COMMERCIAL FISHERIES REVIEW

May 1960 Washington 25, D.C. Vol. 22, No. 5

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

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ABSTRACT

Data are given on the keeping quality of raw whole pink shrimp in (1) ice and (2) refrigerated sea water at 30° and 32° F., at sodium chloride concentrations of 3 percent and 6 percent, and at shrimp-to-brine ratios of 1 to 1 and 1 to 2. The limit of acceptability of the shrimp was established subjectively and the relative quality was estimated by objective methods. An improved keeping quality of shrimp was obtained at (1) the lower temperature, (2) the higher brine concentration, and (3) the higher shrimp-to-brine ratio.

BACKGROUND

This report is part of a series in which the potential use of refrigerated sea water for holding Alaskan shrimp is being studied.

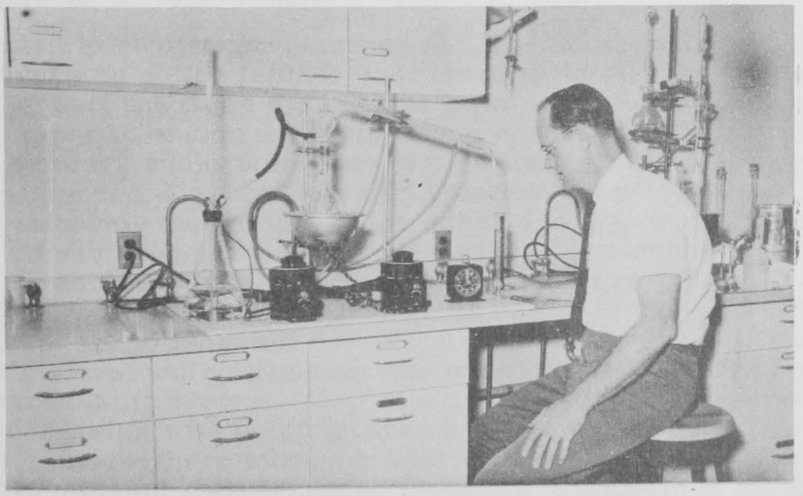

Fig. 1 - Chemist analyzing shrimp for volatile acid.

The purpose of the work reported here was to determine the effect of temperature, brine concentration, and shrimp-to-brine ratio on the keeping quality of the raw whole shrimp in comparison with the keeping quality of such shrimp held in ice.

EXPERIMENTAL

The experimental approach was to hold shrimp in refrigerated sea water at different temperatures, brine concentrations, and shrimp-to-brine ratios as well as to hold them in ice and then to see how their quality changed, as determined objectively, with time of holding.

MATERIAL: About 120 pounds of whole fresh pink shrimp (Pandalus species) was obtained from Wrangell, Alaska. The shrimp had been landed within a few hours of capture. They were held overnight without ice (air temperature approximately 30° to 32° F.) and shipped via air to the laboratory the following day. The

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shrimp were then briefly rinsed with cold fresh water and allowed to drain for a few minutes. At this point, hereafter referred to as zero time, approximately 30 hours had elapsed since the capture of the shrimp.

HOLDING METHODS: All samples held in refrigerated sea water were placed (together with the appropriate brine[1] solution) in closed C-enamel, No. 10 cans, which were essentially filled. This closed system was described in the previous report (Collins, Seagran, and Iverson 1960). The cans containing the individual samples were held in large thermostatically-controlled liquid systems (Collins 1960). The variables employed are shown in table 1. Samples held in ice were mixed with at least three times their weight of ice and placed in large cans with perforated bottoms. These cans were held under an additional blanket of ice in an insulated ice chest. Samples were re-iced approximately every other day.

Table 1 - Holding Variables for Shrimp Held in Refrigerated Sea Water (RSW) and Ice

Sample Number	Holding Method	Temperature	NaCl Concentration	Shrimp-to-Brine Ratio
		Degrees F.	Percent	
1	ice	32	-	-
2	RSW	32	3	1 to 1
3	RSW	30	3	1 to 1
4	RSW	30	3	1 to 2
5	RSW	30	6	1 to 1

The series was continued for $10\frac{1}{2}$ days from zero time. At selected intervals, samples were withdrawn, the shrimp were quickly peeled by hand, and the whole unwashed meats were frozen at -20° F. in glass containers. As needed for analysis, a sample was softened by immersing the glass container in cold water. A blade assembly of an electric blender was screwed on the glass container, and the sample was blended until a homogeneous mixture resulted. The mixture was sampled immediately.

ANALYTICAL METHODS: Analyses were carried out as previously described (Collins, Seagran, and Iverson 1960) for total solids, total chloride, total nitrogen, nonprotein nitrogen, amino nitrogen, total volatile acid, and trimethylamine. The limit of acceptability of the ice-held and refrigerated-sea water-held shrimp was obtained subjectively by smelling the cold, drained, whole shrimp.

RESULTS AND DISCUSSION

The results of the analyses are given in table 2. In general, regardless of holding method, all samples showed a progressive apparent loss of total solids as a function of holding time. It is not known, however, to what degree this apparent loss is due to actual leaching of soluble constituents of the meats or to the uptake of water by the tissue, which is considerable for fish tissue held in certain aqueous systems (Seagran 1956). Of the refrigerated sea-water samples, the one held in 6-percent brine showed the least loss, probably owing much to the relatively higher amounts of salt absorbed by this sample. In addition, an increase in holding temperature or a lowering of the shrimp-to-brine ratio caused a slightly greater loss of solids. The iced sample showed the greatest loss of solids as a function of holding time. With the iced sample, it is likely that a true leaching accounted for most of the loss, owing to the lack of electrolyte in the washing medium and to the very low levels of chloride ion retained by the meats (Seagran 1956).

In the analyses of protein nitrogen (total nitrogen less nonprotein nitrogen), the sample held in 6-percent brine also showed the least decrease as a function of holding time. As was suggested above, assuming that the total solids for this sample included relatively more salt than did the samples held in 3-percent brine, the greater relative retention of protein by the sample held in 6-percent brine is even more meaningful. All samples, however, showed a rather slow progressive apparent loss of protein, the rates being approximately the same except for the samples held in 6-percent brine.

1/Sodium chloride solutions were used rather than natural sea water (Collins 1960).

In the analysis of the total nonprotein nitrogen fraction of the meats, a rapid leaching by the brine (or the ice-melt) was indicated. As with total solids, there was an indication that an increase in holding temperature or a lowering of shrimp-to-brine ratio caused a slightly greater loss, at a given salt concentration, until equilibrium was reached. The nonprotein fraction reached a minimum value in brine

Table 2 - Analytical Data1/ Obtained on Pink Shrimp Held in Ice and in a Closed Refrigerated Sea-Water (RSW) System

Sample Number	Holding Time Days	Total Solids Percent	Total Chloride Percent NaCl	Total Nitrogen Percent	Nonprotein Nitrogen Percent	Amino-N Nitrogen Percent	Volatile Acid Meq.H+ 100 Gm.	Trimethylamine Mg. TMA-N 100 Gm.
Zero-time	0	20.67	0.603	3.014	0.846	0.394	0.025	0.60
1 (ice, 32° F.)	0.5	19.42	0.648	2.897	0.791	0.366	0.069	0.55
	1.5	17.40	0.528	2.601	0.673	0.295	0.073	0.54
	3.5	15.98	0.416	2.352	0.566	0.246	0.073	0.52
	5.5	15.19	0.337	2.313	0.498	0.213	0.090	0.57
	6.5	14.29	0.221	2.136	0.436	0.172	0.067	0.82
	8.5	13.33	0.126	2.016	0.325	0.133	0.114	1.33
	10.5	12.87	0.107	1.909	0.265	0.140	0.149	2.58
2 (RSW-3%, 1 to 1, 32° F.)	0.5	19.80	1.096	2.883	0.720	0.322	0.038	0.05
	1.5	18.28	1.443	2.540	0.591	0.252	0.023	0.10
	3.5	16.92	1.664	2.272	0.504	0.199	0.073	1.05
	5.5	15.86	1.768	2.160	0.456	0.170	0.266	15.4
	6.5	15.89	1.772	2.205	0.471	0.174	0.554	26.4
	8.5	15.19	1.811	2.070	0.429	0.159	1.403	42.0
	9.5	15.02	1.804	2.036	0.445	0.143	1.859	46.8
	10.5	14.96	1.854	2.052	0.447	0.148	2.710	56.4
3 (RSW-3% 1 to 1, 30° F.)	0.5	19.63	1.106	2.791	0.674	0.317	0.020	0.07
	1.5	18.50	1.374	2.637	0.640	0.271	0.021	0.25
	3.5	17.23	1.552	2.391	0.525	0.198	0.015	0.55
	5.5	16.64	1.608	2.158	0.456	0.195	0.085	5.28
	6.5	16.29	1.738	2.075	0.417	0.185	0.314	14.9
	8.5	15.87	1.679	2.079	0.500	0.179	0.671	28.8
	9.5	15.69	1.712	2.156	0.477	0.178	1.052	39.4
	10.5	15.61	1.737	2.000	0.504	0.176	1.639	50.4
4 (RSW-3%, 1 to 2, 30° F.)	0.5	19.68	1.148	2.778	0.717	0.317	0.061	0.15
	1.5	18.20	1.468	2.518	0.601	0.230	0.037	0.19
	3.5	16.58	1.569	2.264	0.465	0.180	0.045	0.85
	5.5	15.88	1.817	2.090	0.420	0.162	0.166	6.93
	6.5	15.62	1.922	2.048	0.394	0.151	0.250	12.3
	8.5	15.32	2.036	1.897	0.395	0.141	0.691	23.1
	9.5	14.97	2.013	1.858	0.389	0.128	1.061	29.4
	10.5	14.98	2.002	1.962	0.412	0.127	1.561	38.0
5 (RSW-6%, 1 to 1, 30° F.)	0.5	21.53	1.923	3.000	0.794	0.336	0.018	0.00
	1.5	20.72	2.663	2.590	0.572	0.246	0.053	0.12
	3.5	19.38	2.907	2.417	0.420	0.205	0.067	0.19
	5.5	18.80	3.065	2.338	0.445	0.186	0.111	1.05
	6.5	18.46	3.034	2.219	0.442	0.179	0.078	2.20
	8.5	17.93	3.032	2.258	0.446	0.180	0.295	13.6
	9.5	17.99	3.117	2.261	0.452	0.193	0.500	24.6
	10.5	17.58	3.082	2.159	0.430	0.173	0.716	37.6

1/Data calculated on a wet-weight basis.

and then held rather constant at values characteristic for each refrigerated sea-water holding system. Considering the fact that the salt and water contents are also increasing with holding time, it is apparent that nonprotein nitrogen was slowly and continuously forming, presumably by enzyme hydrolysis of protein. This situation becomes more apparent after the initial leaching has been accomplished. The free amino acids appeared to behave in a fashion similar to the total nonprotein nitrogen fraction, except that the free acids continued to decrease slightly, suggesting that this fraction was preferentially being utilized as a source of nutrients for bacterial growth. The protective effects of lower temperature and 6-percent salt were also noticeable in this latter respect.

Salt uptake in refrigerated sea water was rapid, particularly for the sample held in 6-percent brine, so that after about $3\frac{1}{2}$ days holding time, each sample only slowly increased to an equilibrium. The content of salt (as NaCl) attained at equilibrium in the 6-percent and 3-percent brines was approximately 3 percent and 1.8 percent, respectively.

The first definite off-odors detected in the whole shrimp occurred after $8\frac{1}{2}$ days holding in ice, after $5\frac{1}{2}$ days in either 3-percent or 6-percent2/ refrigerated sea water at 30° F., and after $3\frac{1}{2}$ days in refrigerated sea water at 32° F. The odor was determined on the whole unwashed shrimp, and the objective tests were carried out on the peeled unwashed shrimp. A strict comparison of the samples held in ice with those held in refrigerated sea water in this study thus would not seem feasible, since in the former case most spoilage products would be washed from the meats by the generous ice-melt. In the case of the refrigerated sea-water samples, however, the spoilage products would be retained within the system and, it is believed, to a large degree by the shrimp. Commercially, whole shrimp are subjected to a continuous washing operation with large amounts of water while being mechanically peeled. Spoilage products accumulating during holding in refrigerated sea water may be materially reduced by such washing action (Collins 1960). Accordingly, the keeping quality for samples held in refrigerated sea water given in this report probably represent minimum storage life for shrimp held under similar conditions. The data given for ice-held shrimp, on the other hand, probably represent maximum storage life, owing to the ideal icing conditions employed.

Distinct differences in the keeping characteristics of the various samples held in refrigerated sea water were noted, both from objective and subjective standpoints. For example, lowering the temperature 2 degrees (from 32° F. to 30° F.) gave an effective increase of approximately 2 days in storage life, based on odor, volatile acid, and trimethylamine data. Further, at a given temperature (30° F.), an increase of the salt concentration from 3 percent to 6 percent increased the storage life from 1 to 2 days. Changing the shrimp-to-brine ratio had no apparent effect on storage life.

From the data of this study, spoilage products contained in raw shrimp in excess of 1 milligram of trimethylamine nitrogen per 100 grams of wet meat and in excess of 0.1 milliequivalent of volatile acid per 100 grams of wet meat would indicate a product of limited subsequent storage life. The trimethylamine test seemed particularly sensitive to changes in the keeping quality of raw shrimp.

From a practical standpoint, when shrimp are to be processed within 3 days from time of catch, assuming holding conditions are good (maximum holding temperature of 32° F.), there would appear to be no need of using a 6-percent brine holding system. On the other hand, the potential advantages of the 6-percent system for somewhat longer holding periods are considerable from the standpoint of slowing down bacterial processes. Earlier work by Roach and Harrison (1954) in Canada suggested that holding raw shrimp in sodium chloride brines somewhat saltier than sea water (up to 6 percent NaCl) gives a firmer, better quality, more easily picked (Collins 1960) product than does holding in chilled sea water (approximately 3 percent salt) at the same temperature for the same length of time. The relatively high salt content of shrimp held in such a system should be recognized, although it is likely that the generous washing that the meats receive when the shrimp are peeled by machine would materially reduce the salt content (Collins 1960). Since salt is normally added to a commercial pack, a slightly higher salt content in the shrimp used for canning may not be objectionable for such packs.

SUMMARY

1. A $10\frac{1}{2}$-daytime study, using whole fresh pink shrimp held in refrigerated sea water and in ice, is described. The effects of certain holding variables (temperature, 30° F. and 32° F.; brine concentration, 3 percent and 6 percent NaCl; and

2/Although subjective data are difficult to evaluate, the degree of odor measured indicated that shrimp held in 6-percent refrigerated sea water kept considerably longer (1 to 2 days) than did those held in 3-percent refrigerated sea water (at 30° F.). Objective data confirmed this conclusion.

shrimp-to-brine ratio, 1 to 1 and 1 to 2) on the keeping quality of the raw whole shrimp was studied.

2. For all holding methods, the shrimp meats showed a progressive decrease in contained solids with increased holding time. Total solids content appeared to decrease at a greater rate with higher temperature, with lower brine concentration, and with lower shrimp-to-brine ratio.

3. Nonprotein nitrogen slowly formed presumably by enzyme hydrolysis. Free amino acids appeared to be preferentially utilized for bacterial growth. The protective effects of lower temperature and higher salt concentration were observed in this latter respect.

4. The salt content (as NaCl) of the meats attained at equilibrium in the 6-percent and 3-percent brines was approximately 3 percent and 1.8 percent, respectively.

5. The maximum storage life of fresh whole shrimp in ice appeared to be approximately $8\frac{1}{2}$ days. The minimum storage life of fresh whole shrimp in 3-percent refrigerated sea water at 30° F., in 3-percent refrigerated sea water at 32° F., and in 6-percent refrigerated sea water at 30° F. appeared to be at least $5\frac{1}{2}$, $3\frac{1}{2}$, and $6\frac{1}{2}$ days, respectively. It appeared that either lowering the temperature from 32° to 30° F. or increasing the brine concentration from 3 percent to 6 percent sodium chloride gave an effective increase of storage life of from 1 to 2 days, other conditions being kept constant.

6. Spoilage products contained in raw shrimp in excess of approximately 1 milligram of trimethylamine nitrogen per 100 grams of wet meat and in excess of 0.1 milliequivalent of volatile acid per 100 grams of wet meat would indicate a product of limited subsequent storage life.

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