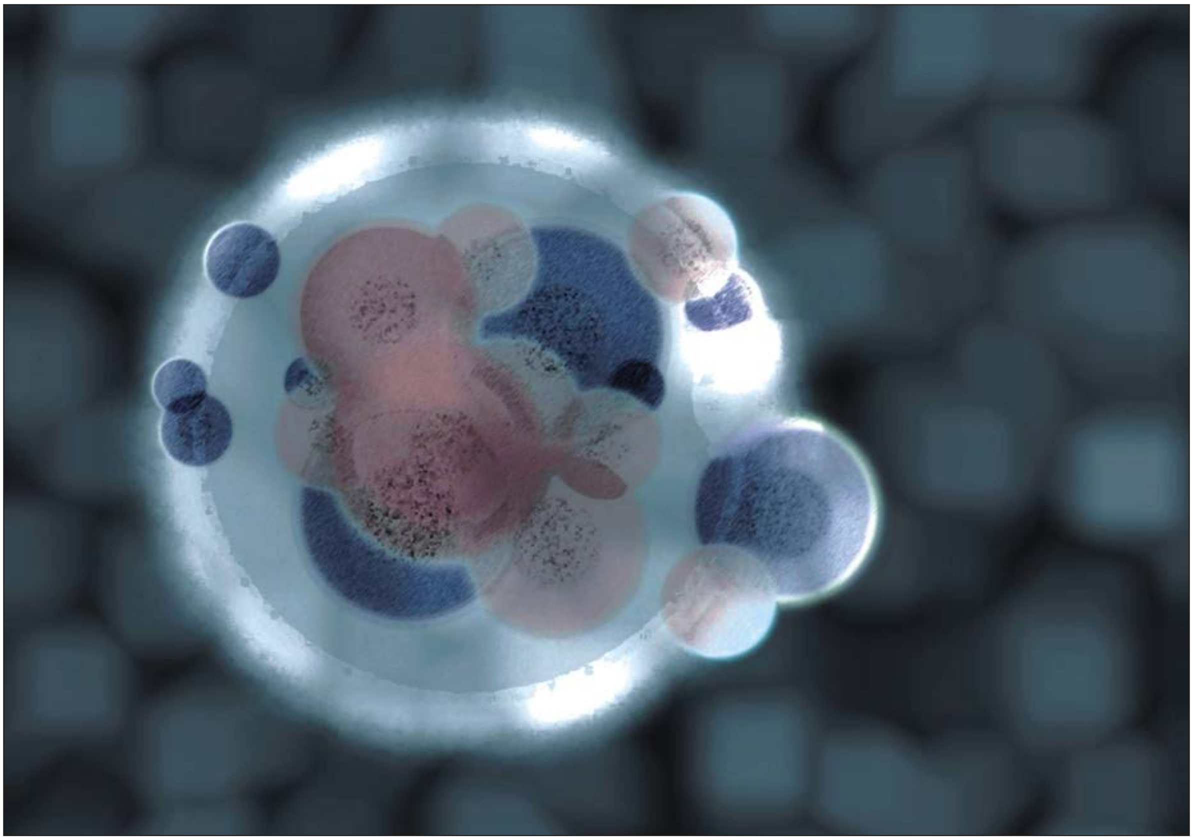

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Influence of Ice Storage on Raw Materials for the Production of High Quality Dried Fish Products

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Abstract: Studies were conducted to evaluate the influence of ice storage on the raw materials for the production of high quality dried fish products in solar tunnel dryer by determining organoleptic, biochemical and bacteriological aspects. Fresh fish samples of silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish were collected from the landing centre of Cox's Bazar and stored in ice for 13 days. During the storage period, required quantity of fish samples were taken out every three days for drying in a Hohenheim type solar tunnel dryer. The quality of the raw materials during storage and corresponding dried products produced in the dryer were evaluated. One day ice stored raw materials exhibited excellent quality on the basis of odour, colour, appearance and consistency of flesh. However, the overall organoleptic qualities of all samples were acceptable conditions up to 10 days of ice storage. Four days ice stored raw materials produced excellent quality of dried products in the solar dryer, while the dried products produced from 10 days of ice stored fishes were also found acceptable qualities judged by their characteristic colour, odour, texture, infestation and broken pieces. There were little or no changes in initial moisture content of 70.5 to 89.1% in raw materials during 13 days of ice storage. The initial total volatile base, peroxide value and aerobic plate count of the raw materials were 2.37 to 5.15 mg N $(100\ g)^{-1}$, 1.27 to 2.81 m eq kg^{-1} oil and 2.75×10^2 to 2.0×10^3 CFU g^{-1}, respectively, which increased considerably beyond the acceptable limits after 13 days of ice storage. The moisture content of the dried products prepared from various days of ice stored fish samples were in the range of 15.9 to 16.4% which were within the acceptable limit. The TVB-N, peroxide and APC values of the dried products produced from up to 10 days of ice stored raw materials were found within the limit of acceptable levels, which increased beyond the acceptable limits when raw materials stored up to 13 days in ice were used to produce solar tunnel dried fish products.

Key words: Ice storage, solar tunnel dryer, total volatile base, aerobic plate count, acceptable limit

INTRODUCTION

Fish as food is susceptible to rapid spoilage at an ambient temperature. They deteriorate during post-mortem period as a result of a variety of biochemical and microbial breakdown mechanisms. Icing is an important method of preservation for maintaining the quality of fish/shellfish immediately after capture for further processing. In the coastal region of Bangladesh, Estuarine Set Bag net (ESBN), Marine Set Bag net (MSBN), long lining and gill net fishing provide major raw materials for production of traditional dried fish products[1]. Mechanized boats having sufficient amount of ice in the fish hold of the vessel continue to catch fish and store in ice on board of the vessel in the sea for 3-10 days trips and then return to the landing centers with sufficient quantities of fish. These fishes are mostly used as raw materials for preparation of dried fish products by the small-scale fishing communities in the coastal belt of Bangladesh.

After landing in the landing centers, the catch also passes through different marketing chains[2] and the time required to reach the destination varies widely according to location but it often takes a considerable portion of the normal shelf life of a tropical fish species. There are frequent complains about the quality of dried products prepared from various days of ice stored raw materials[3, 4]. It is well known that the final quality of any product largely depends on the quality of raw materials, where once the quality of raw materials deteriorates there is no way of improving the quality by any means of preservation. There is little or no information available about the duration of ice storage on raw materials for the

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production of quality dried products although there are a number of factors that influence the quality of the fish in which includes species variation, method of fishing, handling, transportation and preservation. It is important to know how long each species of fish can be kept in acceptable conditions in ice for the production of high quality dried products for developing effective marketing infrastructure and facilities.

The present research was therefore, designed to evaluate influence of ice storage on raw material for the production of high quality dried products.

MATERIALS AND METHODS

Fresh fish samples of silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish were obtained from the nearby private landing centre at Kutubdiapara and landing centre of Bangladesh Fisheries Development Corporation (BFDC) at Cox's Bazar in several lots during the period of October to November 2001. About 40 kg of each species of fish were collected and transported to the yard of Marine Fisheries and Technology Station (MFTS) of Bangladesh Fisheries Research Institute (BFRI), Cox's Bazar in ice in an insulated box. Fresh commercial block ices after crushing into small pieces were used for chilling the fish samples immediately after collection from the landing centres. The fishes were kept in the insulated box containing ice and fish at 1:1 ratio. The icebox had a number of holes at the bottom to drain out the melted water. The ice was replenished every alternate day until termination of the experiment. The fish samples were stored in ice for 13 days and during storage period required quantity of fish samples were taken out after every three days for drying in the solar tunnel dryer.

Fish drying experiment was conducted in a Hohenheim type solar tunnel dryer[1,5] installed at the Marine Fisheries and Technology Station of the Bangladesh Fisheries Research Institute, Cox's Bazar. The degree of freshness of ice stored raw materials and dried products produced from varying days of ice stored raw materials was determined by organoleptic, biochemical and bacteriological aspects.

Organoleptic quality assessment: Sensory methods were used to assess the degree of freshness of fresh fish/raw materials based on organoleptic characteristics such as odour, colour, general appearance, eyes, slime and consistency of flesh. The organoleptic characteristics were judged by trained panel members and the changes in quality of ice stored fish were assessed at 3 days interval. The grading of fish using score on the characteristics has been followed by EC freshness grade for fishery products with slight modification[6] to judge the quality of the fish.

The grading of dried fish was done using score on the characteristics following the guideline of Fish Inspection and Quality Control (FIQC) of the Department of Fisheries (DoF), Government of The Peoples' Republic of Bangladesh.

CHEMICAL METHODS

Determination of moisture content: Moisture content was determined by air drying of a given sample in a thermostat oven (Gallenkamp, HOTBOX, Model OVB-306) at 105°C for 24 hours until constant weight[7].

Biochemical analysis: The lipid fraction of both fresh and dried fish was extracted separately according to Bligh and Dyer[8] method and the peroxide value (PV) was determined according to the method described by Lima Dos Santos[9]. Total volatile base nitrogen (TVB-N, mg N per 100 g) values were determined as described by Antonacopoulos and Vyncke[10].

Aerobic plate count (APC): About 10-15 g of fish sample was blended with appropriate volume of 0.2% peptone water in a sterilized blender for few minutes until a homogenous slurry was obtained. Total Aerobic Plate Count (APC) expressed as colony forming units per gram of muscle (CFU g^{-1}) of the representative samples was determined by standard plate count methods on plate count agar (Hi-media, India) according to Collins and Lyne[11].

RESULTS AND DISCUSSION

Sensory analysis: The changes in quality of chilled fish during storage were assessed by daily organoleptic assessment. The quality of fish was graded using the scores from 1-5. On the basis of the scores, all the fish samples were found in acceptable condition up to 10 days in ice storage before it became inedible (Table 1A). All the fish samples exhibited excellent quality during the first 3 days of ice storage on the basis of organoleptic characteristics scores. The organoleptic characteristics of quality changes occurred during storage period can be roughly divided into four phases corresponding to periods of 0 to 3, 4 to 6, 7 to 9 and 10 to 13 days in ice. In the phase 1, the fishes were very fresh with species-specific taste and natural flavour and odour. At this stage all the samples of the five species had the characteristics of freshly caught fish. In phase 2 on 4 days of ice storage, there was little deterioration apart from some slight loss of natural flavour and characteristics odour. In phase 3, there was slight dullness with sour off-flavour. In phase 4 on 13 days of ice storage, the fish begins to taste stale and begins to show obvious signs of spoilage and the bleached gills and belly cavity had an unpleasant smell. The result obtained from the present study reveals that most of the fish species were found in acceptable condition up to 10 days of ice storage, although there are a number of factors that influence the quality of the fish in which species variation, method of fishing, handling and transportation are the most important. The results obtained in the present study are in agreement with those reported for other commercial fish species where the fish samples were found in acceptable condition for 2-3 weeks[12, 13].

Dried fish products were also prepared using various days of ice stored raw materials in a solar tunnel dryer. The organoleptic characteristics of dried fish products such as colour, odour/smell, texture, infestation by insects and presence of broken pieces were judged by the panel members (Table 1B). Excellent quality of dried products having attractive colour, characteristic odour with firm texture, no infestation and no broken pieces were obtained from the raw materials stored up to 3 days in ice. The dried products produced using 10 days ice stored fishes were also found acceptable quality for consumption. However, the products prepared from 13 days of ice stored fishes were poor in quality due to dark brown colour, rancid odour, fibrous texture and presence of some broken pieces.

Chemical analysis: The initial moisture content of 1 day ice stored fishes was in the range of 70.5 to 89.1% with the lowest value in Chinese pomfret and the highest in Bombay duck (Table 2, left panel). There was little change in moisture content of fish samples stored even up to 13 days in ice having a value of 72.1% in Chinese pomfret to 90.7% in Bombay duck. Slight variation might be due to individual species variation or slightly intake of moisture from melted ice during ice storage. The moisture contents of dried products prepared from various days of ice stored fishes were in the range of 15.9 to 16.2%, which is regarded as standard moisture content for most of the dried food products[14].

TVB-N is generally used for the determination of the degree of freshness level during the storage period[15,16]. The initial TVB-N values of the raw fish samples was in the range of 2.37 to 5.15 mg N $(100\ g)^{-1}$ with the lowest in Chinese pomfret and the highest in ribbon fish. During ice storage, the TVB-N values increased considerably and at the end of the 13 days of storage the values increased to over 30 mg N $(100\ g)^{-1}$ in all samples which were beyond the acceptable level for chilled fish. According to Connell[17], the value of 35 to 40 mg N $(100\ g)^{-1}$ TVB-N are regarded as a limit beyond which whole chilled fish can be considered spoiled for most uses. In the present study the TVB-N values of 10 days of ice stored samples were within the acceptable limit of 30 mg N $(100\ g)^{-1}$ TVB-N as suggested by many researchers[16,18].

As shown in right panel of the Table 2, the TVB-N content of the dried products produced from 1 day ice stored samples were in the range of 1.9 to 5.1 mg N $(100\ g)^{-1}$ and was found the lowest in Bombay duck and the highest in ribbon fish. On the other hand, longer period of the raw materials stored in ice led to increased TVB-N values in the final dried products. The dried products produced from 10 days of ice stored samples had TVB-N values ranging from 21.3 in Bombay duck to 30.0 mg N $(100\ g)^{-1}$ in big-eye tuna which were within the range of acceptable limit for dried fish products[19]. The TVB-N values of the dried products produced using 13 days ice stored raw materials were in the range of 30 to 36.3 mg N $(100\ g)^{-1}$, the values which are quite high, although within the acceptable limit.

Volatile bases (ammonia, mono-, di- and tri-methyleamines) are of minor significance in muscle of living fish but most important to fish handling, as they are found in the common pattern of spoilage. Volatile bases other than TMA are formed during spoilage. One point must be stressed upon that, during drying a considerable quantity of volatile bases, especially ammonia arising mainly by bacterial action, has a chance to escape. This reflects in decreased TVB-N values. Obviously the values obtained give no clue as to how much ammonia was formed and how much was lost. Sen[19] reported that TVB-N value of the sun dried fish product varied from 32.5 to 41.0 mg N $(100\ g)^{-1}$. On the basis of the TVB-N values, the dried products produced from 10 days ice stored raw materials were found acceptable.

Table 2 also shows the Peroxide Value (PV) of fresh silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish and their corresponding solar tunnel dried products. For the ice stored fresh fish samples, the initial peroxide values were below 5 m eq kg^{-1} oil (units are mL of 0.002 N sodium thiosulfate required to titrate the iodine liberated from 1 g fat extracted from fish) which increased gradually with the lapse of storage period. Many workers suggested that peroxide value gives a measure of the first stages of oxidative rancidity which does not necessarily correlate well with the sensory assessment of rancidity. However, the value above 20 m eq kg^{-1} oil, the fish will probably smell and taste rancid. At the end of 13 days of storage,

Table 1A: Organoleptic quality aspects of ice stored raw materials

Storage period of raw material in ice	Fresh fish sample Odour of neck when broken	Odour of gills	Colour of gills	General appearance	Eye	Consistency of flesh	Defect points	Overall quality
Day 1	Natural fishy odour	Natural odour	Bright red gills	Full bloom; bright; shining; iridescent	Convex, transparent eye cap	Firm and elastic	1.25 to 2.20	Excellent
Day 4	Natural odour	Natural odour	Slightly pinkish gill	Bright, shining skin	Slightly plane eye	Some loss of elasticity	2.21 to 2.41	Acceptable
Day 7	Slightly sour odour	Faint sour odour	Pink gill	Slight dullness and loss of bloom	Concave eye cap	Some softening of flesh	2.90 to 3.98	Acceptable
Day 10	Slightly sour odour	Slight moderate sour odour	Brown or gray gills	Loss of bloom of skin	Concave eye cap	Some softening of flesh	3.45 to 4.52	Acceptable
Day 13	Faint or sour odour	Strong sour odour	Bleached gills	Dull, no bloom	Sunken eye with slime	Lump flesh	5.0	Rejected

Table 1B: Organoleptic quality aspects of corresponding solar tunnel dried fish products

Storage period of raw material in ice	Solar tunnel dried fish sample Colour	Odour	Texture	Infestation	Broken pieces	Defect point	Overall quality
Day 1	Like as fresh fish	Characteristic fishy odour	Flexible and firm	No infestation by insects	Nil	1.0 to 1.41	Excellent
Day 4	Slight browning	Slight off odour	Slightly soft	No infestation	Nil	2.1 to 2.41	Excellent
Day 7	Brownish	Slight rancid	Slightly fibrous	No infestation	Nil	2.9 to 3.98	Good
Day 10	Dark brown	Slightly rancid	Slightly fibrous	No infestation	Nil	3.5 to 4.0	Acceptable
Day 13	Dark brown	Rancid	Fibrous	No infestation	Some broken pieces	5	Rejected

Table 2: Biochemical and microbiological quality aspects of ice stored raw materials and the corresponding solar tunnel dried fish products

Storage period of raw material in ice	Fresh fish Moisture (%)	TVB-N value (mg 100 g^{-1})	Peroxide value (m.eq per kg oil)	APC (CFU g^{-1})	Dried fish sample Moisture (%)	TVB-N (mg 100 g^{-1})	Peroxide (m.eq per kg oil)	APC (CFU g^{-1})
Day 1	70.5 to 89.1	2.37 to 5.15	1.27 to 2.81	2.75×10^2 to 2.0×10^3	15.9 to 16.0	1.90 to 5.1	3.9 to 12.1	8.0×10^2 to 5.4×10^4
Day 4	-	6.72 to 11.69	2.96 to 7.96	3.0×10^3 to 7.5×10^4	16.0 to 16.2	4.2 to 13.2	7.5 to 14.25	2.2×10^3 to 12.1×10^4
Day 7	71.1 to 90.5	13.16 to 19.28	4.97 to 11.63	2.25×10^5 to 4.8×10^5	16.1 to 16.4	8.9 to 15.2	11.4 to 18.8	2.6×10^4 to 6.0×10^5
Day 10	-	22.91 to 29.33	13.26 to 28.53	3.1×10^5 to 9.8×10^7	16.1 to 16.2	21.3 to 30.0	14.8 to 20.2	1.8×10^5 to 2.5×10^6
Day 13	72.1 to 90.7	36.26 to 38.26	22.89 to 34.25	1.65×10^8 to 4.3×10^9	15.13 to 16.18	30.0 to 36.3	21.4 to 29.5	2.0×10^6 to 4.2×10^7

the peroxide value of the fresh chilled fishes exceeded to above 20 m eq kg^{-1} oil in all the fresh fish samples which is much more than the suggested value of 10-20 by Connell[17]. The dried product produced from 1 day ice stored samples had peroxide value ranging from 3.9 to 12.1 m eq kg^{-1} oil with the lowest in ribbon fish and the highest in big-eye tuna, respectively. The table also shows that, with the increasing period of ice storage of raw materials in all samples, the peroxide values of their corresponding dried products increased and finally reached values of 21.4 to 29.5 m eq kg^{-1} oil, with the lowest in silver jew fish and the highest in Chinese pomfret, respectively when 13 days ice stored raw materials were used to produce solar tunnel dried products. As shown in the Table, it was observed that peroxide values of dried fish which were produced from 10 days ice stored raw materials were within the acceptable limit, whereas those produced from 13 days ice stored raw materials exceeded much above the acceptable recommended limit as suggested by Connell [20].

Aerobic plate count (APC) of 1 day ice stored raw materials was in the range of 2.75×10^2 CFU g^{-1} in silver jew fish to 2×10^3 CFU g^{-1} in Bombay duck (Table 2, left panel). In all the fish samples, initial count showed a steady state during the first 2 to 4 days of storage and then gradually increased until the end of the experiment. At the end of the 13 days of ice storage, APC reached 10^7-10^9 CFU g^{-1} with minimum of 2.3×10^7 CFU g^{-1} in ribbon fish and maximum of 4.3×10^9 CFU g^{-1} in big-eye tuna (not mentioned in the table), which exceeded the acceptable limit of 10^7 CFU g^{-1}[21]. The dried products of different fish species produced from the 1 day ice stored samples had APC ranging from 8.0×10^2 to 5.4×10^4 CFU g^{-1} with the lowest in Chinese pomfret and the highest in big-eye tuna, respectively (Table 2, right panel). Like TVB-N and peroxide value, with the increase in storage period of the raw materials in ice, the corresponding bacterial loads of the dried products also increased considerably. The products produced from 13 days of ice stored samples contains bacterial loads of 2.0×10^6 to 4.2×10^7 CFU g^{-1} with the lowest value in ribbon fish and the highest in big-eye tuna, respectively, which is considered as the level of unacceptability for dried fish products set by the Fish Inspection and Quality Control (FIQC) of the Department of Fisheries (DoF), Government of the Peoples' Republic of Bangladesh.

CONCLUSIONS

On the basis of organoleptic characteristics, biochemical and bacteriological evaluation, five commercially important marine fish species such as silver jew fish, Bombay duck, big-eye tuna, Chinese pomfret and ribbon fish can be stored in ice for up to 10 days and subsequently can be used as raw material for the production of good quality dried products in a solar tunnel dryer. The dried fish products produced from good quality raw materials possesses the characteristic fish odour, with flexible texture and ultimately help the dry fish producers to get higher market price for their products.

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