measured objectively by the determination of drip, volatile base, pH, and bacterial count was measured subjectively by means of a qualified taste panel's rating the samples for odor, texture, appearance, and flavor. The yield of the scallops was evaluated by (1) proximate analysis for moisture, crude protein, ash, and fat, (2) amount of water absorbed, (3) amount of cooked meats obtained, and (4) loss of drip from frozen meats.

The results indicate that the quality and yield of meats from bay scallops processed mechanically as described above is equivalent to the quality and yield of those processed commercially by hand.

INTRODUCTION

The bay scallop resource along the east coast of the United States has not been fully utilized, owing to the low yield of edible meat (that is, of the adductor muscle), the need for hand labor, and the operating problems associated with processing.

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In recent years several workers have attempted to develop an automatic, mechanical method for the separation of the edible meat from the scallop. Harris (1958) proposed a sequential method involving shock, agitation, and fluid action to process the smaller species of scallops, such as the bay and calico. Subsequently, Polito (1964), Renfroe (1964), Matzer and Seidel (1965), Marvin and Henderson (1966), Wenstrom and Gorton, Jr. (1966), and Brown (1967) developed various methods and apparatus for processing scallops by the single or combined application of mechanical shock, heat shock, rotation, centrifugal force, pressure, vacuum, fluid action, gas pressure, shearing, and scraping. A completely operative mechanical system for shucking and eviscerating scallops has not been available, however, until recently.

The purpose of our study was to determine whether a prototype mechanical processing method, as described herein, would adversely change the quality and yield of the finished scallop meats significantly or present other problems as compared with hand processing. In this study, the prototype unit developed by E. Willis (1968, personal communication) was used.

QUALITY

Materials and Methods

The bay scallops *(Aequipecten irradians)* used in this experiment were harvested from Core Sound, N.C. (34°40′ N., 76°31′ W.), chilled at 3° C. for 48 hours, and randomly divided into two sample lots—namely, the control lots and the experimental lots. The control lots were processed by hand, using standard commercial techniques. The experimental lots were processed with the prototype mechanical unit.

Processing a control sample by the standard commercial technique involved opening the scallop, removing the viscera, and cutting the muscle free from the shell by hand with a scallop-shucking knife. The shucked meats were rinsed in tap water on a stainless-steel, perforated screen for 2 minutes, drained, and packed in 8-pound metal containers. The containers were sampled immediately and the samples were placed in 1-pound Whirl-pac[1] bags. The samples for fresh storage (3° C.) were iced and those for frozen storage (−27° C.) were frozen immediately with liquid nitrogen.

Processing the experimental samples involved using the prototype system, which was a unitized, semiautomatic, mechanical process that could be completed in 8 to 10 minutes. It operated as follows:

1. A loading conveyor (fig. 1) carried the whole scallop shell stock between rotating metal rollers and into a hot-water (95° C.), heat-shocking tank (fig. 2). The shell stock remained in the shocking tank 10 to 12 seconds.
2. The scallops were conveyed from the shocking tank through a second set of rotating metal rollers, which loosened the shell from the adductor muscle and viscera (fig. 3).
3. The adductor muscle and viscera remained attached to each other and were subsequently separated from the larger shell fragments by transfer onto a vibrating screen (fig. 4). This screen was equipped with a shower of cold, fresh water and was perforated with 1¼-inch holes, which were large enough to retain the larger shell fragments but small enough to allow the meat, viscera, and small shell fragments to discharge into a wire-mesh basket located below the discharge pipe (fig. 5).

Figure 1.—Shell stock loading conveyor for delivery to the rotating metal rollers.

[1]The use of trade names is merely to facilitate description; no endorsement is implied.

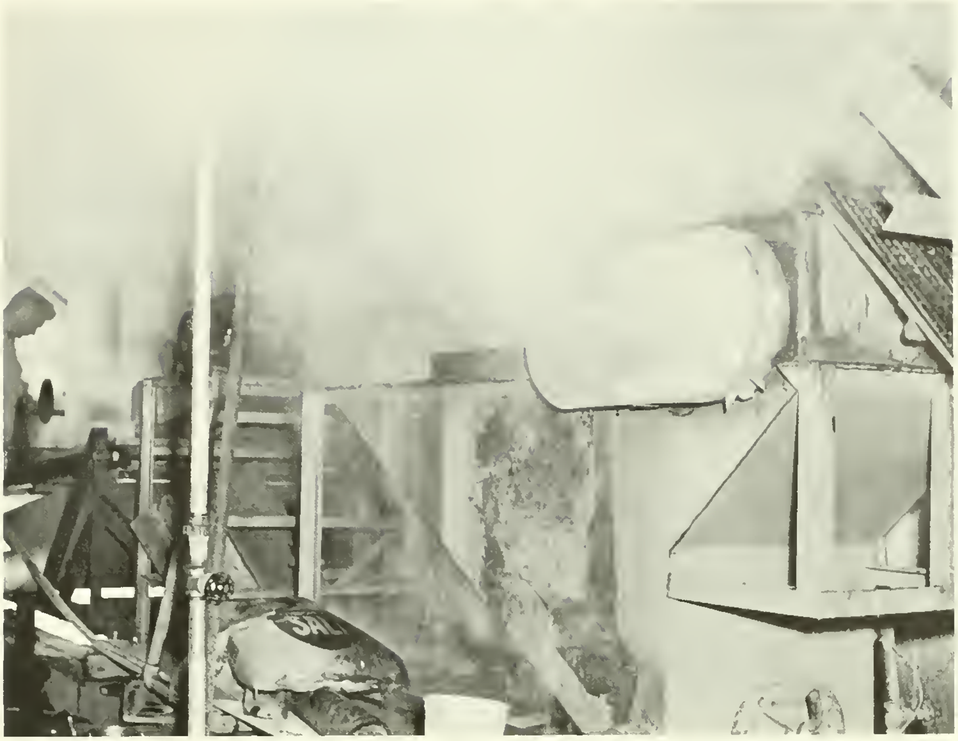

Figure 2.—The shell stock hot water, heat shocking tank with the conveyor for transferring the shell stock to the second set of rotating metal rollers.

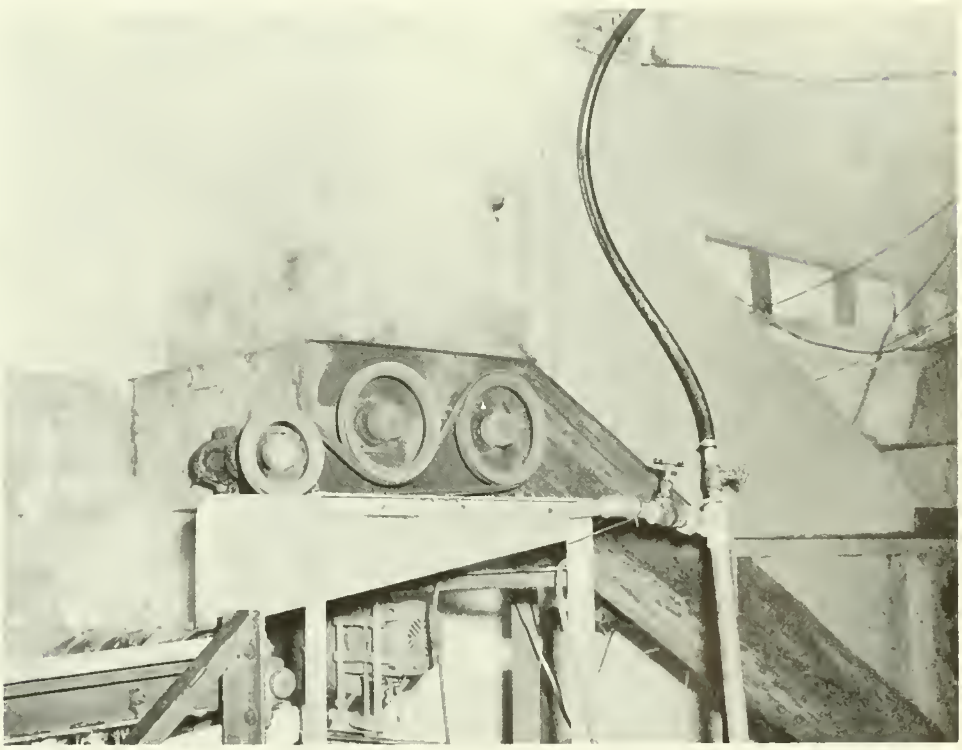

Figure 3.—View of the machine housing for the second set of rotating rollers at the point of delivery onto the vibrating screen.

Figure 4.—The vibrating screen containing shells after removal of the meat and viscera to the discharge pipe.

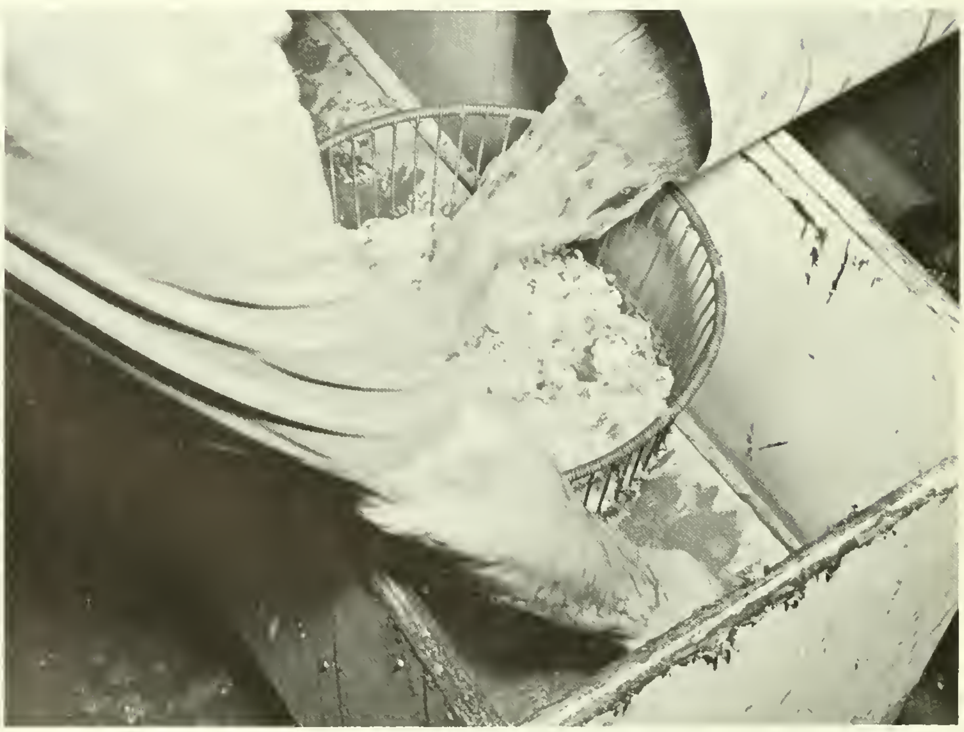

Figure 5.—View of scallop meats and viscera being collected into a wire-mesh basket from the discharge pipe from the vibrating screen.

4. The muscle, the attached viscera, and small shell fragments were transferred to a brine flotation tank containing 8-percent NaCl, where small shell fragments and surface grit were removed by sedimentation (fig. 6).
5. The muscle and viscera were separated from each other on an inclined (15°) eviscerator, which consisted of a series of high-speed rollers and of cold-water showers for rinsing the meats during evisceration (fig. 7).
6. The viscera discharged from the lower surface of the eviscerator, whereas the meats moved down the inclined top surface.
7. The cleaned meats were inspected on a stainless-steel perforated screen and packed in 30-pound metal containers (fig. 8), and the containers, in turn, were packed in ice for chilling.

Samples taken for analyses from the experimental lots were collected at three stages in the mechanical process, as follows:

1. The first sample (Lot 1) was taken from the 30-pound metal containers immediately after packing, without an additional or final rinse. The temperature of the meat at the time of sampling was 14.4° C.
2. The second sample (Lot 2) was taken after the meats had remained in the 30-pound metal containers for 3 hours, without an additional or final rinse. The temperature of the meats at the time of sampling was 15.5° C.
3. The third sample (Lot 3) was taken after the meats had remained in the 30-pound metal containers under iced condition for 3 hours and had then been given an additional or final rinse. The temperature of the meats at the time of sampling had not decreased significantly (15.5° C.). The final rinse was accomplished as stated for the control lot and in addition to the eviscerator rinse. All samples were taken from the center area of the cans and packed in an identical manner as accomplished for the control samples. All sample lots were transferred to the laboratory within 5 hours.

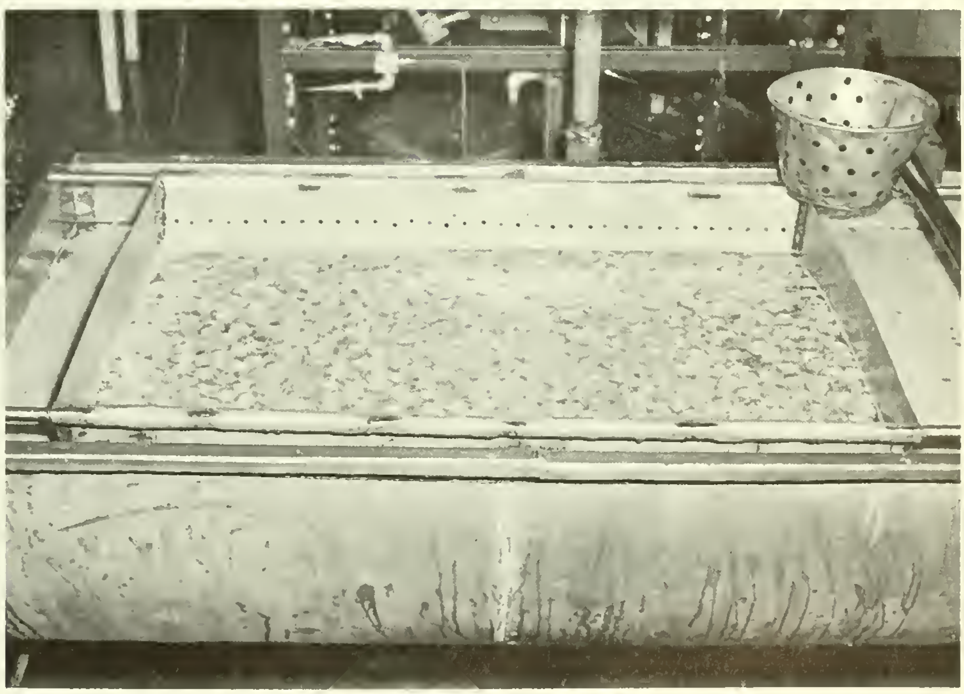

Figure 6.—Brine floating tank (8 percent NaCl) containing the meats, attached viscera and small shell fragments.

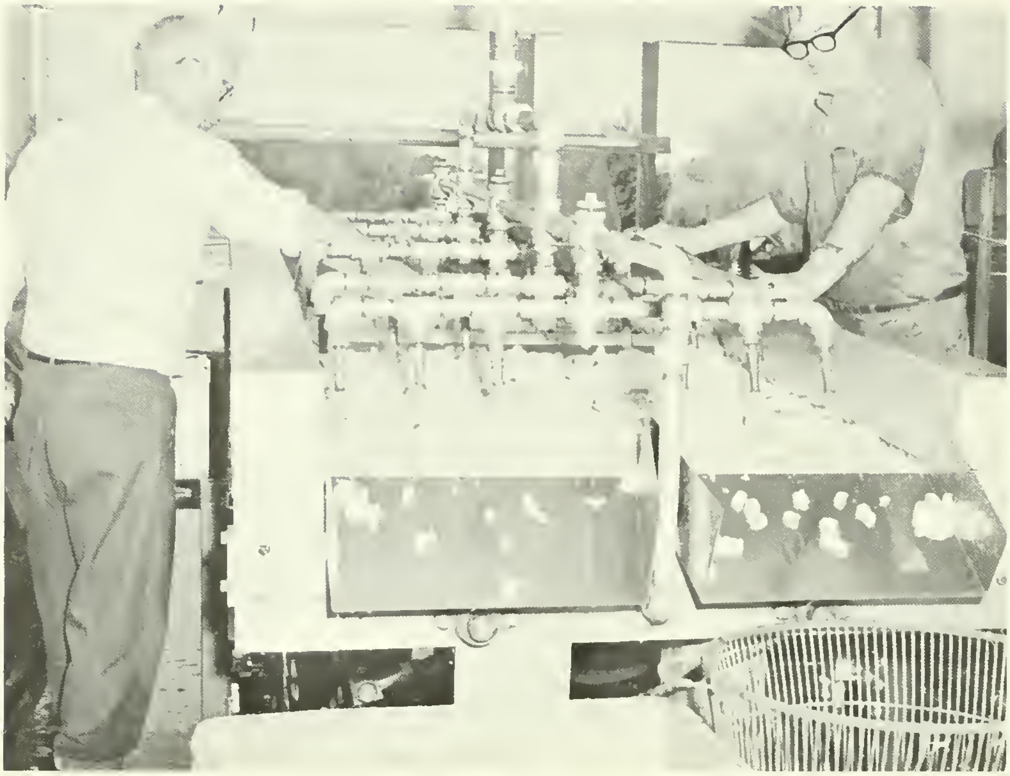

Figure 7.—Eviscerator showing rollers, showers and meats during processing.

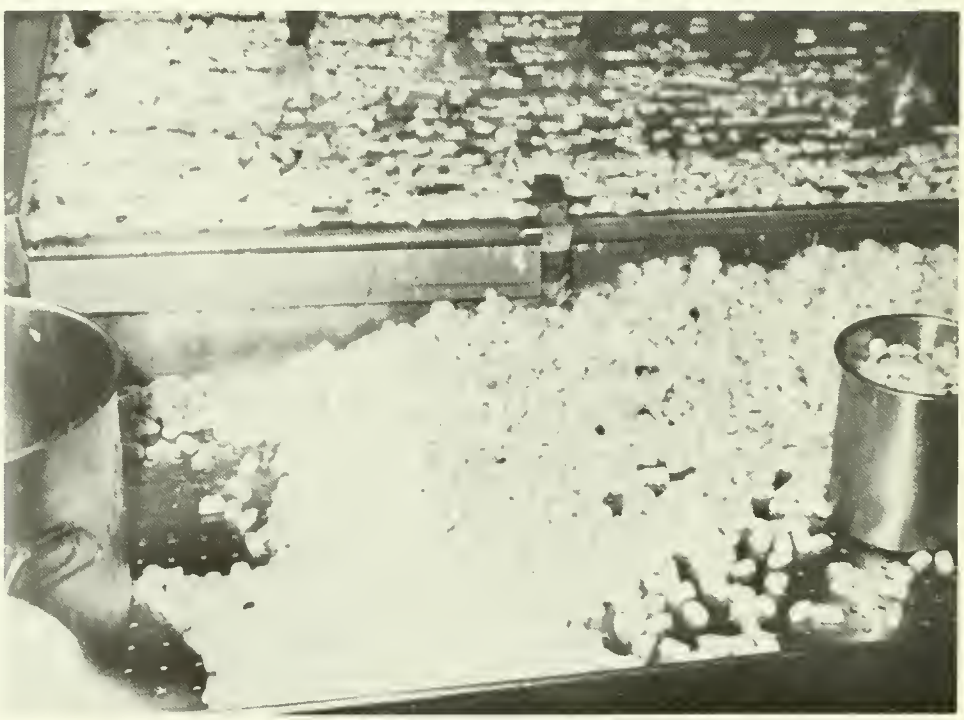

Figure 8.—The processed scallop meats with the stainless-steel perforated screen attached at the point of grading and packing.

Table 1.—Temperatures of facilities, rinse solutions, and meats during the processing of bay scallops by both the standard commercial and mechanical systems.

Processing components investigated	Temperature of: Standard commercial processing components	Mechanical processing components associated with: Lot 1 (which was taken directly from the line without final rinse)	Lot 3 (which was taken from the line, stored 3 hours under ice and given a final rinse)
	°C.	°C.	°C.
Shell-stock storage room	4.4	4.4	4.4
Processing-house air	15.5	6.6	12.2
Shell-stock shock water	..	91.1	92.2
Rinse water used on the vibrating screen	..	18.3	13.3
Scallop meat from the vibrating screen	..	..	23.8
Brine used for flotation (8 percent NaCl)	..	16.6	17.2
Rinse water used in the eviscerator	..	21.1	16.6
Scallop meats just before being packed into containers	14.4	14.4	15.5
Final rinse water	16.6	..	16.6

Temperatures were recorded (table 1) for (1) shell stock in storage, (2) processing-house air, (3) processing fluids at the various stages in the process, and (4) scallop meats at the various stages.

The control lot and the mechanically treated Lots 1 and 3 were analyzed after being held in chill storage for 2, 5, 7, 9, and 13 days at 3° C. or after being held in frozen storage for 14 days at −27° C.

The analyses were for (1) total bacterial count, (2) drip, (3) total volatile base, (4) pH, and (5) panel ratings of the raw meat for odor, texture, and appearance. In addition, panel ratings of the cooked meat for odor, texture, appearance, and flavor were obtained after storage of the fresh samples for 5 days and after storage of the frozen sample for 14 days.

The samples from Lot 2 were analyzed for bacterial count after being held in chill storage for 2, 5, 7, 9, and 13 days.

All analyses were determined as was described by Webb and Thomas (1968).

Results and Discussion

The temperature of the storage room for the shell stock was 4.4° C. (table 1). The scallop meats were efficiently shucked at this storage temperature, even after being held in storage for 48 hours. This finding is important, owing to the need under some operating situations for the shell stock to be prechilled for several hours before it is transferred to the processing facility. The heat-shock treatment did not measurably change the final temperature of the meats in comparison with the temperature of those in the control samples. The data do not indicate that any significant temperature change occurred in the meats due to the mechanical processing operation.

A comparison of the data on drip, total-volatile-base, and pH in table 2 with panel ratings shows that these data were not of much value in indicating the onset of spoilage. Generally, the total-volatile-base level increased during storage to about the point of spoilage (9 days) and then decreased. This peak effect may have been due to the breakdown of undetected end products. Our results for total-volatile-base level agree with those of Waters (1967).

The mechanically processed meats, which were sampled immediately after being processed (Lot 1), were not appreciably different from the control samples initially and during storage as evaluated by the panel and by bacterial counts (fig. 9). When no delay occurred prior to sampling, the initial bacterial counts were essentially the same for the mechanically processed samples as for the control samples. Storage under iced condition for 3 hours resulted in no drop in center can temperature but resulted in an appreciable increase in

Table 2.—Effect of method of processing, degree of rinsing, and storage temperature and time on the quality of bay scallop meats.

Description of sample					Objective test data			Organoleptic panel ratings						
			Storage					Raw meats[1]			Cooked meats[2]			
Shucking method	Lot	Treatment	Temp.	Time	Drip volume	Total volatile base	pH	Odor	Texture	Appearance	Odor	Texture	Appearance	Flavor
			°C.	*Days*	*Ml.*	*Mg./100g.*								
Hand	Control	Samples taken immediately from 8-lb. (net weight) metal containers.	3	2	3.7	2.0	5.98	4.5	4.3	4.8	..	..	..	..
				5	5.1	3.2	6.48	4.0	3.3	4.3	7.0	5.5	6.3	7.0
				7	5.0	4.8	6.42	3.0	3.4	4.0	..	..	..	..
				9	5.9	11.6	6.42	2.0	3.5	3.5	..	..	..	..
		Fresh storage in 1-lb. packages.		13	7.6	20.8	6.65	1.9	2.4	3.5	..	..	..	..
		Quick frozen in 1-lb. packages.	−27	14	2.0	7.6	6.28	3.8	4.5	4.0	7.8	7.5	7.0	7.3
Mechanical	1	Sample taken immediately from 30-lb. metal containers without given a final rinse.	3	2	2.9	11.2	6.30	4.0	4.6	4.8	..	..	..	..
				5	5.0	2.4	6.65	4.3	3.5	4.5	7.3	6.3	7.5	7.3
				7	4.1	4.8	6.17	3.4	3.6	3.8	..	..	..	..
				9	3.1	11.6	6.29	2.5	3.5	3.5	..	..	..	..
		Fresh storage in 1-lb. packages.		13	3.1	8.0	6.70	2.0	3.0	3.0	..	..	..	..
		Quick frozen in 1-lb. packages.	−27	14	3.5	10.4	6.42	3.8	3.5	3.3	7.5	6.3	6.8	6.3
	3	Sample taken from 30-lb. metal containers after stored 3 hrs. and given final rinse.	3	2	3.1	4.4	6.10	4.5	4.6	4.6	..	..	..	..
				5	5.1	4.0	6.50	4.3	3.5	4.0	7.3	6.3	7.5	7.0
				7	3.1	4.0	6.50	2.8	3.0	3.6	..	..	..	..
				9	3.1	10.4	6.30	2.0	3.0	3.0	..	..	..	..
		Fresh storage in 1-lb. packages.		13	6.5	7.6	6.76	1.4	3.0	2.8	..	..	..	..
		Quick frozen in 1-lb. packages.	−27	14	2.1	8.4	6.30	3.5	3.3	3.3	7.3	7.0	7.0	6.3

[1] Raw-meat panel ratings were rated on a 5-point descriptive scale in which 5 = excellent and 1 = unacceptable.
[2] Cooked-meat panel ratings were rated on a 9-point hedonic scale in which 9 = like extremely and 1 = dislike extremely.

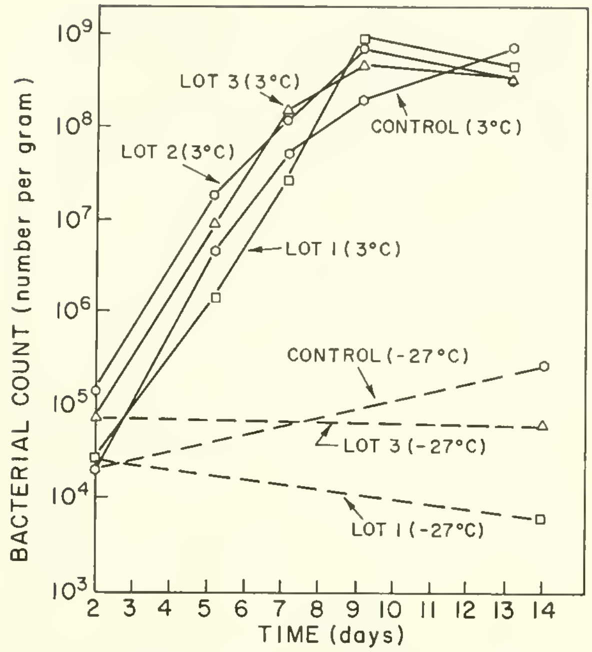

FIGURE 9.—Effect of conventional hand and mechanical processing, degree of rinsing and storage temperature or total microbiological counts following storage times.

bacterial counts. Furthermore, a final rinse did not reduce the count appreciably.

Panel ratings of the cooked meat indicated that mechanical processing or freezer storage did not change the quality of the meats.

Because of the high rate of shucking that can be achieved by mechanical means, the packing operation must be so designed as to prevent the scallop meats from accumulating in large quantity on the processing line. If the meats accumulate, their temperature cannot be efficiently reduced, and their bacterial count rise, which tends to reduce the quality of the meats. The addition of means for chilling the meats during processing thus would further ensure the production of meats of high quality.

YIELD

Materials and Methods

The materials used in this study were the same as those described in previous part on "Quality."

Analyses were made for: (1) proximate composition, (2) absorption of water by fresh and frozen meat, (3) yield of cooked meat (fresh and frozen; and unsoaked and soaked), and (4) loss of drip at the termination of the storage periods on the Control Lot and on Lots 1 and 3. All data were determined using techniques as described by Webb and Thomas (1968). The soaked meats were placed in tap water for 18 hours prior to the determination of yield.

Results and Discussion

Table 3 indicates that the method of processing had no apparent influence on the proximate composition of the finished meats. The fresh meats processed mechanically absorbed slightly less water than did the controls. The mechanically processed frozen and thawed samples, which were taken directly from the line without a final rinse (Lot 1), showed a lower absorption of water and loss of drip than the samples in Lots 2 and 3 showed. The loss of drip from the mechanically processed meats which had a final rinse (Lot 3) was lower than that from the control samples.

These results indicate that the fresh meats processed by standard commercial techniques (Control Lot) had a slightly greater capacity to absorb water than the mechanically processed meats. The meats from the control lot were found, however, to lose greater quantities of drip after being frozen and thawed than the other lots. Interestingly, the mechanically processed meats that were given a final rinse (Lot 3) had a greater amount of drip than did those taken directly from the line (Lot 1). The results of the drip loss of the meat having a final rinse suggest that this rinse produced a substantial loss in the moisture-binding properties during subsequent freezing and thawing. This property was not directly related to the uptake of moisture by the meats during rinsing, as is evidenced by the proximate composition and amount of water absorbed. Table 3 confirms the results of Webb, Thomas, Busta, and Monroe (1967) wherein the soaking of scallop meats significantly reduced the yield of the cooked meat. The yield of cooked fresh, unsoaked scallops that were processed mechanically was less than the yield obtained for the control lot. This suggests that the eviscerator rinsing was more severe than hand rinsing and thus affected the water-binding properties.

Table 3.—Effect of method of processing on proximate analysis, water absorption, cooked-meat yield, and drip loss of bay scallop meats.

Treatment	Proximate composition: Water	Protein	Fat	Ash	Water absorption: Fresh meats	Meats after freezing, thawing, and draining	Cooked-meat yield: Fresh: Unsoaked	Fresh: Soaked	Frozen: Unsoaked	Frozen: Soaked	Drip loss from frozen meats
	%	%	%	%	%	%	%	%	%	%	%
Standard commercial technique (Control Lot)	85.12	13.46	0.86	0.89	13.0	11.0	50.0	30.0	48.0	39.0	28.0
Mechanical processing: Direct from line without final rinse (Lot 1)	84.93	12.56	.91	.79	10.0	3.0	36.0	34.3	52.0	39.0	10.0
Mechanical processing: Storage 3 hours after taken from line followed by final rinse (Lot 3)	84.41	14.37	.77	.79	10.0	10.0	42.8	32.5	50.0	40.0	21.0

Note 1: Proximate analyses were made on the adductor muscle, which was blended, mixed, sealed in moisture-proof containers, and frozen until analyzed.
Note 2: Cooked-meat yield was determined after a 5-minute drainage time following each condition as described.

There was less drip loss, however, during subsequent freezing of the mechanically processed meats, so that the overall yield of the frozen meats was higher, with that from the hand-processed meats being the lowest. This observation suggests that the exposure of the scallop meats to solutions of salt brine during mechanical processing resulted in less damage to water-binding characteristics, which influence losses during freezing and thawing. There is an indication from these data that the exposure of the meats to the mechanical process resulted in a loss of inherent moisture. However, based upon the proximate composition, the greatly reduced cooked meat yield and drip loss of the mechanically processed meats cannot be explained fully by moisture transfer. It appears that changes in the muscle proteins were produced to cause these differences.

These observations also suggest that the flotation in brine may have prevented the removal of the water-soluble meat proteins. This possibility was supported by the slightly higher initial volume of drip from the control samples during the storage studies (table 2). Additionally, heat shock, mechanical agitation or salt-brine flotation, or a combination of these, probably has an influence on the water-binding properties of the fresh-meat proteins. The loss of drip, as a result of freezing, apparently released sufficient water to give similar yields of cooked meat for all frozen treatments. Table 3 shows that the control samples essentially followed the same patterns of water absorption, yield of cooked meat, and loss of drip as was reported for hand-processed scallop meats by Webb, Thomas, Busta, and Monroe (1967).

SUMMARY

The quality of scallop meats was maintained satisfactorily even after the shell stock had been stored for 48 hours at 4.4° C. The harvesting of the shell stock necessitated this storage time. However, observations from preliminary studies indicated that this equipment would perform satisfactorily on freshly harvested shell stock. The mechanical processing of scallops resulted in meats having a quality essentially equivalent to that of hand processing and did not change the proximate composition of the meats to an appreciable extent. Bac-

terial counts and panel ratings of the raw meat were found to be the best indices of quality. Drip volume, total-volatile-base level, pH value, and panel ratings on the cooked meat were not consistent indicators of the quality of scallop meat. The total-volatile-base level increased during the first week of storage of the meats at 3° C. with a subsequent decrease, thus eliminating it as a valid index of quality.

There was very little difference in the proximate composition between hand and mechanically processed scallop meats. The soaking of scallop meats in water resulted in a large increase in water absorption with a concomitant decrease in cooked meat yield. The yield of cooked meat was less for those meats processed mechanically. However, due to an increased drip loss, this difference in the yield of cooked meat was eliminated upon freezing and thawing. Drip from the frozen, mechanically processed meats was less than that from the hand-processed meats, being least from those not receiving a final rinse.

CONCLUSIONS

As compared with hand processing, the prototype mechanical processing method, described herein, did not adversely change the quality and yield of finished scallop meats nor present other major problems.

ACKNOWLEDGMENTS

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