PROCESSING AND QUALITY STUDIES OF SHRIMP HELD IN REFRIGERATED SEA WATER AND ICE

Part 4 - Interchange of the Components in the Shrimp-Refrigerated-Sea-Water System

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ABSTRACT

Whole raw pink shrimp were held for various periods of time in refrigerated sea water. Data were obtained to determine the effect of holding time on the weights of the whole shrimp and of the sea water and on the weights of peeled meats, of peeling waste, and of precooked meats subsequently prepared from the whole shrimp. In addition, water, salt, ash, and solids content of the above products were determined in order that factors affecting the changes in weight could be better understood.

BACKGROUND

In a previous paper (Seagran, Collins, and Iverson 1960) in which the keeping quality of pink shrimp held in ice and refrigerated sea water was studied, it was found that there was an apparent loss in solids of the peeled meats as a function of holding conditions. It was not known, however, to what degree this loss was caused by leaching of the soluble constituents or by water uptake.

The primary purpose of the present study was to resolve this uncertainty and secondly, to more fully characterize the various changes which occur in the shrimp-brine system. Accordingly, a study was made of the material balance of water, solids, ash, and salt contained in the various components of the system; namely, the brine, whole shrimp, peeling waste, and meats obtained from the whole shrimp, and the precooked meats subsequently obtained from the peeled meats.

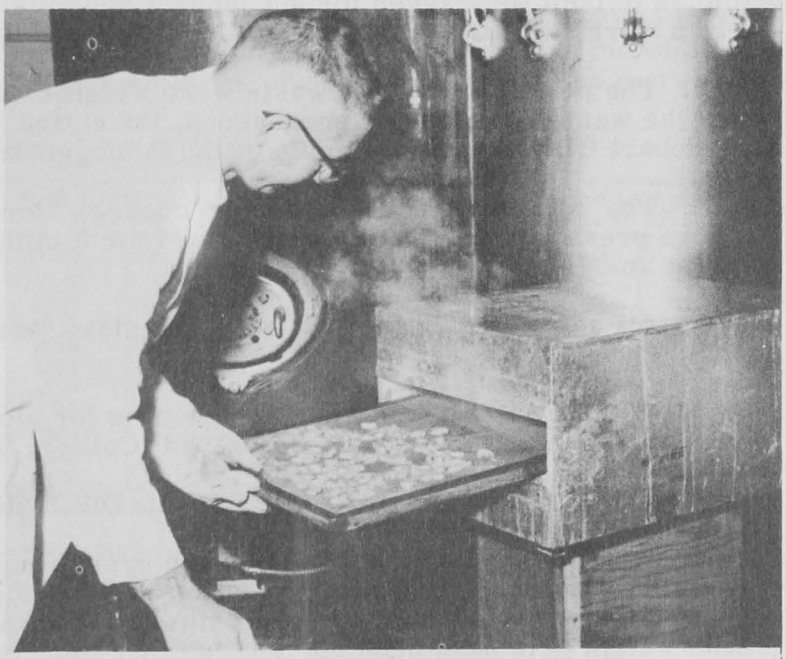

Fig. 1 - Chemist preparing to precook raw peeled shrimp in the laboratory steam box.

The holding system, of course, consists of whole shrimp and 3-percent brine. In the subsequent discussion it is convenient, however, to think of the system as consisting of brine, whole shrimp, peeling waste, peeled meats, and precooked meats. Each of these components of the system will change in its water, solids, ash and salt content as a function of holding time.

EXPERIMENTAL

The general experimental approach was (1) to hold pink shrimp for a period of time in refrigerated sea water, (2) to determine any changes in weight of the whole

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shrimp, its components, or the brine, and (3) to determine the moisture, ash, salt, and solids contents of the components of the shrimp-brine system as a function of holding time.

MATERIAL: About 30 pounds of whole fresh pink shrimp (Pandalus species) were obtained from Petersburg, Alaska. The shrimp, which were about 3 hours old when landed at the plant, were iced overnight and shipped by air to the Ketchikan Technology Laboratory. The shrimp were briefly rinsed in cold fresh water and allowed to drain for about 15 minutes in a wire basket.

HOLDING METHOD: Each of 24 glass jars was essentially filled with 450 grams of raw whole pink shrimp and 450 grams of a 3-percent aqueous solution of sodium chloride. The jars were sealed with rubber-gasketed glass lids and held up to 11 days in a pilot-scale refrigerated-sea-water unit at 30° F. (Collins 1960). (The use of a "closed" system was discussed in a previous paper, Collins, Seagran, and Iverson 1960.)

SAMPLING TECHNIQUE: Since the taking of a sample would change the weight of the system, the sampling had to be devised in such a way that this change in weight could be taken into account. The technique was as follows:

1. Three jars were removed from the tank, the contents combined, and the shrimp drained on a wire screen for 5 minutes.

2. The weights of the whole shrimp and brine were obtained separately and samples of both were taken for subsequent analysis. After reweighing, the whole shrimp were carefully hand-peeled so that all meats were separated from the waste.

3. The peeled meats and waste were weighed and a sample of the meats saved. Since the waste was very heterogeneous, the entire waste was blended for 5 minutes in a Hobart Chopper and a sample of the homogenate saved.

4. The reweighted meats were precooked[1/] for exactly 2 minutes under a slight positive pressure, cooled on a cloth towel for 5 minutes, reweighed, and save for subsequent analysis.

5. All samples were placed in sealed glass jars and held at -20° F. until analyzed.

ANALYTICAL METHODS: The analyses for moisture, total chloride, and ash were carried out as previously described (Collins, Seagran, and Iverson 1960).

RESULTS AND DISCUSSION

The weights of the components of the system and the water, ash, salt, and solids contents of each component are given for each period of holding in tables 1 to 5. In addition, the water, salt, and solids data are illustrated graphically in figures 2 to 4. These weight data have been adjusted so that each value is independent of prior sample removal. The values given for ash are termed "corrected ash" and are obtained by subtracting the salt from the total ash. The solids values do not include ash or salt. The solids, therefore, consist essentially of the nitrogeneous components of the shrimp along with a small amount of oil and other minor constituents.

Changes in the various components--whole shrimp, sea water, raw peeled meat, peeling waste, and precooked meat--were as follows:

1/The precook was carried out in a galvanized sheet metal box containing a stainless steel screen on which the peeled meats were spread. Steam at 40 psig was introduced through a copper tube, perforated so as to fill the chamber without subjecting the sample directly to the jets (fig. 1).

WHOLE SHRIMP: The whole shrimp gained weight rapidly when placed in the refrigerated sea water (table 1). This gain in weight was due to the absorption of water and sodium chloride. Accompanying this increase in weight, however, was a decrease in the amount of corrected ash and in the amount of solids. The loss in

Table 1 - Whole Shrimp: Change in Weight of Whole Shrimp and Their Component Parts With Time of Holding in Refrigerated Sea Water

Holding Time	Total Weight of Whole Shrimp After Various Holding Times	Total Weight of the Components of Whole Shrimp after Holding 1350 g. Whole Shrimp in 1350 g. 3-Percent Brine for Various Times at 30° F.			
		Water	Chloride	Corrected Ash (Ash-NaCl)	Solids 1/
Days	Grams	Grams	As g. NaCl	Grams	Grams
0	1350	1018	7.2	41.4	283
1	1412	1113	19.8	36.9	243
2	1469	1180	21.0	36.7	231
3	1438	1150	22.0	37.5	228
4	1483	1180	22.4	41.7	239
7	1484	1193	22.7	40.8	227
8	1462	1176	22.5	38.5	225
9	1437	1162	22.5	37.9	215
11	1430	1157	22.7	36.6	214

1/Solids: The total weight of solids, other than ash and NaCl (salt). This solids value is essentially the nitrogeneous components plus certain minor constituents. The solids value is obtained by subtracting the water, NaCl, and ash from the total weight of the component for each holding period.

solids was relatively large. By the end of the holding period, about one-fourth of the original weight of solids had been lost, even though the total weight of the whole shrimp was 6-percent higher than the original starting weight.

SEA WATER: Reflecting the over-all increase in the weight of the whole shrimp, the refrigerated sea water lost weight (table 2). This loss in weight was due to the water and sodium chloride that the shrimp had absorbed. Inasmuch as the whole shrimp lost corrected ash and solids, the sea water correctly showed an increase in

Table 2 - Brine: Change in Weight of Brine and Its Component Parts With Time of Holding in Refrigerated Sea Water

Holding Time	Total Weight of Brine After Variou Holding Times	Total Weight of the Components of the Brine after Holding 1350 g. Whole Shrimp in 1350 g. 3-Percent Brine for Various Times at 30° F.			
		Water	Chloride	Corrected Ash (Ash-NaCl)	Solids 1/
Days	Grams	Grams	As g. NaCl	Grams	Grams
0	1350	1309	40.2	-0.27	1
1	1270	1215	27.5	2.67	26
2	1227	1165	25.1	3.07	34
3	1258	1191	25.3	3.90	38
4	1207	1138	24.0	3.62	42
7	1213	1137	23.6	4.37	48
8	1228	1148	23.8	4.91	52
9	1225	1166	24.0	5.75	55
11	1250	1166	22.7	6.25	56

1/See footnote table 1.

these two constituents. The relations between the weights of water, sodium chloride, and solids and the holding time for both the whole shrimp and the refrigerated sea water are shown graphically in figures 2, 3, and 4.

Table 3 - Peeled Meats: Change in Weight of Peeled Meats and Their Component Parts With Time of Holding in Refrigerated Sea Water

Holding Time	Total Weight of Peeled Meats After Various Holding Times	Total Weight of the Components of the Peeled Meats After Holding 1350 g. Whole Shrimp in 1350 g. 3-Percent Brine for Various Times at 30° F.			
		Water	Chloride	Corrected Ash (Ash-NaCl)	Solids 1/
Days	Grams	Grams	As g. NaCl	Grams	Grams
0	470	377	2.5	5.4	85
1	526	432	7.1	4.7	82
2	558	464	8.6	4.8	81
3	556	465	9.3	4.4	77
4	550	460	8.9	4.6	76
7	550	466	9.3	4.5	72
8	543	459	9.0	4.1	71
9	529	447	8.7	4.2	69
11	514	434	8.7	4.1	67

1/See footnote table 1.

RAW PEELED MEAT: Similarly to the whole shrimp, the raw peeled meats gained weight rapidly, owing to the absorption of water and salt (table 3). Again this increase in weight was accompanied by a decrease in the weight of corrected ash and solids. By the end of the holding period, the peeled meats had lost about one-fifth of their solids content, although the total weight of the peeled meats showed a net increase of about 9 percent.

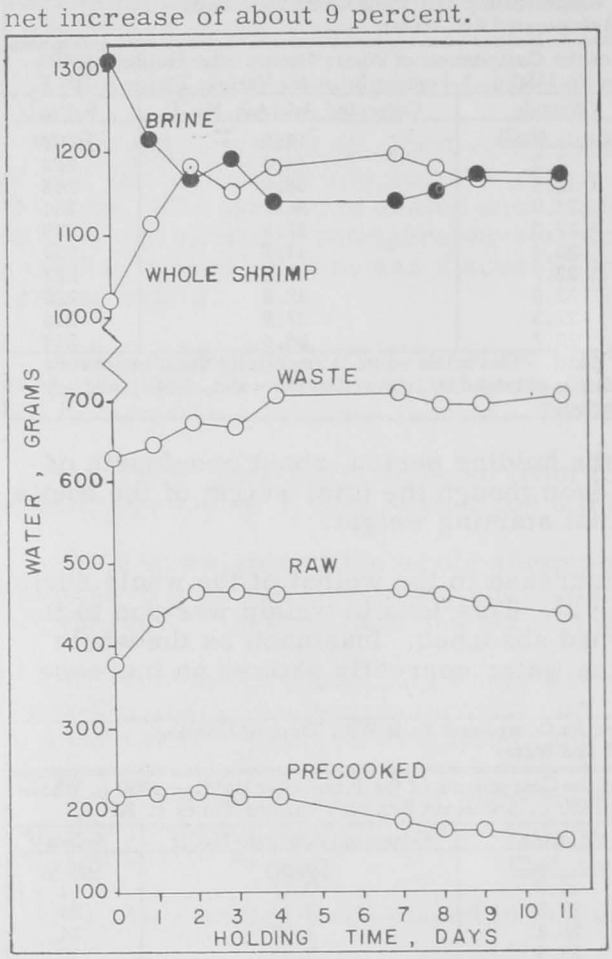

Fig. 2 - The water content of the various components of the shrimp-brine system as affected by the holding time in refrigerated sea water.

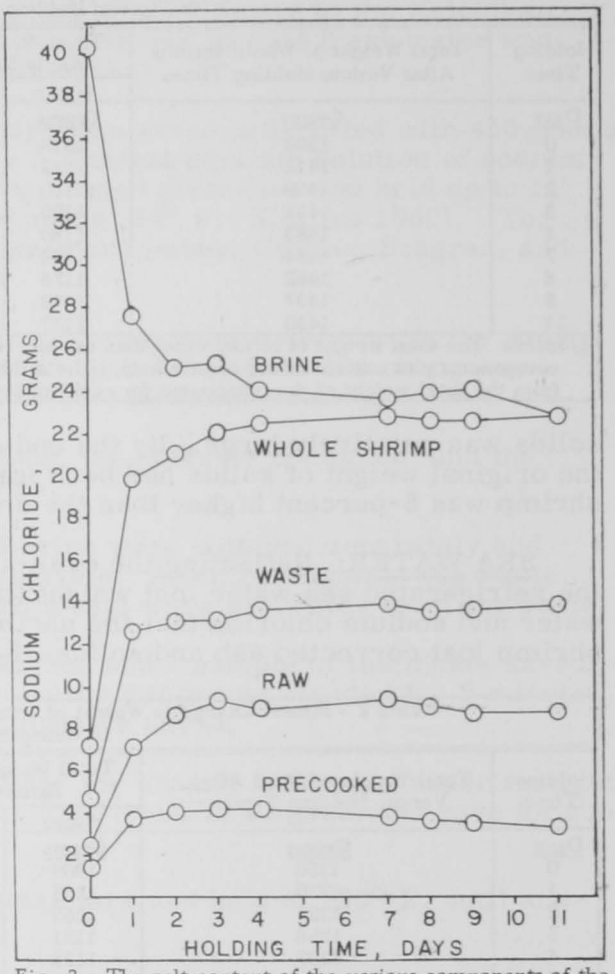

Fig. 3 - The salt content of the various components of the shrimp-brine system as affected by the holding time in refrigerated sea water.

PEELING WASTE: The peeling waste (table 4) constituted about 65 percent of the shrimp. The waste gained up to 5 percent in weight. This increase was due to the absorption of water and sodium chloride. This increase, however, was very nearly balanced by the loss in corrected

Table 4 - Peeling Waste: Change in Weight of Peeling Waste and Its Component Parts With Time of Holding in Refrigerated Sea Water

Holding Time	Total Weight of Peeling Waste After Various Holding Times	Total Weight of the Components of the Peeling Waste After Holding 1350 g. Whole Shrimp in 1350 g. 3-Percent Brine for Various Times at 30° F.			
		Water	Chloride	Corrected Ash (Ash-NaCl)	Solids[1/]
Days	Grams	Grams	As g. NaCl	Grams	Grams
0	862	627	4.7	39.9	190
1	859	643	12.6	35.1	168
2	885	670	13.1	36.0	166
3	864	664	13.1	33.9	153
4	915	702	13.6	35.6	164
7	904	704	13.8	34.3	152
8	887	689	13.5	35.3	149
9	885	689	13.6	33.6	149
11	893	700	13.8	33.7	145

1/See footnote table 1.

ash and solids. As in the whole shrimp, about one-fourth of the weight of the original solids was lost. The decrease in corrected ash was probably the result of leaching of carbonate from the shells, for they became rough to the touch.

PRECOOKED MEAT: Reference to figures 2, 3, and 4 show that the precooked meats maintain a constant water content the first few days then decrease in water content, but tend to reach a maximum in absorbed salt and to undergo a continuous decrease in solids content.

Over the 11-day holding period, the precooked meats lost up to 35 percent of their solids content (table 5). Although the data for the raw and precooked meats exhibit almost parallel trends, there is a greater rate of loss from the latter. This greater rate indicates that changes in the raw meats are taking place during holding that result in significant losses of solids during the precook. That this loss may be largely ascribed to leaching of protein-breakdown products during the precook appears to be reasonable, for this view is supported by an earlier finding (Seagran, Collins, and Iverson 1960) that nonprotein nitrogen is continuously being formed at the expense of protein.

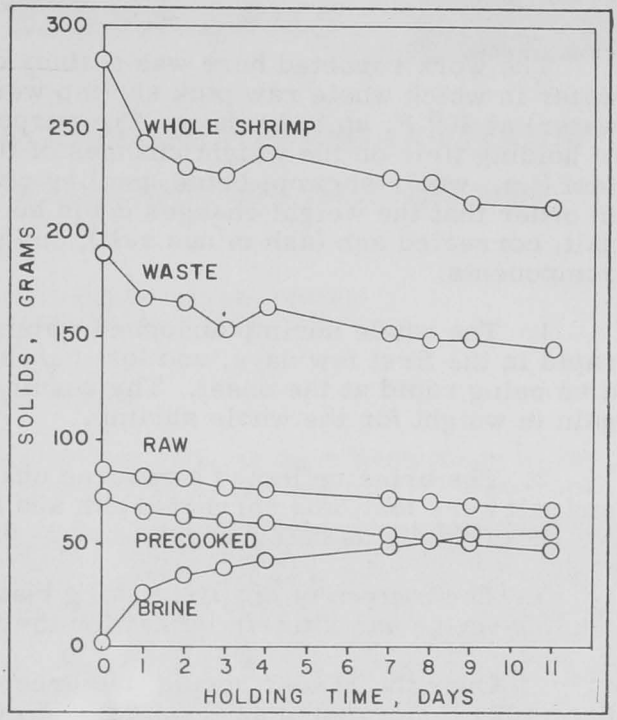

Fig. 4 - The solids content of the various components of the shrimp-brine system as affected by the holding time in refrigerated sea water.

Although the percentage composition data are not given for the precooked meats, these data may easily be calculated from the data of table 5. For all practical purposes, the percentage composition of the precooked meats are constant from the 2nd to the 11th day of holding. This indicates that under the conditions of this experiment, the precooked meats will not vary in their water, salt, corrected ash, or solids ratio after the 2nd day of holding.

Table 5 - Precooked Meats: Change in Weight of Precooked Meats and Their Component Parts With Time of Holding in Refrigerated Sea Water

Holding Time	Total Weight of Precooked Meats After Various Holding Times	Total Weight of the Components of the Precooked Meats After Holding 1350 g. Whole Shrimp in 1350 g. 3-Percent Brine for Various Times at 30° F.			
		Water	Chloride	Corrected Ash (Ash-NaCl)	Solids 1/
Days	Grams	Grams	As g. NaCl	Grams	Grams
0	292	215	1.4	3.2	72
1	292	220	3.7	3.0	65
2	290	220	4.1	3.1	63
3	284	216	4.2	2.6	61
4	281	214	4.2	3.1	60
7	245	184	3.8	3.0	54
8	231	173	3.6	2.9	52
9	230	173	3.5	2.9	51
11	215	161	3.3	2.8	47

1/See footnote table 1.

It is likely that the cut-out weight of commercially-canned shrimp is related to the solids content of the precooked meats as defined here. The loss in yield of the solids in this experiment, therefore, can be equated to a loss in yield in the final number of cases of canned shrimp. An inspection of the data for the solids content of the precooked meats (table 5, fig. 4) shows that an 11-day holding period in refrigerated sea water would result in a 35-percent loss in yield. Even after 4 days,

which is about the maximum time a processor could hold shrimp and still maintain good quality, the yield will drop 17-percent; that is, if 100 cases can be obtained using fresh shrimp, then only 83 cases will be obtained after 4 days' holding. Two days in refrigerated sea water is required for proper machine peeling (Collins 1960). After that time, a processor might expect to experience a yield loss of about 2-percent per day upon additional holding.

SUMMARY

The work reported here was a study of a system of shrimp and refrigerated sea water in which whole raw pink shrimp were held in 3-percent brine (simulated sea water) at 30° F. up to 11 days. The purpose of the work was to determine the effect of holding time on the weight changes of the various components of the holding system (i.e., whole shrimp, brine, peeling waste, peeled meats, and precooked meats). In order that the weight changes could be interpreted, changes in weight of water, salt, corrected ash (ash minus salt), and solids contents were determined for all components.

1. The whole shrimp absorbed water and salt, the rate of absorption being most rapid in the first few days, and lost corrected ash and solids, the rate of this loss also being rapid at the onset. The result of these two opposing tendencies was a net gain in weight for the whole shrimp.

2. The brine reflected a reverse change from the whole shrimp; that is, water and salt were lost, and corrected ash and solids were gained, with the net change in weight of the brine being a loss.

3. The pattern of changes taking place in both the raw peeled shrimp and the peeling waste was similar to that for the whole shrimp.

4. Over the 11-day period, the precooked meats showed a gain in salt content but a loss in corrected ash, solids, and even water; the result was a net loss in weight. As a function of holding time, the precooked meats had a greater rate of loss of solids than did the raw meats. This observation indicates that the holding period resulted in a change in the raw meats so that the solid material became more soluble during the precook.

5. Assuming that the loss in solids, as defined in this experiment (total weight of precooked shrimp minus weight of water, salt, and corrected ash), is related to the yield of commercially-processed shrimp, a processor will suffer a loss of more than 2 cases per 100 for each day the shrimp are held over the minimum time of 2 days required for proper machine peeling.

LITERATURE CITED

COLLINS, J.
1960. Processing and Quality Studies of Shrimp Held in Refrigerated Sea Water and Ice. Part 1 - Preliminary Observations on Machine-Peeling Characteristics and Product Quality. Commercial Fisheries Review, vol. 22, no. 3 (March 1960), pp. 1-5. (Also see Separate No. 581.)

_____; SEAGRAN, H.; and IVERSON, J.
1960. Processing and Quality Studies of Shrimp Held in Refrigerated Sea Water and Ice. Part 2 - Comparison of Objective Methods for Quality Evaluation of Raw Shrimp. Commercial Fisheries Review, vol. 22, no. 4 (April 1960). pp. 1-5. (Also see Separate No. 583.)

SEAGRAN, H.; COLLINS, J.; and IVERSON, J.
1960. Processing and Quality Studies of Shrimp Held in Refrigerated Sea Water and Ice. Part 3 - Holding Variables and Keeping Quality of the Raw Whole Shrimp. Commercial Fisheries Review, vol. 22, no. 5 (May 1960), pp. 1-5. (Also see Separate No. 587.)