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Quality assessments of traditional, rotary and solar tunnel dried small indigenous fish products

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Abstract

Studies on the quality assessments of three traditional, rotary and solar tunnel dried SIS products were conducted. Organoleptic quality of traditional dried SIS products available in the markets was poor compared to those produced in rotary and solar tunnel dryer. Reconstitution of samples were in the range of 54.26% to 75.24%, 69.37% to 83.73% and 55.08% to 80.24% when soaked at 80°C for traditional, rotary and solar tunnel dried products, respectively. The percentage of reconstitution increased with the increase of soaking time and the uptake of water was maximum after 60 min of soaking. The moisture contents of traditional, rotary and solar tunnel dried products were in the range of 26.02% to 27.33%, 16.23% to 22.84% and 13.71% to 19.30%, respectively. The protein contents were in the range of 60.78% to 72.59%, 62.17% to 76.27% and 61.11% to 76.00%, respectively; lipid contents were in the range of 12.26% to 22.60%, 14.00% to 24.71% and 13.92% to 22.39%, respectively and ash contents in the range of 15.11% to 16.59%, 8.32% to 13.51% and 8.71% to 16.45%, respectively on dry matter basis. The TVB-N content of rotary and solar tunnel dried products was low compared to traditional one ranging from 10.64 to 17.52 mg/100g and 14.34 to 15.68 mg/100g, respectively whereas the TVB-N content of traditional samples was in the range of 15.46 to 20.36 mg/100g. The bacterial load of traditional, rotary and solar tunnel dried products were in the range of 1.43×10^8 CFU/g to 2.89×10^8 CFU/g, 1.91×10^8 CFU/g to 2.84×10^8 CFU/g and 1.95×10^8 CFU/g to 2.59×10^8 CFU/g, respectively. The results of the study indicated that dried fish products from rotary dryer and solar tunnel dryer were found to be of better quality in nutritional and food quality aspects than those of traditional dried products.

Key words: SIS, Traditional dried, Rotary dried, Solar tunnel dried

Introduction

Sun drying is practiced in some selected inland and coastal areas of Bangladesh and about 20% of the artisanal catch of our country is being sun dried by the traditional process (Coulter and Disney 1987). About 97% of the traditional dried fish is marketed for national consumption while the remaining 3% is exported (Kleih 2001). However drying of fish by traditional method is not hygienic and the physical and organoleptic qualities of most of the traditional sun dried products available in the market are not satisfactory for human consumption (Kamruzzaman 1992, Khan 1992, Saha 1999, Reza *et al.* 2005). Traditional dried products are often infested by insects and cause considerable loss in terms of quality and quantity of the finished products every year. To avoid insect infestation, the processors, whole sellers and retailers often use various harmful insecticides and fungicides like DDT, Nogos, Rubral etc. which was reported in a market survey in Cox's Bazar (BFRI 1998). This highly contaminated dried products creates broad spectrum of environmental and health hazards and results in the deterioration of food and nutritional quality. Rotary dryer and solar dryer may be used to alternate the traditional drying method. Solar tunnel drying can be carried out by using solar energy but it cannot be operated in bad weather conditions whereas rotary dryer can be operated in all weather conditions even in a small room. The present study was undertaken to assess the nutritional and food quality of traditional, rotary and solar tunnel dried Small Indigenous Species of fish (SIS) products.

Materials and methods

Traditional dried SIS products namely Mola (*Amblypharyngodon mola*), Tengra (*Mystus vittatus*) and Katchki (*Corica soborna*) were collected form local markets of Mymensingh town. On the other hand fresh samples of Mola, Tengra and Katchki were collected from a local market and dried in solar tunnel dryer and rotary dryer (in room condition and under direct sunlight) in the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. For preparation of samples, whole dried fish samples were ground in an electric blender to produce a homogenous powder before being sampled for analysis. Samples of each species were packed in polyethylene bags tightly using a sealer and kept for further analysis.

Organoleptic quality assessment

A large number of schemes have been proposed for sensory evaluation for various types of fish and fishery products. 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. Representative whole sample of dried products were taken on a tray to assess the organoleptic characteristics such as colour, odour, texture, broken pieces and insect infestation by 4 member panel of experts constituted in the Department of Fisheries Technology.

Physical study (Water reconstitution behaviour)

Percentage of water absorbed by dried fish at a certain temperature and time is called water reconstitution. It is one of the most important physical parameters to assess the quality of the dried products.

Five gram of fish sample was soaked in one litre of water at different temperature up to 60 minutes with occasional stirring. Water was drained off through a coarse nylon net. All the flesh was then transferred to the strainer and extraneous water was wiped off by a piece of blotting paper and flesh was weighed again. By the given soaking time, flesh could reabsorb maximum amount of water. Results in this respect have been expressed in terms of weight of water absorbed by the sample. The reconstitution behavior was measured in water at 30°C, 40°C, 60°C and 80°C temperature. Reconstitution percentage was measured at 15 minutes intervals for each temperature.

Proximate composition analysis

Proximate composition analysis of moisture, ash, lipid and crude protein were carried out according to the methods given in AOAC (1980).

Determination of Total Volatile Base Nitrogen (TVB-N)

Total Volatile Base Nitrogen (TVB-N) was determined according to the method described in European Commission (EC 1997).

Study on total bacterial count

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

Organoleptic characteristics

The organoleptic parameters such as colour, odour, texture, insect infestation, presence of broken pieces and overall quality of traditional, rotary and solar tunnel dried SIS products (Mola, Tengra and Katchki) were examined. The results on organoleptic characteristics of dried products obtained from the present study are summarized in the Table 1. The colour of the traditional dried SIS products collected from local markets was brown to dark brown with variations in colour among different species. Emission of slightly to moderately off odour and alteration in the textural characteristics of all the products was found. In traditional dried products insect infestation and presence of broken pieces were very common. The organoleptic characteristics of freshly prepared dried products were almost absent in these samples. The overall quality of these samples was not up to the mark of acceptable limit.

It was found that the colour of dried Mola, Tengra and Katchki fish produced in rotary dryer ranged from whitish to shiny whitish with little difference among the three species. Texture was firm and flexible and characteristic odour was found. No infestation or broken pieces were found around the products and the overall quality of all three dried fish products was excellent.

Table 1. Organoleptic characteristics of traditional, rotary and solar tunnel dried SIS products

Dried fish	Organoleptic characteristics		
	Traditional	Rotary dryer	Solar tunnel dryer
Mola	Slight brownish colour Slight off odour Texture somewhat soft Infested by insects Broken piece present	Whitish colour like as fresh fish Characteristic odour, like as fresh fish Firm and flexible texture No infestation No broken pieces found	Whitish to slight brownish Good fishy odour Firm and flexible texture No infestation No broken pieces found
Tengra	Dark browning Slight off odour Texture somewhat soft Infested by insects Broken piece found	Whitish colour similar to that of fresh fish Characteristic odour similar to that of fresh fish Firm and flexible texture No infestation No broken pieces found	Slight brownish colour Good fishy odour Firm and flexible texture No infestation No broken pieces found
Katchki	Slight browning Off odour Soft texture Infested by insects Broken piece present	Shiny whitish colour Characteristic odour, like as fresh fish Firm and flexible texture No infestation No broken pieces found	Shiny yellowish colour Good fishy odour Firm and flexible texture No infestation No broken pieces found
Overall quality	Poor	Excellent	Excellent

On the other hand, the colour of solar tunnel dried Mola, Tengra and Katchki was in the range of whitish to light brown colour with little difference among the three species. The odour was very natural and the textural characteristics were firm and flexible in all of the samples. The products were not infested by insects or any other means and there was no broken piece around the products. The overall quality of all the products was excellent.

Water reconstitution properties

The reconstitution properties of traditional, rotary and solar tunnel dried fish muscles was assessed at a wide range of temperature after soaking for maximum 60 min. The samples (Mola, Tengra and Katchki) were soaked in water at temperatures of 30°C, 40°C, 60°C and 80°C for one hour and the ability of the samples to absorb moisture was investigated every 15 minutes intervals.

At 30°C, the traditional dried samples showed reconstitution level in the range of 13.17% to 38.66% after 15 min of soaking with minimum in Mola and maximum in Katchki (Fig. 1). After soaking for 60 min, the reconstitution properties were in the range of 26.97% to 54.73% with minimum in Mola and maximum in Katchki (Fig. 1). On the other hand, at 40°C, the highest reconstitution properties of 40.00% and the lowest of 15.18% after 15 min of soaking was exhibited by Katchki and Mola, respectively whereas after 60 min soaking the highest of 60.25% and the lowest of 30.17% was exhibited by Katchki and Mola, respectively. Reconstitution capacity increased with increase in temperature up to 60°C. The highest reconstitution properties of 50.00% for Katchki and the lowest of 21.66% for Mola were obtained at this temperature after 15 min of soaking whereas after 60 min soaking the reconstitution properties attained in the range of 45.24% to 75.44% with minimum for Mola and maximum for Katchki. Reconstitution capacity decreased with further rising of temperature to 80°C for Katchki and Tengra fish species. At this temperature, the reconstitution of traditional dried SIS products varied from 25.75% to 55.00% after 15 min of soaking with highest values from Katchki and lowest value from Tengra whereas after 60 min soaking the highest value of 75.24% was for Katchki and the lowest value 54.26% was for Tengra at this temperature.

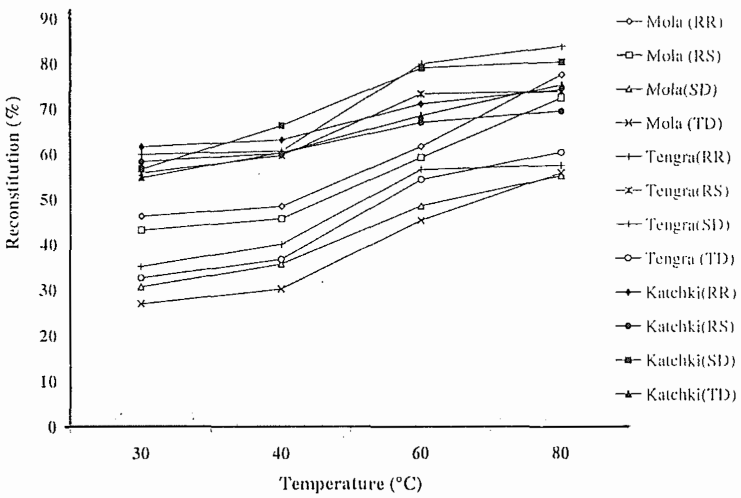

Fig. 1. Reconstitution behaviour of dried SIS after 60 min soaking at various temperature.
RR- Rotary dryer in room condition, RS-Rotary dryer under sunlight, SD- Solar tunnel dryer, TD- Traditional dried

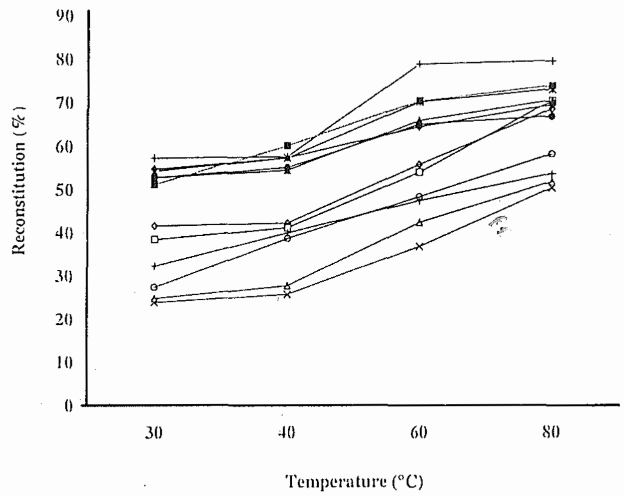

Fig. 2. Reconstitution behaviour of dried SIS after 45 min soaking at various temperature.

Reconstitution capacity of Mola, Tengra and Katchki dried in rotary dryer under room condition and direct sunlight was investigated. For the dried products produced by rotary dryer in room condition, it was found that, after 15 min of soaking at 30°C (room temperature) the reconstitution capacity ranged from 31.49% to 52.51% where minimum and maximum reconstitution were found in Mola and Tengra, respectively whereas at this temperature after 60 min of soaking the highest of 61.56% was for Katchki and the lowest of 46.22% reconstitution was for Mola. At 40°C, the reconstitution properties ranged form 34.67% to 53.65% with minimum for Mola and maximum for Tengra after 15 min of soaking whereas after 60 min of soaking the highest of 63.08% in Katchki and lowest of 48.37% in Mola were found, respectively. At 60°C, the highest reconstitution of 61.29% in Tengra and lowest reconstitution of 41.67% in Mola were found after 15 min soaking and after 60 min soaking the highest and the lowest value of 79.89% and 61.59% were found for Tengra and Mola, respectively. On the other hand at 80°C, the reconstitution capacity ranged from 50.26% to 71.11% with minimum in Mola and maximum in Tengra after 15 min of soaking whereas after 60 min of soaking the minimum value was 74.19% for Katchki and the maximum value was 83.73% for Tengra, respectively.

Investigation on reconstitution properties of dried products produced in rotary dryer under direct sunlight showed that at 30°C, reconstitution capacity ranged from 29.46% to 49.51% with minimum in Mola and maximum in Tengra after 15 min of soaking whereas after 60 min of soaking the highest value was 58.30% for Katchki and the lowest value was 43.14% for Mola, respectively. The reconstitution percentage increased with increase in temperature up to 80°C. At 40°C, the reconstitution capacity ranged from 31.78% to 51.22% where minimum and maximum reconstitution percentage was found in Mola and Tengra, respectively after 15 min soaking and after 60 min of soaking the lowest reconstitution value was attained by Mola of 45.61% and the highest value by Katchki of 60.12%, respectively. At 60°C, maximum and minimum reconstitution capacity of 55.17% and 46.92% was found in Tengra and Mola after 15 min of soaking and after 60 min of soaking the highest and the lowest reconstitution value was attained by Tengra (73.21%) and Mola (59.11%). Highest reconstitution percentage was observed at 80°C. After 15 min of soaking the lowest value of 52.47% was for Mola and the highest value of 70.17% was for Tengra. After 60 min of soaking minimum and maximum reconstitution percentage was attained by Katchki and Tengra of 69.37% and 73.68%, respectively.

For solar tunnel dried SIS products the reconstitution properties at 30°C ranged from 19.81% to 38.23% where minimum and maximum capacity were found in Mola and Katchki after 15 min of soaking, respectively. After 60 min soaking at 30°C the maximum and the minimum reconstitution percentage was attained by Katchki and Mola of 56.66% and 30.69%, respectively. The reconstitution properties of solar tunnel dried SIS products at 40°C ranged from 21.60% to 40.00% for Mola and Katchki, respectively after 15 min of soaking whereas after 60 min of soaking the minimum and the maximum value was for Mola and Katchki of 35.62% and 66.24%, respectively. At 60°C the reconstitution properties ranged from 23.85% to 52.63% where minimum and maximum capacity were attained by Mola and Katchki, respectively after 15 min of soaking whereas after 60 min of soaking the minimum and the maximum value was attained by Mola and Katchki of 48.46% and 78.94%, respectively. At 80°C the highest (55.00%) and the lowest (38.13%) reconstitution was found in Katchki and Mola after 15 min soaking whereas after 60 min of soaking the highest (80.24%) and the lowest (55.08%) reconstitution value was attained by Katchki and Mola, respectively.

A close relationship was observed between the reconstitution capacity and physical properties of the samples. The quality of the dried fish is also related to final water activity (a_w). Water activity is normally expressed as the relative availability of water in a substance. In other words a_w is the amount of water available for hydration of materials. At low a_w values, water uptake proceeds more quickly because water tends to migrate from high a_w substance to low a_w substance. In properly dried fish the water uptake is reported to be completed in 3-15 minutes (Sikorski *et al.* 1995).

Traditional dried SIS products exhibited poor rehydration properties which might be due to the denaturation of protein that took place during drying process and caused severe damage to the cellular structure in an irreversible manner. Thus proper reconstitution was impossible due to cemented and compact structure of the muscle with few interfibrillar spaces. With a tough and rubbery tissue, water penetrates mostly to the centre of large pieces by diffusion through the protein of the fibre itself and the process is very slow (Connell 1957, Sen *et al.* 1961, Lahiry *et al.* 1961).On the other hand, the rotary dryer and solar tunnel dried products exhibited an enormously rapid initial rehydration rate due to water being carried deep into the pieces by porous structure which absorbed and retained sufficient water by capillary (Jason 1965).

Considering the reconstitution ability of the dried SIS products from different sources, it can be stated that dried fish products from rotary dryer were of better quality compared to that of solar tunnel and traditional dried products because products from this source exhibited ready, rapid and maximum reconstitution properties almost in every case at various temperature and soaking period (Fig. 1 to 4).

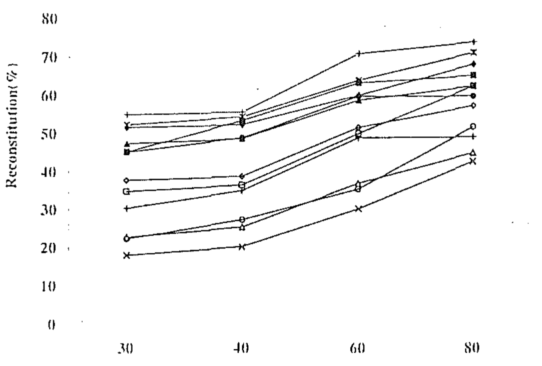

Fig. 3. Reconstitution behaviour of dried SIS dried after 30 min soaking at various temperature at various
Fig, legend same as Fig. 1 and Fig.2.

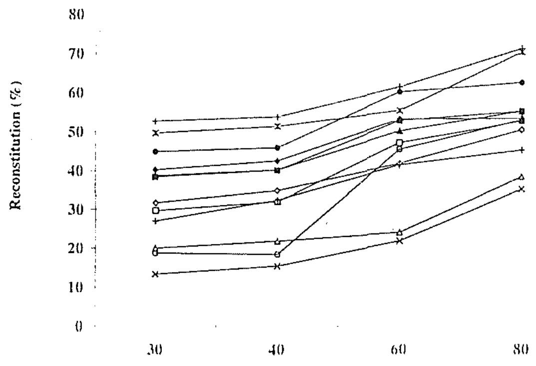

Fig. 4. Reconstitution behaviour SIS after 15 min temperature

Proximate composition of dried SIS products

Proximate composition i.e. moisture, protein, lipid and ash content of traditional, rotary and solar tunnel dried SIS products are presented in Table 2.

Table 2. Proximate composition of traditional, rotary and solar tunnel dried SIS products

Composition (%)	Drying techniques	Fish Species		
		Mola	Tengra	Katchki
Moisture	RR	16.23	22.63	19.44
	RS	18.13	22.84	20.62
	SD	13.71	19.96	14.08
	TD	26.02	26.42	27.33
Protein	RR	54.70 (65.39)	47.89 (61.89)	56.56 (70.21)
	RS	53.46 (63.29)	47.76 (63.98)	55.74 (69.22)
	SD	56.35 (65.30)	48.64 (60.79)	60.33 (72.22)
	TD	49.63 (67.09)	44.72 (60.78)	52.75 (72.59)
Lipid	RR	14.82 (17.63)	17.00 (21.97)	10.28 (12.77)
	RS	14.49 (18.69)	16.96 (20.98)	10.13 (13.76)
	SD	15.27 (17.69)	18.07 (22.59)	10.96 (12.76)
	TD	13.13 (17.76)	16.63 (22.59)	8.91 (12.26)
Ash	RR	14.21 (16.92)	12.46 (16.10)	13.70 (17.01)
	RS	13.89 (17.96)	12.43 (15.01)	13.50 (16.98)
	SD	14.63 (16.95)	13.28 (16.60)	14.61 (15.00)
	TD	11.18 (15.11)	12.21 (16.59)	11.00 (15.14)

*RR-Rotary dryer in room condition, RS-Rotary dryer under sunlight, SD- Solar tunnel dryer, TD-Traditional dried
**Values within parenthesis indicate the results on dry matter basis

The moisture content of dried SIS products was in the range of 13.71% to 27.33% with the lowest value obtained from solar tunnel dried Mola and the highest value from traditional dried Katchki. The moisture content of dried SIS products produced in rotary dryer under room condition was in the range of 16.23% to 22.63% whereas the moisture content was in the range of 18.13% to 22.84% in those products produced in rotary dryer under direct sunlight. These values are much lower than those of traditional dried products (26.02% to 27.33%) whereas the moisture content of solar tunnel dried products was found in the range of 13.71% to 19.30%.

Moisture content of traditional dried SIS products was high because in most cases traditional dried products are marketed and stored without packaging materials. As a result, moisture uptake from the environment takes place giving rise to the chance of the growth of microorganisms, loss of nutrients and short shelf-life of the product.

The protein content of traditional dried SIS products was in the range of 44.72% to 52.75% on fresh weight basis and 60.78% to 72.59% on moisture free basis whereas protein content of dried SIS products produced in rotary dryer under room condition and direct sunlight was in the range of 48.49% to 61.44% and 47.97% to 58.09%, respectively on fresh weight basis whereas on moisture free basis it was in the range of 62.67% to 76.27% and 62.17% to 73.09%, respectively with lowest value from Tengra and highest value from Katchki. These values are more or less similar to those of solar tunnel dried SIS products which was in the range of 61.11% to 76.00% on moisture free basis.

Lipid content of traditional dried SIS products ranged from 8.91% to 16.63% on fresh weight basis and 12.26% to 22.60% on moisture free basis, where the lowest value was from Katchki and the highest value was from Tengra. On the other hand lipid content of dried SIS products produced in rotary dryer under room condition and direct sunlight was in the range of 11.28% to 18.42% and 12.13% to 19.07%, respectively on fresh weight basis whereas on dry weight basis the value was in the range of 14.00% to 23.80% and 15.26% to 24.71%, respectively with lowest value in Katchki and highest value in Tengra in every case. These values are more or less similar to those of solar tunnel dried SIS products which was in the range of 13.92% to 22.39% on dry matter basis.

Ash content of traditional dried SIS products was in the range of 11.00% to 12.21% on fresh weight basis and 15.11% to 16.59% on dry matter basis. Ash content of dried SIS products from rotary dryer produced under room condition and direct sunlight was in the range of 8.32% to 13.51% and 9.50% to 13.10%, respectively on dry matter basis. These values are more or less similar to those of solar tunnel dried SIS products which was in the range of 8.08% to 16.45% on dry matter basis.

The most significant variation in chemical composition among the products was the higher moisture content in traditional dried products than others. It was evident from the study that there was an inverse relationship between fat content and protein content of dried fish products. Species like Mola and Katchki had relatively high protein content and low fat content whereas Tengra had high fat content and relatively low protein content. The results of the present study also agree with the opinion of Ahmed *et al.* (1979) that is solar dried fishes contain increased percentage of protein and fat over the traditional sun dried products.

Food quality analysis

Food quality of traditional, rotary and solar tunnel dried products was analyzed by determining the biochemical and bacteriological aspects like Total Volatile Base Nitrogen (TVB-N) and Aerobic Plate Count (APC).

TVB-N value of traditional, rotary and solar tunnel dried SIS products

The results of the Total Volatile Base Nitrogen (TVB-N) are presented in Table 3. The TVB-N values of traditional dried SIS products were in the range of 15.46 mg/100g to 20.36 mg/100g with lowest value in Katchki and highest value in Mola. On the other hand the TVB-N values of the dried products from rotary dryer ranged from 10.64 mg/100g to 17.52 mg/100g with lowest in Mola dried in rotary dryer in room condition and highest in Tengra dried in rotary dryer under direct sunlight. In case of solar tunnel dried SIS products, the TVB-N value ranged from 14.34 mg/100g to 15.68 mg/100g with lowest in Katchki and highest in Mola. The TVB-N values of all the samples were found lower than the recommended value (100-200 mg/100g) for variety of salted and dried products (Connell 1995).

Table 3. TVB-N value and APC of traditional, rotary and solar tunnel dried SIS products

Dried sample name		TVB-N value (mg/100g)	APC (CFU/g)
Mola	RR	10.64	1.91×10^{8}
	RS	13.80	2.55×10^{8}
	SD	15.68	2.16×10^{8}
	TD	20.36	2.49×10^{8}
Tengra	RR	16.52	2.04×10^{8}
	RS	17.52	2.84×10^{8}
	SD	14.38	2.59×10^{8}
	TD	16.74	2.89×10^{8}
Katchki	RR	14.52	2.33×10^{8}
	RS	13.52	2.06×10^{8}
	SD	14.34	2.08×10^{8}
	TD	15.46	1.43×10^{8}

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

Bacteriological study

The total aerobic plate count expressed as colony forming unit in one gram of sample (CFU/g) of the representative samples of Mola, Katchki and Tengra was determined by standard plate count method on plate count agar media. The results of the above mentioned samples are presented in Table 3. The bacterial load of traditional dried SIS products ranged from 1.43×10^{8} CFU/g to 2.89×10^{8} CFU/g with highest value in Tengra and lowest value in Katchki. On the other hand, the total bacterial load in the dried products from rotary dryer was in the range of 1.91×10^{8} CFU/g to 2.84×10^{8}

CFU/g. The highest value was obtained from Tengra dried in rotary dryer under direct sunlight and the lowest value was obtained from Mola dried in room condition. Total bacterial load of solar tunnel dried SIS was in the range of 1.95×10^8 CFU/g to 2.59×10^8 CFU/g with the lowest load in Mola dried in solar tunnel dryer under black polyethylene and the highest in Tengra.

A close relationship exits between the moisture content and the bacterial load in fish products. According to Sen *et al.* (1961), when the water content of fish fell below 25% of wet weight, bacterial action stopped and when the water content further reduced to 15%, mold ceased to grow. The heat applied during drying process cause considerable reduction of microorganisms of various types, but bacterial spores and molds usually survive.

In the present study the bacterial load was high in rotary and solar tunnel dried SIS products. This may be due to the presence of bacterial spores on the raw materials used for drying or may be due to 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. There is evidence that the flora of fish is directly related to its aquatic environment (Venkataraman and Sreenivasan 1952). 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. The slime, gills and in actively feed fish, the intestines usually carry heavy bacterial loads which have been recorded as 10^2 to 10^7 per cm^2 of skin , 10^3 to 10^8 per ml of intestinal fluid and 10^3 to 10^6 per gram of gill tissue (Shewan 1949, Liston 1955 &1956, Georgala 1957 & 1958). The bacterial load in the slime and gill of fishes are influenced by seasonal variation, plankton outburst, catching method etc. But future research is quite necessary to find out the exact reason why the bacterial load was high in present study.

Fish drying through traditional manner is an old practice in Bangladesh. But the present study indicated that traditionally dried fish products available in the markets are of inferior quality in terms of nutritional and food quality aspects. On the other hand, findings of the study revealed that rotary dryer and solar tunnel dryer can be used to produce improved quality dried products which may satisfy consumers demand in terms of nutritional and food quality aspects.

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