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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

By Jeff Collins,* Harry Seagran,* and John Iverson**

ABSTRACT

A report on the suitability of certain objective tests as quality indices for raw shrimp held in refrigerated sea water and in ice.

BACKGROUND

The technical literature indicates that a refrigerated sea-water system has several potential advantages over an icing system. In the first study reported in the present series on the possible use of refrigerated sea-water with Alaska shrimp (Collins 1959), it was found that pink shrimp machine peeled satisfactorily after being held in refrigerated sea-water and yielded a product of satisfactory quality. Before the relative usefulness of refrigerated sea-water could be evaluated, however, data were needed on how the quality of the shrimp is affected by holding and processing variables.

Fig. 1 - An Alaska shrimp boat showing the beam trawl on deck.

For this work, objective methods of assessing quality were necessary. Many objective tests--such as total volatile base, total volatile acid, trimethylamine, and so on--have been proposed, each one of which gives certain information. The purpose of the present work was to find which of these various tests is the most suitable for the objective evaluation of the quality changes of shrimp held in refrigerated sea-water as well as in ice.

*Chemists, Technological Laboratory, Division of Industrial Research and Services, U. S. Bureau of Commercial Fisheries, Ketchikan, Alaska.
**Formerly Chemist, Alaska Department of Fish and Game, Technological Laboratory, Ketchikan, Alaska.

EXPERIMENTAL

The general experimental approach was (1) to hold shrimp for a period of time in refrigerated sea-water and in ice, (2) to make measurements at intervals of time by various objective tests and by a subjective test as well, and (3) to determine which of the objective tests yielded the most information in the light of the findings of the subjective test. Details of the experiment follow.

MATERIAL: About 120 pounds of whole fresh pink shrimp (Pandalus species) were obtained from Wrangell, Alaska. The shrimp were landed within a few hours of capture, iced overnight, and shipped via air to the laboratory on the following morning. The shrimp were then briefly rinsed in cold fresh water and allowed to drain for a few minutes.

HOLDING METHODS: Iced: The drained shrimp were mixed with crushed ice (about 2 to 1, ice to shrimp ratio), placed in an insulated ice chest in perforated containers, and held up to 10 days. The shrimp were re-iced daily.

Fig. 2 - Gathering the beam-trawl net prior to brailing the catch.

Refrigerated Sea Water--"Closed": The whole drained shrimp were held by the normal refrigerated sea-water method (Collins 1959) except that the shrimp were held in this time series up to 8 days in a closed system. That is, 1.5 kg. (2.2 pounds) of shrimp and 1.5 kg. (2.2 pounds) of brine were placed in No. 10 (C-enamel) cans, seamed, and then submerged and held in the refrigerated sea-water tank. The cans were essentially filled.

Refrigerated Sea Water--"Open": A stainless-steel kettle containing the shrimp and brine was suspended in the refrigerated sea-water tank. Circulation of the brine in the kettle was obtained by use of an external centrifugal pump. In this "open" system, the only deviation from the normal refrigerated sea-water system was that of temperature. The temperature varied between 31° and 35° F. (rather than the normal 29°-31° F.).

The purpose in maintaining comparative samples in "closed" and "open" systems was to determine what effects (if any) the limitation of oxygen would have on the results of the tests employed. It is recognized that at least initially the closed system is not anaerobic. During storage, it is likely that such a system becomes less aerobic, and as a result, the over-all spoilage products may include products of anaerobic processes. If the results of the tests employed do not reflect a difference between systems, the closed system would be employed in subsequent series on refrigerated sea-water-holding variables, since more exact control of experimental conditions are possible.

PREPARATION OF SAMPLES FOR ANALYSIS: At selected intervals during this time series, as well as for a control, about 1.5 kilograms (3.3 pounds) of the whole shrimp, for each of the methods of holding, was quickly peeled by hand. The unwashed meats were homogenized in an electric blender, vacuum-seamed in ½-pound, flat, C-enamel cans, and held in a plate freezer at -20° F.

ANALYTICAL METHODS: The following analyses were carried out on these samples: total nitrogen, oil, total solids, ash, total chloride (Association of Official Agricultural Chemists 1955), total volatile base (Stansby, Harrison, Dassow, and Sater 1944), total volatile acid (Friedemann and Brook 1938), trimethylamine (Dyer 1945), amino nitrogen (Pope and Stevens 1939), and glycogen (Van Der Kleij 1951). Nonprotein nitrogen was obtained by extracting the homogenized meat three times with 5-percent trichloroacetic acid and determining the total nitrogen content (AOAC 1955) of the centrifuged and filtered extract. A glass electrode was used to determine the pH of a 2-to-1 mixture of distilled water and homogenized meat. In addition to these objective tests, the whole, raw, cold shrimp at each time interval were subjectively judged for odor prior to being peeled.

RESULTS AND DISCUSSIONS

The analytical data obtained using these objective tests on the shrimp held in ice or in refrigerated sea-water are given in table 1.

Table 1 - Analytical Data on Pink Shrimp Held in Ice and Refrigerated Sea-Water (RSW) Using Various Objective Quality Assessment Methods

Holding		Nitrogen			Total Volatile Base	Total Volatile Acid	Trimethylamine	Oil	Total Solids	Ash	Total Chloride	Corrected Ash (ash-NaCl)	Glycogen	pH
Method	Time	Total	Nonprotein	Amino										
	Days	....	.(Percent).	.....	Mg. N/100g.	Meq. H+/100g.	Mg.TMA-N/100g.	....	(Percent)	...	As %NaCl	.....(Per	cent)....	
Control	0	3.008	0.800	0.333	5.56	0.107	0.24	1.08	20.50	1.46	0.48	0.98	0.026	8.15
Ice	1	2.781	0.703	0.279	5.82	0.115	0.40	1.06	18.32	1.27	0.51	0.76	0.027	7.68
"	2	2.578	0.590	0.222	6.01	0.115	0.20	1.14	16.96	1.02	0.30	0.72	0.032	7.83
"	3	2.300	0.442	0.161	6.14	0.163	0.52	1.06	15.35	0.82	0.18	0.64	0.028	8.10
"	4	2.318	0.446	0.175	7.12	0.186	0.92	1.08	15.27	0.89	0.20	0.69	0.031	8.40
"	5	2.239	0.387	0.140	7.57	0.218	0.52	1.08	14.82	0.87	0.15	0.72	0.028	8.24
"	6	1.992	0.303	0.108	6.66	0.236	1.72	1.12	13.76	0.79	0.10	0.69	0.023	8.25
"	8	2.014	0.251	0.082	7.89	0.226	1.72	1.07	13.55	0.62	0.09	0.53	0.021	8.35
"	10	1.921	0.240	0.060	9.58	0.262	2.92	1.08	12.85	0.55	0.04	0.51	0.020	8.29
RSW (open)	1	2.568	0.514	0.190	4.60	0.069	0.28	0.94	16.67	2.00	1.42	0.58	0.026	7.98
"	2	2.279	0.478	0.143	5.05	0.178	0.52	0.94	16.24	2.23	1.58	0.65	0.029	8.20
"	3	2.098	0.429	0.140	6.31	0.200	0.76	0.94	15.49	2.08	1.63	0.45	-	8.20
"	4	2.058	0.390	0.133	9.35	0.360	1.44	0.92	14.83	2.34	1.65	0.69	0.028	8.44
"	5	1.982	0.409	0.140	25.64	0.740	26.88	0.92	14.80	2.38	1.65	0.73	0.024	8.35
"	6	2.042	0.437	0.165	42.63	1.13	46.40	0.94	15.06	2.31	1.62	0.69	0.023	8.20
"	8	2.023	0.479	0.150	59.67	1.86	61.66	0.94	14.85	2.31	1.65	0.66	0.022	8.43
RSW (closed)	1	2.562	0.584	0.227	4.63	0.061	0.40	1.06	18.18	1.91	1.17	0.74	0.024	7.70
"	2	2.460	0.532	0.187	5.15	0.117	0.20	0.86	17.06	2.02	1.49	0.53	0.033	7.95
"	3	2.295	0.428	0.165	4.88	0.177	0.92	0.96	16.59	2.28	1.51	0.77	0.031	8.06
"	4	2.214	0.450	0.157	6.95	0.215	1.72	1.12	16.53	2.31	1.51	0.80	0.032	8.33
"	5	2.160	0.455	0.160	13.52	0.356	9.60	1.04	16.19	2.32	1.60	0.72	0.029	8.25
"	6	2.173	0.457	0.149	27.42	0.606	28.80	0.92	15.71	2.31	1.59	0.72	0.029	8.32
"	8	2.100	0.478	0.166	47.86	1.40	55.20	1.02	15.68	2.37	1.60	0.77	0.027	8.35

The samples that had been held in ice were noted as being completely fresh for 5 days, as being somewhat stale on the 6th day, as possessing a very slight off-odor on the 8th and 10th day, and as being definitely spoiled by the 13th day. The limit of acceptability could probably be set at about the 7th day. The long acceptability period of the shrimp held in ice in this experiment was undoubtedly due to the very thorough icing condition employed.

By the subjective test, the samples held in refrigerated sea water were considered to be fresh at the time of examination on the 4th day of storage. Sometime thereafter, between the 4th and 5th day, the compressor of the refrigerated sea-water unit malfunctioned, causing a significant rise in temperature for a period of several hours. As a result, on the 5th day, shrimp in both of the refrigerated sea-water systems had a definite spoilage odor.

A direct comparison of the ice-held and refrigerated sea-water-held shrimp was not possible because of the malfunction. However, certain of the objective quality tests picked up this malfunction, whereas others did not. Of the various objective spoilage tests, only volatile base, volatile acid, and trimethylamine values correlated well with the subjective ratings or picked up the malfunction. Trimethylamine seemed particularly good as a spoilage test for all samples. The pH values indicated a slight upward trend over the storage period but were of insufficient magnitude to be of any value as a spoilage test. Glycogen values showed a slight upward trend to a maximum after about 2 days and then a very gradual drift back down to about the initial value.

In fresh pink shrimp, about 25 percent of the total nitrogen is nonprotein nitrogen and about 40 percent of this nonprotein nitrogen is alpha amino nitrogen (free amino acids). All three nitrogen fractions (total, nonprotein, and amino) decreased in the shrimp during the holding period in ice. The continuous washing action of melting ice is thought to cause a true leaching of the initial nonprotein nitrogen and a further leaching of this material as it is formed through enzymatic hydrolysis of protein. For the shrimp held in refrigerated sea-water, the total nitrogen also decreased, but at a slower rate than did that of the shrimp held in ice. The nonprotein and amino nitrogen fractions decreased to a minimum at the 4th day and then slowly increased for the remainder of the holding time. It appears that in the refrigerated sea-water system, a condition exists such that after the initial leaching period (to the 4th day here), the total nonprotein nitrogen accumulates through enzymatic hydrolysis of protein at a faster rate than it is utilized by bacteria.

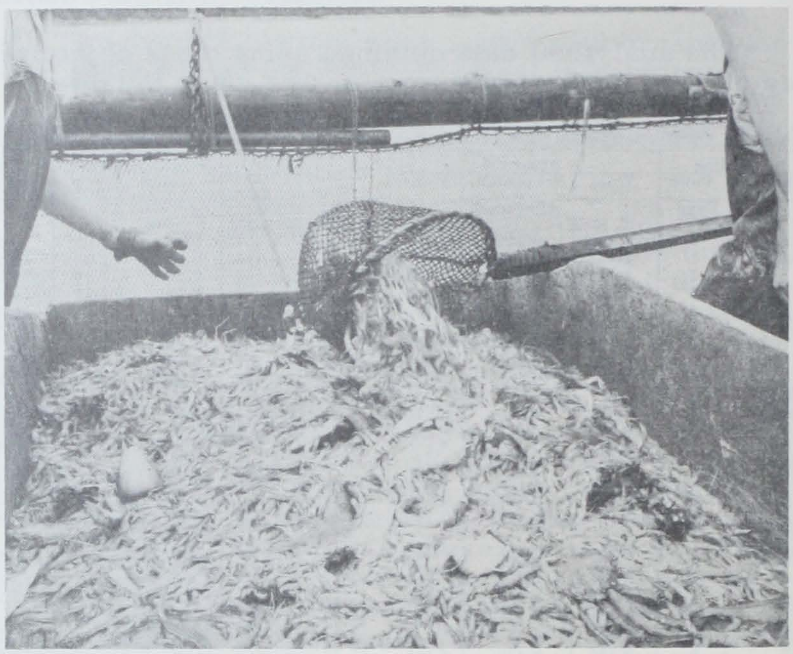

Fig. 3 - Brailing the catch from the beam trawl.

Total solids and corrected ash[1/] tended to decrease over the holding period, whereas oil showed little change. The salt uptake of the shrimp in the refrigerated sea-water system was rapid, equilibrium being reached within 3 days.

With respect to the refrigerated sea-water systems employed in this study, it was observed that the odors for the shrimp held in the "open" system were slightly different from the odors of those held in the "closed" system, and the shrimp held in the open system spoiled at a faster rate than did those held in the closed system. Although it is recognized that there are certain differences in aerobic and anaerobic spoilage which may account for the slight differences in odor noted, it was concluded that the different rates of spoilage, as determined by the objective tests, were caused by the differences in temperatures between the two systems. The objective tests appeared to apply equally well to the detection of spoilage in either system and to the detection of that in ice.

SUMMARY AND CONCLUSIONS

The purpose of this study was to determine which of 13 objective tests would adequately serve as spoilage indices and provide for general characterization of shrimp held in refrigerated sea-water and in ice. In addition, information was required on any differences which might arise between the quality of shrimp held in a "closed" or "open" refrigerated sea-water system.

From the data obtained, the following objective tests were concluded to be suitable: (1) trimethylamine and volatile acids, as indices of bacterial spoilage; (2)

1/Corrected ash: total ash minus NaCl.

amino nitrogen, non-protein nitrogen, and total nitrogen, as indices of enzymatic action; and (3) total solids and total chloride, for general characterization. The "closed" system will be used in subsequent studies, since no differences were found by the methods employed in this study between shrimp held in the two refrigerated sea-water systems (except those caused by temperature differences).

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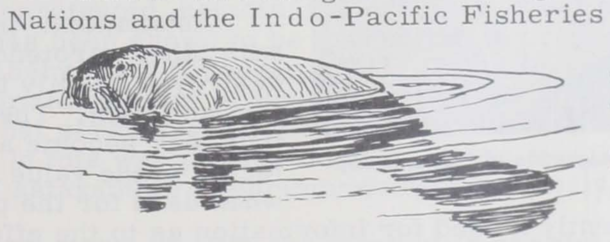
MANATEE FOR AQUATIC VEGETATION CONTROL?



The Food and Agricultural Organization of the United Nations and the Indo-Pacific Fisheries Council are exploring the possibility of introducing manatees (sea cows) into Ceylon and Thailand to control aquatic vegetation. In the United States manatees are most abundant in Florida waters, though their range is said to cover much of the Gulf of Mexico coast; they occur also on the northern coast of South America. Unfortunately, little is known of their age at maturity, maximum size, longevity, and tolerances for temperature variations and transportation over long distances. If successful, this would be true biological control of aquatic weeds, a problem in many parts of the world.