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Shelf-life of rotary and solar tunnel dried SIS products under different packaging and storage conditions

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Abstract
A study was conducted on the shelf-life of rotary and solar tunnel dried SIS products under different packaging and storage conditions. Organoleptically dried products were found in good condition after a storage period of 60 days in ambient and chilled conditions. The moisture content, TVB-N value and bacterial load slightly increased during 60 days of storage in ambient and chilled conditions. The changes in moisture content and bacterial load were faster in ambient temperature than in chilled storage condition whereas changes in TVB-N value was higher in chilled condition than in ambient temperature. The initial moisture content was in the range of 13.71% to 22.84%. After 60 days of storage in ambient and chilled condition the moisture content of dried products was in the range of 15.09% to 25.11% and 14.49% to 25.01%, respectively. The initial TVB-N value was in the range of 10.64 to 17.52 mg/100g and after 60 days of storage in ambient and chilled condition, TVB-N value was in the range of 29.00 to 34.82 mg/100g and 31.41 to 39.11 mg/100g, respectively. The initial bacterial load was in the range of 1.91×10^8 to 2.84×10^8 and after 60 days of storage in ambient and chilled condition, the bacterial load was in the range of 6.2×10^8 to 1.8×10^9 and 5.75×10^7 to 5.05×10^8 CFU/g, respectively. The results of the present study indicated that it is necessary to store high quality dried products in sealed packed in chilled condition to ensure good quality up to a certain period of time.

Key words: SIS, Dried products, Shelf-life, Packaging, Storage

Introduction

Sun drying of fish is considered as traditional and low cost method of fish preservation. About 20% of the artisanal catch of our country is being sun dried by traditional process and consumed mostly in the internal domestic markets (Coulter and Disney 1987). About 97% of the traditional dried fish is marketed for national consumers while the remaining 3% is exported (Kleih 2001). But the traditional dried fish products available in the markets are not satisfactory for human consumption due to poor physical and organoleptic qualities (Kamruzzaman 1992, Khan 1992, Saha 1999, Reza *et al.* 2005). The problem markedly evident with traditional dried products is the contamination during different stages of handling due to lack of proper packaging. Solar drying of fish

may be considered as an alternative to sun drying although this method has some drawbacks like outdoor drying process. On the other hand, rotary dryer may be used to overcome the limitations of solar drying. In an attempt to produce improve quality dried products a study was conducted on rotary and solar tunnel drying of some Small Indigenous Species of fishes (SIS) and high quality dried SIS products with excellent sensory and physical properties were obtained from both sources. Now it is very important to observe the shelf-life of rotary and solar tunnel dried SIS products although the shelf-life of dried products largely depends on various parameters: water activity (a_w), air humidity, temperature, exposure to oxygen, use of preservatives and infestation by insects. But little information is available on shelf-life of dried products under various packaging and storage conditions. The present study was conducted to observe how long these dried SIS products could be kept in acceptable condition under different packaging and storage conditions.

Materials and methods

Dried samples of three small indigenous species of fish namely Mola (*Amblypharyngodon mola*), Tengra (*Mystus vittatus*) and Katchki (*Corica soborna*) produced in rotary dryer and solar tunnel dryer were used for investigation. These samples were packed in sealed transparent polyethylene bags of 120μm and 80μm density (Plate 1 to 3) and stored in ambient atmospheric temperature and chilled condition for 60 days. The quality of dried samples was examined with 20 days time interval by determining the organoleptic, biochemical and bacteriological aspects. For preparation of samples, whole dried fish samples were ground in an electric blender to produce a homogenous one before being sampled for analysis.

Plate 1. Transparent 80μm polyethylene

Plate 2. Transparent 80μm polyethylene

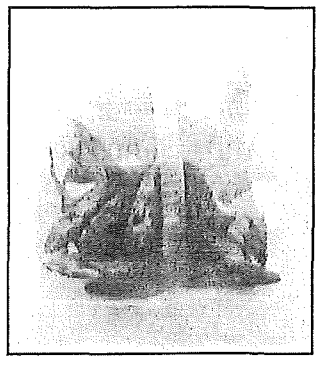

Plate 3. Transparent120μm polyethylene

Organoleptic quality evaluation

The organoleptic quality evaluation method used in this study was based on the method currently used by Fish Inspection and Quality Control (FIQC) of Department of

Fisheries (DoF), Ministry of Fisheries and Livestock, Government of Bangladesh with slight modification. The organoleptic and physical characteristics like colour, odour, texture, broken pieces and insect infestation were evaluated by 4 member panel of experts constituted in the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh.

Biochemical analysis

Moisture content

Moisture content was determined by placing an accurately weighed 2 g ground sample in a pre-weighed porcelain crucible in a thermostat oven (Gallenkamp, HOTBOX, Model OVB-306) at 105°C for 24 hours until constant weight was obtained. The loss of moisture was calculated as percent moisture.

Total Volatile Base Nitrogen (TVB-N)

Samples were taken at 20 day interval for evaluation of TVB-N value. Total Volatile Base Nitrogen (TVB-N) was determined according to the method described in European Commission (EC 1997).

Total bacterial count

Studies were also conducted on the total bacterial count at 20 day intervals. The total aerobic plate count expressed as colony forming unit per one gram (CFU/g) of the representative samples were determined by standard plate count method on plate count agar following the dilution technique described by Seeley and Vandemark (1972).

Results and discussion

The storage life of dried samples of three species of SIS namely Mola (*A. mola*), Katchki (*C. soborna*) and Tengra (*M. vittatus*) produced in solar tunnel dryer and rotary dryer investigated under different density of polyethylene bags and different storage conditions are presented in Table 1.

The quality of these fish products produced in solar tunnel dryer and rotary dryer were found in good condition for storage up to 60 days determined by the organoleptic, physical and biochemical aspects irrespective of packaging materials and storage conditions. This finding is in agreement with those reported for marine dried fish products of Silver Jew fish (*Johnius argentatus*), Bombay duck (*Harpodon nehereus*) and Ribbon fish (*Trichiurus haumela*) under different density of polyethylene packaging materials during 90 days of storage in room condition (Reza 2002, Mehbub 2004).

Table 1. Overall quality of dried SIS products after storage under different packaging conditions

Packaging materials	Name of SIS		Storage period	Overall quality
Transparent polyethylene 80μm	Mola	RR	60 days	Good
		RS		
		SD		
	Katchki	RR		
		RS		
		SD		
	Tengra	RR		
		RS		
		SD		
Transparent polyethylene 120μm	Mola	RR	60 days	Good
		RS		
		SD		
	Katchki	RR		
		RS		
		SD		
	Tengra	RR		
		RS		
		SD		

* RR- Rotary dryer in room condition, RS- Rotary dryer under sunlight, SD- Solar tunnel dryer

Changes in organoleptic characteristics

The organoleptic and physical characteristics of the rotary and solar tunnel dried products such as colour, texture, insect infestation, presence of broken pieces and overall quality were examined at regular interval to observe the changes in organoleptic characteristics which are summarized in Table 2. It was found that the rotary and solar tunnel dried Mola, Tengra and Katchki had characteristic fishy odour, whitish colour, firm and flexible texture. There was no insect infestation around the products and no broken pieces in freshly dried condition with excellent overall quality. The overall quality of these fishes is more or less similar to that of solar dried Silver Jew fish (*Johnius argentatus*), Bombay duck (*Harpodon nehereus*) and Ribbon fish (*Trichiurus haumela*) reported by Mehbub (2004), where excellent products were produced without any infestation with firm and flexible texture and natural odour.

The overall organoleptic characteristics of rotary and solar tunnel dried Mola, Tengra and Katchki in sealed packed condition up to 20 days of storage in ambient temperature and chilled condition was found to be excellent where the colour of dried fishes were whitish with very little difference among three fish species. Texture was firm and flexible and odour was natural in every cases. After 40 days of storage, the colour became whitish to slight brownish with excellent overall quality. But after 60 days of storage the colour became brownish with rancid odour, firm and flexible texture, no insect infestation and no broken pieces around the products. The overall quality of the

Table 2. Organoleptic quality assessment for rotary and solar tunnel dried SIS products under different packaging and storage conditions

Stored in sealed packed condition at ambient temperature					Stored in sealed packed in chilled condition		
Storage period (days)	Fish	Characteristics (Colour, odour, texture, broken pieces)	Infestation	Overall quality	Characteristics (Colour, odour, texture, broken pieces)	Infestation	Overall quality
1	Mola (RR, RS, SD), Katchki (RR, RS, SD), Tengra (RR, RS, SD)	Characteristic whitish colour like fresh fish, good fishy odour, firm and flexible, no broken pieces	No insect infestation	Excellent	Characteristic whitish colour like fresh fish, good fishy odour, firm and flexible, no broken pieces	No insect infestation	Excellent
20		Like fresh fish, good fishy odour, firm and flexible; no broken pieces	No insect infestation	Excellent	Like fresh fish, good fishy odour, firm and flexible, no broken pieces	No insect infestation	Excellent
40		Slight brownish with slight rancid odour, firm and flexible, no broken pieces	No insect infestation	Excellent	Slight browning, slight rancid odour, firm and flexible, no broken pieces	No insect infestation	Excellent
60		Brownish colour, slight rancid odour, firm and flexible texture, no insect infestation	No insect infestation	Good	Brownish colour, rancid odour, firm and flexible, no insect infestation	No insect infestation	Good

* RR-Rotary dryer in room condition, RS- Rotary dryer under sunlight, SD- Solar tunnel dryer

products was considered good by the panel of experts after 60 days of storage. During the investigation no significant changes in organoleptic characteristics were noticed between the products from rotary and solar tunnel dryer. No significant effect of packaging materials of different densities was observed during the study period.

The changes of colour from whitish to brownish may be due to lipid oxidation during the storage period. Dried products from rotary dryer were found more susceptible to lipid oxidation due to the action of wind over these products during the drying process. Lipid oxidation may also take place due to the presence of oxygen inside the polyethylene bags as these bags were not sealed in vacuum condition. The results obtained from this study is more or less similar to those reported for marine dried products of Silver Jew fish (*Johnius argentatus*), Bombay duck (*Harpodon nehereus*) and Ribbon fish (*Trichiurus haumela*) under different density of polyethylene packaging materials during 90 days of storage (Islam 2004, Mehbub 2004).

Changes in moisture content

The changes in the moisture content of rotary and solar tunnel dried SIS products in packaging condition during 60 days of storage in ambient temperature and chilled condition are presented in Table 3 and Figs. 1 and 2, respectively. The initial moisture content was in the range of 13.71% to 22.84% with high moisture content in Tengra dried in rotary dryer under direct sunlight and low in Mola dried in solar tunnel dryer. The initial moisture content increased slightly with the lapse of storage time in ambient temperature and at the end of 60 days the moisture content reached to a range of 15.09% to 25.11% with highest value in Tengra dried in rotary dryer in room condition and lowest in Mola dried in solar tunnel dryer. On the other hand, after 60 days of storage the moisture content of the dried products stored in chilled condition was in the range of 14.49% to 25.01% with highest moisture content in Tengra dried in rotary dryer under room condition and lowest in Mola dried in solar tunnel dryer.

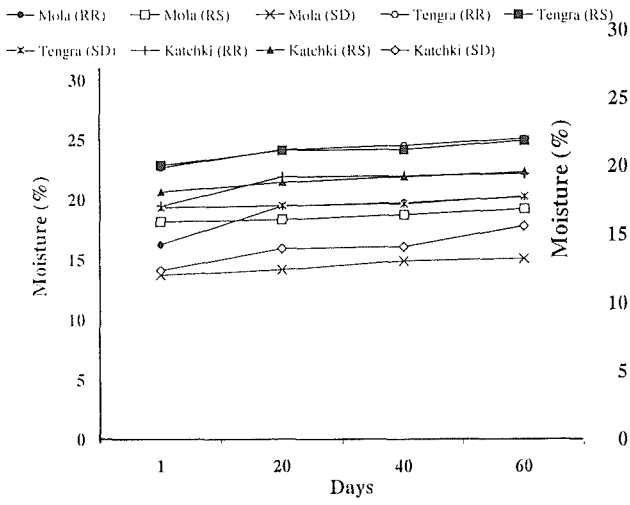

Fig. 1. Changes in moisture content of dried SIS products stored in ambient temperature

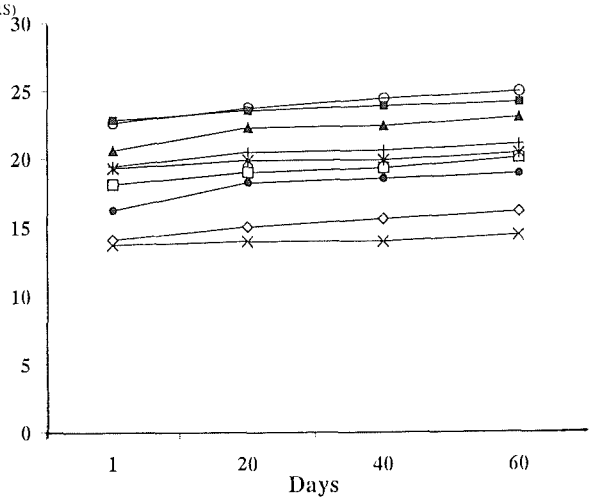

Fig. 2. Changes in moisture content of dried SIS products stored in chilled condition

Table 3. Changes in moisture content of dried SIS products with time of storage

Name of the sample		1st day	20th day		40th day		60th day	
			Ambient	Chill	Ambient	Chill	Ambient	Chill
Mola	RR	16.23	19.44	18.27	19.74	18.59	20.21	18.97
	RS	18.13	18.32	19.03	18.72	19.36	19.21	20.13
	SD	13.71	14.15	13.98	14.87	14.01	15.09	14.49
Tengra	RR	22.63	24.16	23.75	24.51	24.46	25.11	25.01
	RS	22.84	24.09	23.56	24.17	23.92	24.93	24.22
	SD	19.30	19.48	19.90	19.63	19.94	20.27	20.47
Katchki	RR	19.44	21.89	20.50	21.96	20.65	22.14	21.14
	RS	20.62	21.42	22.31	21.88	22.47	22.31	23.10
	SD	14.08	15.91	15.04	16.06	15.65	16.79	16.19

* RR- Rotary dryer in room condition, RS- Rotary dryer under sunlight, SD- Solar tunnel dryer

The initial moisture content of Tengra dried in rotary dryer and solar tunnel dryer was slightly higher than the recommended level. The initial moisture content of dried Tengra was high because of high fat content and there is strong relationship between fat and moisture content of fish. The initial moisture content may also be high due to thickness of skin and muscles. After 60 days of storage, moisture content of Mola and Katchki was in the range of 14.49% to 20.21% and 16.19% to 23.10%, respectively which was slightly higher than the recommended limit of 16% for dried fishery products but this change may be considered as negligible in respect to the initial moisture content of the dried products.

The changes in moisture content were high in dried products from rotary dryer. This is probably due to the high water uptake properties of dried products from rotary dryer. Changes in moisture content of dried SIS products are irrespective of packaging materials used in this study. On the other hand, changes in moisture content was high in products stored in ambient temperature than those stored in chilled condition almost in every case. This may be due to controlled atmosphere and humidity level in chilled storage condition.

Changes in TVB-N and APC of rotary and solar tunnel dried SIS products

The changes in Total Volatile Base Nitrogen (TVB-N) and Aerobic Plate Count (APC) of rotary and solar tunnel dried SIS products under different packaging and storage conditions are presented in Table 4 and Figs. 3 and 4, respectively. There was little or no difference in TVB-N value and APC within dried Mola, Tengra and Katchki fish species packed under various polyethylene densities. But variation was observed in TVB-N value and APC in products during storage period.

Table 4. Total Volatile Base Nitrogen (TVB-N) of rotary and solar tunnel dried SIS products under different storage conditions

Name of the sample		1st day	20th day		40th day		60th day	
			Ambient	Chill	Ambient	Chill	Ambient	Chill
Mola	RR	10.64	19.08	19.55	21.66	23.52	32.48	38.64
	RS	13.80	21.34	19.46	25.11	23.94	34.82	34.33
	SD	15.68	18.00	20.28	24.78	25.69	31.20	37.5
Tengra	RR	16.52	19.30	22.38	27.69	28.96	33.8	39.11
	RS	17.52	20.14.	23.06	25.04	31.03	34.61	38.08
	SD	14.38	17.02	21.01	28.28	29.18	32.06	37.39
Katchki	RR	14.52	18.50	20.50	27.88	26.32	29	31.41
	RS	13.52	18.48	20.21	26.67	24.78	32.11	36.66
	SD	14.34	16.80	21.42	24.5	27.41	29.73	34.92

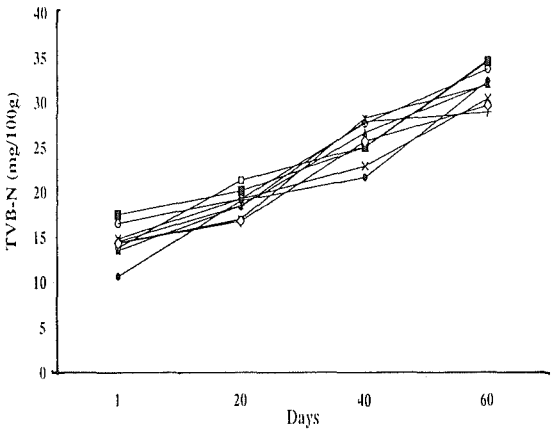

Fig. 3. Changes in TVB-N value of dried SIS products stored in ambient temperature
Fig legend same as Fig. 1 and Fig. 2

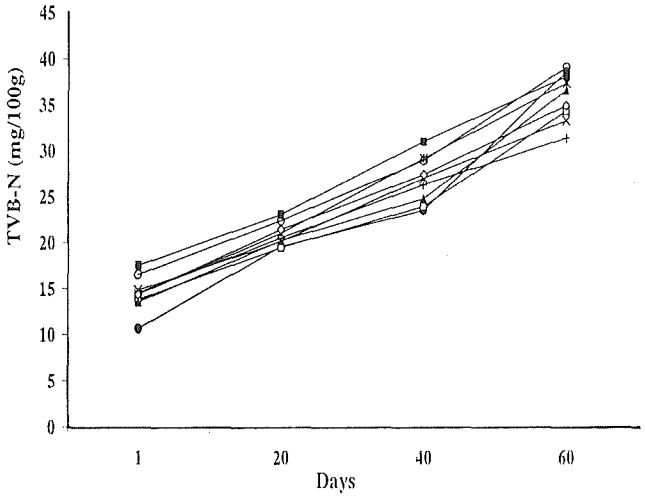

Fig. 4. Changes in TVB-N value of dried SIS products stored in chilled condition

The initial TVB-N value of the dried fish products from rotary dryer and solar tunnel dryer was in the range of 10.64 mg/100g to 17.52 mg/100g with the lowest value for Mola dried in rotary dryer in room condition and the highest value for Tengra dried in rotary dryer under direct sunlight. The TVB-N value increased slowly during the storage period and after 60 days of storage in ambient temperature, the values were in the range of 29 mg/100g to 34.82 mg/100g with the highest value for Mola dried in rotary dryer under sunlight and lowest value for Katchki dried in rotary dryer in room condition. The TVB-N value increased in dried products stored in chilled condition during 60 days of storage with the highest value of 39.11mg/100g for Tengra dried in rotary dryer in room condition and lowest value of 31.41mg/100g for Katchki dried in rotary dryer in room condition. But these values were much lower than the

recommended value of 100-200 mg/100g for variety of dried and salted fish products (Connell 1995).

Studies were also conducted on the bacterial load of the dried products during 60 days of storage under different temperature and packaging conditions and the results are presented in Table 5. The initial APC was in the range of 1.91×10^8 CFU/g to 2.84×10^8 CFU/g with the highest value for Tengra dried in rotary dryer under direct sunlight and the lowest value for Mola dried in rotary dryer in room condition. The bacterial load increased slowly with the lapse of storage time and after 60 days of storage in ambient temperature the bacterial load increased to in the range of 6.2×10^8 to1.8×10^9 CFU/g with the highest value for Tengra dried in rotary dryer under sunlight and the lowest value for Katchki dried in solar tunnel dryer, respectively.

Table 5. Aerobic plate count (APC) of rotary and solar tunnel dried SIS products under different storage conditions

Name of the sample		1st day	20th day		40th day		60th day	
			Ambient	Chill	Ambient	Chill	Ambient	Chill
Mola	RR	1.91×10^8	2.50×10^8	4.32×10^7	7.30×10^8	7.95×10^7	9.1×10^8	9.35×10^7
	RS	2.55×10^8	3.54×10^8	3.78×10^7	5.30×10^8	1.18×10^8	9.2×10^8	5.05×10^8
	SD	2.16×10^8	2.69×10^8	5.36×10^7	8.25×10^8	7.65×10^7	9.21×10^8	9.5×10^7
Tengra	RR	2.04×10^8	2.72×10^8	3.46×10^7	7.25×10^8	7.81×10^7	9.54×10^8	9.05×10^7
	RS	2.84×10^8	3.33×10^8	4.74×10^7	9.20×10^8	9.88×10^7	1.8×10^9	1.77×10^8
	SD	2.59×10^8	2.74×10^8	2.70×10^7	9.05×10^8	4.05×10^7	1.3×10^9	5.75×10^7
Katchki	RR	2.33×10^8	2.38×10^8	2.92×10^7	7.52×10^8	8.60×10^7	9.2×10^8	9.55×10^7
	RS	2.06×10^8	2.46×10^8	2.71×10^7	8.60×10^8	5.34×10^7	9.87×10^8	7.71×10^7
	SD	2.08×10^8	2.16×10^8	2.34×10^7	4.75×10^8	7.05×10^7	6.2×10^8	8.05×10^7

* RR- Rotary dryer in room condition, RS- Rotary dryer under sunlight, SD- Solar tunnel dryer

On the other hand, the initial bacterial load decreased in the dried products stored in chilled condition. After 60 days of storage the bacterial load was in the range of 5.75×10^7 to 5.05×10^8 CFU/g with the highest value for Mola dried in rotary dryer under sunlight and the lowest value for Tengra dried in solar tunnel dryer, respectively.

The initial bacterial load was very high in dried products. This may be due to the presence of large quantity of spore forming bacteria on the raw materials used for drying or may be due to the extreme contamination of the raw materials. The raw materials were collected from local markets in the winter season. During this time of the year most of the water bodies dries up resulting in high bacterial load in the fish body. This may be one of the reasons why the initial bacterial load was very high. Another reason is that whole dried fishes were ground for evaluation of bacterial load. It is well known that the bacterial load is high in the intestinal and head region, which may contribute to the higher bacterial load during initial investigation.

Considering the organoleptic characteristics and biochemical aspects, it is quite clear that the dried SIS products stored in sealed packet remain in good condition for certain period of time. The present study revealed that chilled storage condition results in longer shelf-life of dried fish products by minimizing the moisture regain in sealed

packed condition and by minimizing the initial bacterial load because due to cold shock where most of the mesophilic bacteria are dried in chilled condition. However, the present study indicated that it is necessary to store high quality dried products in sealed packed in chilled condition to ensure good quality up to a certain period of time.

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