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EFFECT OF ICE STORAGE PRIOR TO FREEZING ON THE QUALITY OF FROZEN-SHRIMP

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Studies have been carried out to determine the effect of ice storage prior to freezing on the subsequent quality of frozen shrimp. The quality was evaluated both organoleptically and by objective means. It was observed that quality of frozen shrimp is inversely proportional to the time of ice-storage prior to freezing. Data are presented to indicate that shrimp frozen after 10-day ice-storage are poorer in quality and result in an unacceptable product.Shrimp kept in ice for 0–3 days give a superior quality product on freezing and those kept for 4–10 days give inferior (medium) quality shrimp on freezing as compared to shrimp kept for 0–3 days in ice. Proposals for obtaining superior quality frozen shrimp are made.

INTRODUCTION

While freezing still remains the processing procedure capable of giving consumer the best product marketable, the frozen fish industry is not always successful in providing a first class product. Our understanding of the basic principles involved in determining the quality of frozen fish products is progressing. There are many factors which are still unknown. Precisely how the various factors involved operate in practice under commercial conditions is not clear in many areas [1]. An understanding of these factors should enable us to improve quality and to see more clearly which areas need further study, both of the principles involved and the actual application of those principles.

Pakistan earns a considerable amount of foreign exchange from the fishery sector. Frozen shrimp contribute over 85% to the total foreign exchange earning. However, our frozen shrimp are ranked No. 3 in international markets and receive 20–30% lower price as compared to shrimp of same size and type from other exporting countries. This results in a loss of over $ (US) 10 million in foreign exchange each year. In Pakistan sea fisheries, the catch of shrimp after harvest is stored in ice in the hold. At the time of landing, the catches contain shrimp which have been stored for various lengths of time up to 2 weeks. It is also likely that the catch may sometimes be stored in the factory for a few additional days before processing.

It has been reported that holding raw unfrozen crustacea beyond one day of catching leads to increasing loss of yield and quality [2]. Control of storage temperature is important and efficient ice or ice water chilling should be carried out immediately after catching. Further evidence that chilled storage in ice prior to freezing tends to decrease frozen storage quality and life has been obtained [3].

Since storage in ice prior to freezing is one of the principal factors contributing to the quality of the finished product, a study was, therefore, undertaken to ascertain the effect of storage in ice prior to freezing on the quality of frozen shrimp.

This information will be of a considerable importance to the local shrimp industry. It was necessary to provide data showing the maximum time of ice storage before which freezing must be carried out if high quality frozen shrimp are required. The present paper describes results on frozen shrimp which were stored in ice prior to freezing for various lengths of time.

MATERIALS AND METHODS

Shrimp of commercial importance mainly *Peneaus merguiensis*, locally known as Jiara were collected from Ibrahim Hyderi. They were brought by the fishermen who operate small boats and generally make short trips. These fishermen go to fishing in the morning and come back at about 4–5 p.m. in the afternoon. The whole trip does not take more than 10 hr. The shrimp were packed in ice immediately after purchase and transported to the Laboratory within 1 hr.

On arrival at the Laboratory the shrimp were deheaded. The headless shrimp were washed and divided in two portions: one portion was packed in plastic bags, about 100 g shrimp taiis were packed per bag. At least ten bags of headless and peeled shrimps were placed in crushed ice in a refrigerator maintained at 5 ± 1^{o}. The shrimp were constantly kept covered with ice during storage period and re-iced as required. About 100 g shrimp were frozen

immediately at -40^{o} for 1 hr and stored at -20^{o} for 2 months and this was taken as 0 hr sample. The samples were removed after 1, 2, 3, 6, 8, 10, 14, 18 and 22-day ice-storage and frozen in a Votsch freezing cabinet at -40^{o} for 1 hr. They were subsequently stored in a deep freezer at -20^{o} for two months. For analysis the samples were thawed at room temperature, the volume of the drip measured and both the meat and the drip was analysed for various parameters.

Organoleptic Examination. Although different methods of determining quality of frozen shrimp have been applied, the use of a taste panel persists as the most universally applicable one. The scoring difference test described by Larmond [4] was used. A scale was set up from 11 (excellent) to 1 (very poor) for each of the following paraters: raw odour, texture, colour and cooked flavour. The score of each parameter was calculated in terms of average score points awarded by a panel of 10 judges. Panelists were presented thawed raw-shrimp and a cooked sample boiled for 3 min in salt water.

Chemical and Biochemical Examination. The objective methods used were selected on the basis that they either has reached an advanced state of development as tests of quality or were of particular relevance to quality assessment of frozen fish and shrimp. Analyses were performed on an extract prepared by blending shrimp tail with 7.5% trichloroacetic acid for 2 min in a ratio of 1:3. Total and nonprotein nitrogen (NPN) were determined using a Micro-kjeldahl method with direct nesslerisation [5]. Salt-soluble protein was estimated by the method of Dyer [6,7] amino acid nitrogen (AAN) was determined by the method of Spice and Chambers [8] as modified by Cobb *et al.*[9].

Total volatile nitrogen (TVN) was determined according to Cobb *et al.*[9]. Dyers modified picrate method [10] was used for the determination of trimethylamine (TMA). Reducing substances (RS) was determined by the method of Schafer *et al.*[11].

The pH was measured after homogenizing 10 g flesh with 20 ml distilled water for 1 min.

RESULTS AND DISCUSSION

The organoleptic score assigned to the shrimp frozen after storage in ice for different periods are shown in Table 4. A distinct difference was observed between shrimp processed without any delay as compared with shrimp which underwent storage for longer periods in ice before being processed. As expected, shrimp stored for shorter periods in ice scored more than those stored for longer periods. The degree of influence of each attribute to the overall quality is given. It may be seen that the changes in texture are less significant in overall assessment of quality than is the odour and colour. Headless shrimp received better organoleptic score. However, there was no significant difference whether the samples were frozen peeled or headless in the shell.

Table 1. Organoleptic scores obtained for shrimp frozen after storage in ice for different priods.

	Mean organoleptic response (MOR) (average of 10 penalists)									
	Headless					Peeled				
Storage time in ice (day)	Raw odour	Raw texture	Raw colour	Mean average	Cooked flavour	Raw odour	Raw texture	Raw colour	Mean average	Cooked flavour
0	10.2	10	9.8	10	10.2	–	–	–	–	–
1	9.4	10	9.6	9.66	10.0	9.2	10	9.6	9.6	9.4
2	8.8	9.8	8.4	9.0	9.5	8.6	9.6	8.6	8.93	9.4
3	8.2	9.0	8.8	8.66	9.5	8.3	8.7	8.4	8.64	9.2
6	7.1	7.8	8.1	7.66	8.8	7.0	8.4	7.8	7.7	8.1
8	6.3	7.1	6.4	6.66	8.6	6.15	6.93	6.27	6.45	8.0
10	6.0	6.8	6.1	6.3	8.2	5.9	6.7	6.3	6.3	8.0
14	5.1	6.2	5.2	5.5	–	5.0	6.1	5.1	5.4	–
18	4.9	6.2	5.2	5.5	–	4.7	5.2	4.9	4.93	–
22	4.3	6.3	5.1	5.2	–	4.2	5.4	4.8	4.8	–

Not determined.

Table 2. Objective characteristics of shrimp frozen after storage in ice for different periods.

	Headless								Peeled							
Storage time in ice (day)	Protein N X 6.25 (g/ 100 g)	NPN (mg/ 100 g)	SSP (g/ 100 g)	TVB (mg/ 100 g)	AAN (mg/ 100 g)	TMA-N (mg/ 100 g)	RS (mg/ 100 g)	pH	Protein N X 6.25 (g/ 100 g)	NPN (g/ 100 g)	SSP (g/ 100 g)	TVB (mg/ 100 g)	AAN (mg/ 100 g)	TMA-N (mg/ 100 g)	RS (mg/ 100 g)	pH
0	14.6	370.0	9.7	2.5	389.2	0.148	49.0	6.9	14.6	322.1	9.42	1.16	256.3	1.30	47.5	6.9
1	14.8	368.5	9.65	2.64	387.4	0.159	49.1	6.9	14.53	321.1	9.49	1.18	166.4	1.31	46.75	7.0
2	14.7	321.0	9.2	2.7	386.7	1.61	49.3	7.0	14.25	311.1	9.12	1.69	256.17	1.618	49.66	7.1
3	14.7	291.88	8.81	4.92	329.6	2.349	47.4	7.0	14.5	302.2	8.108	1.86	236.3	1.89	48.88	7.2
6	14.38	290.0	8.1	6.359	308.89	4.132	42.01	7.1	14.1	286.2	7.875	2.798	186.0	1.95	47.49	7.3
8	14.5	237.0	7.8	9.036	285.56	4.78	47.9	7.3	14.2	272.6	6.92	8.9	143.65	2.5	44.65	7.4
10	14.6	236.7	7.2	13.02	276.6	5.2	43.12	7.4	14.6	265.4	6.61	7.8	142.32	2.8	45.32	7.4
14	14.1	177.49	5.1	95.12	196.2	16.36	37.92	7.4	14.1	226.3	5.342	96.2	11.15	19.5	18.68	7.5
18	14.28	120.6	4.468	144.0	181.1	24.44	22.12	7.5	14.1	178.4	4.382	111.09	103.65	24.36	34.18	7.55
22	14.7	119.8	4.24	123.0	186.2	26.839	18.87	7.6	14.1	120.3	3.946	129.99	101.20	31.38	31.26	7.6

Table 3. Effect of ice storage prior to freezing on drip characteristic of frozen peeled and headless shrimp.

	Headless								Peeled							
Storage time in ice (day)	Drip vol (ml/ 100 g meat)	Protein N X 6.25 (mg/ vol drip)	NPN (mg/ vol drip)	TVB (mg/ vol drip)	AAN (mg/ vol drip)	TMA (mg/ vol drip)	RS (mg/ vol drip)	pH	Drip vol (ml 100 g meat)	Protein N X 6.25 (mg/ vol drip)	NPN (mg/ vol drip)	TVB (mg/ vol drip)	AAN (mg/ vol drip)	TMA (mg/ vol drip)	RS (mg/ vol drip)	pH
0	7.0	176	6.4	0.16	102	0.0	2.2	7.1	7.9	156.4	5.5	0.11	112.0	0.0	3.7	7.0
1	7.4	180	6.8	0.156	108	0.0	2.28	7.1	7.9	156.0	5.0	0.105	111.0	0.0	3.75	7.0
2	7.4	182	7.6	0.328	112	0.042	3.1	7.1	7.9	160.0	7.0	0.135	125.0	0.0	3.5	7.25
3	8.0	210	8.4	0.76	140	0.0	2.29	7.1	7.9	162.0	7.0	0.294	180.0	0.0	3.75	7.3
6	9.5	224	9.6	0.836	246	0.352	2.88	7.3	9.3	181.35	8.0	0.672	221	0.0	3.45	7.5
8	10.0	214	10.6	1.44	272	0.33	2.4	7.3	10.0	195.0	9.0	0.756	–	0.0	3.62	7.5
10	10.5	217	16.4	1.66	316	0.377	5.8	7.6	10.0	195.0	11.0	0.705	780	0.48	3.54	7.7
14	12.2	212	20.0	2.6	630	0.816	5.0	7.7	13.0	243	19.2	2.7	801	0.631	5.32	7.7
18	12.6	218	25.0	2.9	780	0.825	3.36	7.8	11.4	204	19.2	2.7	823	0.816	5.76	7.75
22	12.4	216	35.0	2.95	795	1.226	2.24	7.95	13.0	243	23.65	3.1	827	0.827	6.32	7.8

Not determined

During freezing and subsequent storage, the samples were handled in the same way and the only variation was the duration of ice storage prior to freezing. There is a clear indication from the data that the organoleptic score both for raw and cooked shrimp decreased with the increase of ice-storage period. It may be seen that the samples which were frozen after 14 days ice storage lost all their charcteristic odour, colour and texture in the raw state. These samples were not cooked for flavour assessment.

From commercial point of view, frozen shrimp processed without delay or after 3 days storage in ice and stored for 2 months at -20^{o} prior to thawing in air, possessed a high sensory quality. Samples have characteristic flavour which is somewhat sweet. Shrimp processed after 4–10 days ice storage have only medium quality after two months frozen storage, since the shrimp are still acceptable, there being no marked change in the attributes. However, they had relatively less sweet flavour as compared to the shrimp processed before 3 days ice storage. Shrimp processed after 10 days ice storage have a poor quality due to unpleasent odour, dull colour and poor texture. It is clear from the results obtained that ice storage prior to freezing has a profound effect on the qulaity of frozen product, therefore, we do not recommend the freezing of shrimp that have been stored for longer periods in ice, prior to freezing because the sale of this type of product will reflect adversely on the shrimp industry.

Table 2 gives the results of the influence of ice storage of shrimp prior to freezing upon protein, NPN, SSP, TVB, AAN, TMA-N, RS and pH of the frozen shrimp. These experiments provided a considerable amount of data and numerous correlations between the various parameters can be calculated. It is not possible within the scope of this paper to present all this material, therefore, only selection of main findings will be given. One of the changes in frozen fish during storage which affects the organoleptic quality is the denaturation of protein. In general it may be said that the longer the shrimp were kept in ice storage prior to freezing the greater was the degree of protein denaturation as is clear from the decrease of SSP, since the denaturation of frozen fish is accompanied by decrease in extractibility of SSP (Reay) [12]. This was generally true whether the shrimp were headless or peeled. There was also simultaneous decrease in NPN and AAN and a gradual increase in TVB and TMA-N indicators of pre-frozen spoilage. An increase in pH and decrease in RS was also noted. These parameters were also found to be useful in following the organoleptic changes in shrimp.

It was also observed that as the length of ice storage increased, the denaturation occurred at a faster rate. Consequently on denaturation more drip is exuded in shrimp proportional to the length of storage in ice prior to freezing. Effect of ice storage prior to freezing on drip characteristics is reported in Table 3. The volume of the drip was found to be directly proportional to storage period in ice. Loss of liquid during thawing was 7.4 and 7.9% for headless and peeled shrimp frozen without ice storage whereas this amounted to 12.4 and 13.0% respectively for headless and peeled shrimp after 22 days ice storage. There was also a simultaneous increase in the loss of total nitrogen and ANN through the drip.

On the basis of the data presented in Table 2, three phases of change, similar to those found with organoleptic properties, may be recognized. During the first phase (0–3 days) very little change in the parameteres was obtained, during the second phase (4–10 days) the parameters changed but at a slower rate. A sharp change in all the parameters was noted after 10 days ice storage prior to freezing.

On the basis of this study it may be concluded that the postfreezing quality of shrimp is apparently a function of its prefreezing quality. It is recommended that the freezing be applied as soon as possible after capture.

No doubt short trips for the commercial harvesting of shrimp will be more expensive than longer trips of 10–15 days duration. However, we must consider the following points: (1) The relative value of the product. The higher the value the more can logically be spent on processing. (2) The amount of improvement for which the buyer is willing to pay.

When the cost of the finished product is low, high cost handling and processing may be difficult to justify unless there is no alternative. On the other hand, an improvement in quality might be easy to justify in frozen shrimp. Where the country is losing over $ (US) 10 million in foreign exchange due to inferior quality of the product.

It must be noted that in these experiments the shrimp were kept covered with plenty of ice during storage and temperature of close to 0^{o} was maintained throughout the storage period. This is an ideal situation. In commercial practice sufficient ice is not generally available and shrimp never reach close to 0^{o}. It may, therefore, be suggested that in a commercial situation holding time in ice for good quality shrimp may be less than that presently realized. The effect of ice storage prior to freezing on quality has been shown for other fish, shellfish and fish products by many workers. It was reported by Govindan [13] and Susamma *et al.* [14], that during storage of Indian prawn in ice, water-soluble protein and other nitrogenous extractives especially amino acids were leached out by melting ice and when such material was used for freezing the poorer quality of raw material is reflected in the final

product. Byer *et al.* [15] assessed the palatability of frozen cod fillets having three initial grades of quality and obtained similar results. Dyer and Peters [16] showed the haddock and pollock fillets prepared and frozen after between one and three days storage in ice had a storage-life of 86 weeks, but those prepared and frozen after nine days in ice-storage were near the end of their storage-life. Notevarp and Heen [17] reported very much reduced keeping quality on frozen storage when cod were stored 3–8 days in ice before freezing as compared to the fish frozen fresh. Reay *et al* [18] mentioned a time of 3 days as a limit for cod storage in ice.

Banks [19] mentioned that in the United Kingdom it was observed that freshly caught cod could be kept for 3 days in ice before freezing before they become unsuitable for filleting. With haddock two days was the limit but flat fish, lemon sole and plaice could be held for 5 days and still be suitable for filleting to give a satisfactory product.

Todays market demands have forced us to change our outmoded techniques of handling shrimp prior to freezing preservation. We are forced not to undertake long cruises with our fishing vessels. Shrimp fishing must be confined to shorter fishing trips of 1–3 days duration. The shirmp must be constantly covered with crushed ice on the deck till landed at the harbour. If these measures are not taken the processor will receive shrimp of less than acceptable quality and when these shrimp are frozen, the end-product will be rated No. 3 in the international market and receive lower price as compared with high quality shrimp from other competing countries.

In recent years, adaptation of methods and equipment enabling processing and freezing at sea has played an important role in rapid development of worldwide shrimp and tuna fisheries. We can also look into the possibility of freezing shrimp on board. Although this is obviously not economically viable at present in this country.

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