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Quality Evaluation of Solar Tent Dried *Puntius sophore* and *Mystus gulio* of North East India

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Abstract

Two commercially important small variety fish of north-east India, namely, *Puntius sophore* and *Mystus gulio* were dried using indigenously made solar tent dryer. The quality of the dried products was compared with the market sample of dry fish dried under open sun. Biochemical, microbiological and organoleptic characteristics were compared. Moisture and ash components were found higher in market sample in addition to protein and lipid degraded products. Although, bacteriological count was within the acceptable limit in both the products, fungal colonies were detected in market samples. Rehydration properties of market samples were lower than the solar tent dried products. The average temperature difference in the peak hours (12 – 3 o'clock) between outside and inside of the solar tent dryer was 9.94°C and 11.43°C while drying *Puntius sophore* and *Mystus gulio* respectively for 3 days. Sensory scores for appearance, colour, odour and texture of the solar tent dried products were above 4 in the case of both the fishes, whereas, in the case of market samples, the scores for the similar quality attributes were between 3 and 4 and were within the acceptable limit.

Keywords: *Puntius sophore*, *Mystus gulio*, solar tent dryer, dry fish, rehydration property

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Introduction

Drying is an efficient and cheap method for food preservation. The demand for dried fish and shrimp has been driven by the characteristic flavour of each product. In India, about 17% of the total fish catch is being used for salting and drying (Anon, 2001). The fish must be cleaned and dried quickly to protect it from microbes, insects and dirt. Traditionally, fishes are sun dried on ground, rocks, wooden platforms, palm leaves and also on the sandy beaches. The fishes dry slowly and unhygienically in direct sunlight in the absence of moving air. Also, there is every possibility of contamination when fish is dried using these traditional methods. During the past few years, there has been a decline in the export of Indian cured fishery products (Sugumar et al., 1995) mainly because of their poor quality. This causes considerable loss to the fish curing industry in India.

Several methods have been reported to arrest different problems usually encountered during open sun drying of fish, of which solar tent drying is the one most reported. Solar tent dryer has replaced traditional sun drying practices in some areas. Different types of solar tent dryer and their advantages over the open sun drying has been reported by different authors (Doe et al., 1977; Chakraborti, 1995; Wazed et al., 2009). Bala & Janjai (2005) dried fish using Solar Tunnel Dryer (STD) where Bombay duck was dried to a moisture content of 15 from 89.8% in 9 h of drying as compared to 20 h of open sun drying. Several investigations proved that the use of solar tunnel fish drier leads to a considerable reduction of the drying time. The efficiency of solar dryer is evaluated depending on the temperature difference between inside and outside the tent. Mukherjee et al. (1990) developed a green house type of solar fish dryer by which it was possible to dry fresh fish of mixed variety and size to the desired moisture content within 2-3 days. Chakraborti (1995) designed another type of dryer based on the principle of green house effect. Solar drying systems must be properly designed in order to meet particular drying requirements of specific crops and to give satisfactory performance with

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respect to energy requirements (Steinfeld & Segal, 1986).

In north-eastern part of India, the small varieties of freshwater fishes sun dried without salt are available abundantly in the markets. Small indigenous fish species are valuable source of macro and micronutrients and play an important role in providing essential nutrients. Small indigenous fish like mola (*Amblypharyngodon mola*), chapila (*Gudusia chapra*), punti (*Puntius sophore, P. ticto*), chanda (*Pseudoambassis nama*, *Chanda ranga*) and batashi (*Ailia coila*) have high nutritional value in terms of proteins and vitamins that are not commonly available in other foods. *Puntius sophore* (commonly called 'punti') and *Mystus gulio* (commonly called 'gulaiya') are two commercially important small variety food fish of northeast India. During their glut (usually in post monsoon period in Assam State), a major portion of harvest is sun-dried. Traditionally, the fishes are dried by spreading in ground or on bamboo mattress or occasionally on raised platform made with bamboo. These methods do not have any control on the quality of the final product and usually it takes seven to eight days to dry the fish below 15% moisture content. During solar tent drying, considerable reduction of the drying time than conventional sun drying of fish was reported by several workers (Bala & Janjai, 2005; Wazed et al., 2009; Muhlbauer, 1986; Mohod et al., 2011). Oparaku (2010) reported that drying time required only three days for the fish to be completely dried in the solar drier compared with open-sun dried fish products which took complete seven days to be dried. The aim of the present work was to evaluate the quality of solar tend dried *Puntius sophore* and *Mystus gulio* and compare the quality with market procured samples of same species.

Materials and Methods

Fresh sample of *Puntius sophore* and *Mystus gulio* collected from the local markets were used for the study. The average size and weight of the fish were 9.0 ± 0.5 cm, 12.26 ± 0.99 g and 13.3 ± 0.3 cm, 26.6 ± 1.6 g respectively for *Puntius sophore* and *Mystus gulio*. The fish was transported to the laboratory well packed with ice in insulated box. In the laboratory, fishes were first made free of faecal matter by squeezing abdomen followed by thorough washing with potable water. While drying, fishes were spread uniformly on wire mesh trays placed inside the solar tent dryer. Twice a day, fishes were altered for uniform drying.

Materials used for the construction of solar tent dryer include black and white polythene sheet, bamboo poles and a drying rack made of bamboo (Fig. 1). In constructing the solar tent dryer, pieces of straight bamboo poles each measuring 180 cm were taken. Two of the poles were tied together at one end and the two other ends were tied at 150 cm apart with the help of another bamboo pole. The same was done for the fourth, fifth and sixth bamboo poles which were tied in the opposite direction at a distance of 200 cm apart. Three other bamboo poles measuring 220 cm were fastened on the top, front and back side of the two pairs of bamboo poles to form a tent-like structure. Transparent polythene was sewn into shape of the bamboo framework except covering the back side. The back side of the tent was sewn with black polythene. A rack of bamboo fencing was set inside the tent 30 cm above the ground so that a continuous flow of air towards the tent is obtained. The bamboo rack at base was covered with black polythene sheet. At the extreme narrow tops of the triangular part of the tent, openings of 15 cm x 15 cm were made to serve as outlet of the hot air from the dryer.

The dryer was exposed to the sun from 0900 h in the morning to 1600 h in the afternoon (7 h day^{-1}). The tents were positioned facing the direction of the prevailing wind, to allow air readily into the tents. The transparent side of the tent was always positioned facing the sun and the position changed with the change in position of the sun. The dryers were set-up 30 min before fish were put inside. The drying operation of *M. gulio* and *P. sophore* was

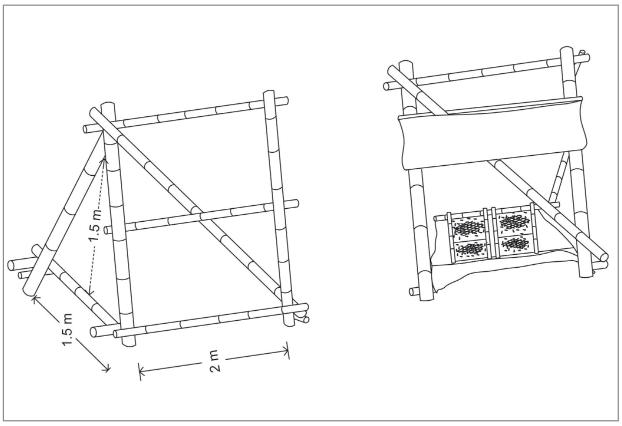

Fig. 1. Solar tent dryer (a) outside and (b) inside view

conducted in the month of September and October respectively. While drying *M. gulio*, the inside and outside temperature of dryer was in the range of 32.54 to 48.47^{o}C and 32.54 to 34.26^{o}C respectively. The average inside and outside temperature during peak hours (1200 to 1500 h) was 45.38^{o}C (with highest 48.47^{o}C at 1300 h) and 33.95^{o}C (with highest 34.26^{o}C at 1300 h) respectively with average temperature difference of 11.43^{o}C (Fig. 2). In the case of *P. sophore*, the temperature difference recorded during drying operation was in the range of 25.76 to 41.53^{o}C and 25.76 to 28.80^{o}C in the inside and outside of the dryer respectively. In the peak hours, the average temperature was 39.2^{0}C (with highest 41.53^{0}C at 1300 h) and 28.1^{0}C (with highest 28.8^{0}C at 1300 h) respectively in the inside and outside of the dryer with average temperature difference of 9.94^{0}C (Fig. 3). The average drying time required to reduce the moisture content below 15% was 3 days for both *M. gulio* and *P. sophore.*

Meat portion was collected from few fish of same species and mixed to make a representative sample before analysis. Three replications were done for each parameter. Chemicals used for biochemical

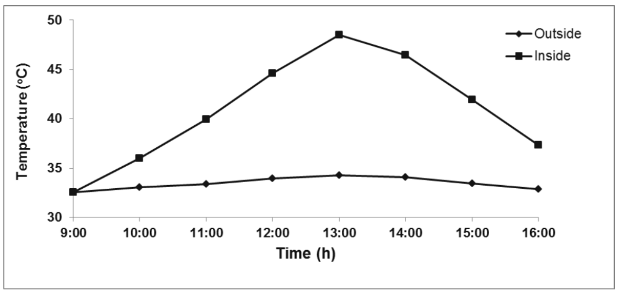

Fig. 2. Mean changes in outside and inside temperature of solar tent drier while drying *Mystus gulio*

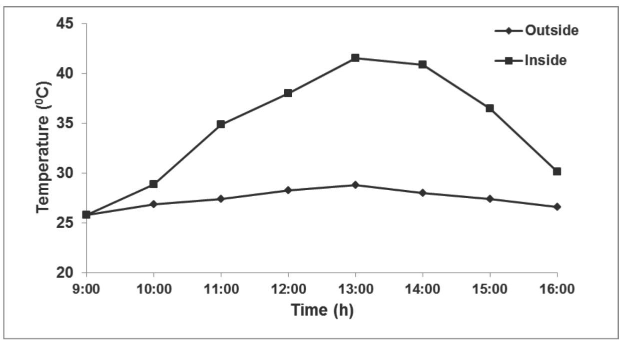

Fig. 3. Mean changes in outside and inside temperature of solar tent drier while drying *Puntius sophore*

analysis were procured from Merck (India) Ltd. Moisture, ash, total lipid, crude protein and non-protein nitrogen were estimated using standard procedures of AOAC (2000). Total volatile basic nitrogen (TVBN) was determined by using the Conway's micro-diffusion method (Conway, 1947). The peroxide value (PV) was determined using chloroform extracts of tissues according to the method suggested by Jacobs (1958). Thiobarbituric acid reactive substances (TBARS) were determined as described by Benjakul & Bauer (2001). The flesh (0.5 g) was dispersed in 2.5 ml of a solution containing 0.0375% thiobarbituric acid, 15% trichloroacetic acid and 0.25N HCl. The mixture was heated in boiling water for 10 min, followed by cooling in running tap water. The mixture was centrifuged at 8000 rpm for 20 min at room temperature. The absorbance of supernatant was measured at 532 nm using a spectrophotometer (SHIMADZU, UV 2550). TBARS were calculated and expressed as mg malondialdehyde kg fish meat^{-1}.

Total viable count of the samples was determined as per BAM (1995). Total fungal count was done following spread plate techniques (APHA, 1995) using readymade Rose Bengal Chloramphenicol Agar (RBCA). All the constituents of the media used were acquired from Hi Media Laboratories Pvt. Limited, Mumbai, India. Reconstitution property of the dried fish was assessed as percentage of water imbibed by 5 g of the dried fish sample soaked in 50 ml of cold water (1: 10) for a period of 3.5 h as suggested by Valsan (1975). The soaked sample with water was then transferred into test tube and centrifuged for 10 min at 2000 rpm. The water was drained out by keeping the test tube in inverted position and final weight of sample was taken. The result was expressed as ml of water absorbed per 100 g of dried samples.

Organoleptic quality and overall acceptability of sun dried fish was assessed by a panel of ten members on the basis of 5 point scale suggested by Ninan et al. (2008). Study of sensory characteristics of dry fish included general appearance, colour, odour and texture. The scores were given in the decreasing order scale with 5 for excellent, 4 for very good, 3 for good, 2 for poor and 1 for unacceptable. The mean of the score given by the panel represented the overall sensory quality. A score below 3 was considered as unacceptable.

Results and Discussion

The proximate composition of *Puntius sophore* and *Mystus gulio* meat is given in Table 1. The moisture, protein and lipid contents were found as 72.55, 16.19, 4.49 and 74.76, 16.06, 5.69% for *Puntius sophore* and *Mystus gulio* respectively. The higher ash content (>1.5%) as obtained in this study was due to unintentional inclusion of small bones while picking meat. The composition, however, varies greatly from species to species and also from individual to individual depending on age, sex, environment and season (Sankar & Ramachandran, 2001). In the present study, proximate analysis was done during September to October, which is considered as post spawning, feeding season of fish. However, it is important to know proximate composition of fish and variations throughout the year (Boran & Karacam, 2011).

From the proximate analysis of the dry fish (Table 2.), moisture content of solar tent dryer products (STD product) were found to be 10.34 and 13.06% for *Puntius sophore* and *Mystus gulio* respectively. Moisture content seems to be within the acceptable limit of 15% as reported by several workers. Bombay duck was dried to a moisture content of 15% from 89.8% in 9 h of drying in STD (solar tunnel dryer) as compared to 20 h of open sun drying (Bala & Janjai, 2005). Ali et al. (2011) reported that moisture content of fresh *Tilapia nilotica*, *Arius parkii* and *Silurus glanis* after sun drying was reduced to 14.06, 13.92 and 11.50% respectively. The moisture content of sun dried *Bonga* spp., *Sardinella* spp. and *Heterotis niloticus* was found to be 10.74, 9.79 and 12.88% respectively and were lower than the smoke dried fish (Akinneye et al., 2010). In the market samples, moisture content was 17.36 and 19.57% respectively for *Puntius sophore* and *Mystus gulio*. Such higher moisture in market sample could be due to moisture uptake of product during storing. From the Tripura markets, moisture contents of sun-dried *Puntius sophore* and *Mystus gulio* were reported as 19.9 ± 0.21 and 7.6 ± 0.73% respectively (Karthikeyan et al., 2007). Kalaimani et al. (1988) reported the moisture content of 12.3-54% for 23 dried marine fish products in India. Azam et al. (2003) investigated moisture content of four dried fishes of Bangladesh and found in the range of 19.3-24.4%.

Table 1. Proximate analysis of *Mystus gulio* and *Puntius sophore*

	Puntius sophore	*Mystus gulio*
Moisture	72.55 ± 1.79	74.76 ± 1.75
Ash (%, muscle)	1.69 ± 0.17	1.58 ± 0.05
Crude protein (%, muscle)	16.19 ± 0.25	16.06 ± 0.12
NPN (%, muscle)	0.37 ± 0.03	0.35 ± 0.02
Lipid (%, muscle)	4.49 ± 0.34	5.69 ± 0.05

The ash contents of the market sample of dry fish were found higher than the laboratory produced ones (Table 2.). Higher ash contents in market sample of dry fish may be due to sand contamination at the time of drying of fish. Wet fish readily uptake dust from the air or ground at the beginning of the drying process. The ash content observed in the laboratory dried products were similar to the dry fish reported by different workers. Ali et al. (2011)

Table 2. Proximate composition of STD (solar tent dryer) product and market sample of dry fish from *Puntius sophore* and *Mystus gulio*

Composition (%)	Product type	*Puntius sophore*	*Mystus gulio*
Moisture	STD product	10.34 (0.28)*	13.06 (0.65)
	Market sample	17.36 (1.94)	19.57 (0.85)
Ash	STD product	4.39 (0.26)	5.42 (0.17)
	Market sample	10.27 (1.12)	8.46 (1.64)
Crude protein	STD product	63.25 (4.00)	64.69 (1.39)
	Market sample	52.73 (2.41)	57.45 (1.84)
Lipid	STD product	13.91 (1.53)	15.10 (0.50)
	Market sample	11.59 (1.72)	13.56 (2.67)

* Values in parantheses denote std. dev.

reported the ash content of sun dried *Tilapia nilotica*, *Arius parkii* and *Silurus glanis* as 4.10, 4.60 and 3.52% respectively. Akinneye et al. (2010) estimated ash content of dry *Bonga* spp., *Sardinella* spp. and *Heterotis niloticus* as 3.8, 3.97 and 2.07% respectively. Karthikeyan et al. (2007) reported that ash contents of sun-dried small variety freshwater fishes of Tripura markets including *P. sophore* and *M. gulio* were in the range from 7.9 to 16.7%. Such higher contents of mineral may be due to ashing of whole fish or contamination of sand during drying. Basu et al. (1989) reported 11.6-22.1% ash content in the dried marine fishes available in Andhra Pradesh and they have attributed the higher ash content to the deposition of sand by wind during drying.

Reduction of moisture content due to product dehydration during drying concentrate protein content and also raise lipid level resulting increased nutritional value (Thot & Pothast, 1984). The crude protein content of fresh *P. sophore* and *M. gulio* increased from approximately 16% to above 60% in STD products, whereas, in market sample, crude protein contents were 52.73 and 57.45% respectively, which could be due to difference in moisture contents. Protein content of the sun-dried fish was found higher than the oven-dried and smoke-dried fish and this was explained as the denaturation of fish protein associated with oven dried and smoked fish (Akinneye et al., 2010). The lipid contents of STD products were 13.91 and 15.1% respectively in *P. sophore* and *M. gulio*, whereas, in market samples, the values were 11.59 and 13.56% respectively. This difference in lipid contents could be explained as the fat content of the raw material and differences in the moisture contents. Fat content of sun-dried *M. gulio* and *P. sophore* were reported as 14.4 ± 0.28 and 18.4 ± 0.22% respectively (Karthikeyan et al., 2007), 3.7-17.8 and 3-8.2% were reported for sun-dried fishes of India and Bangladesh (Kalaimani et al., 1988; Azam et al., 2003).

TVB-N basically comprises of low molecular weight volatile metabolic products generated especially during post mortem bacterial action and is one of the indices of post mortem spoilage. The TVB-N contents of STD products of both the fish were found about 11 mg 100 g^{-1}, whereas, in case of market sample, the values were found as 43.17 mg 100 g^{-1} and 39.27 mg 100 g^{-1} respectively in *P. sophore* and *M. gulio* (Table 3). The higher TVB-N value in commercially sun dried fish product could be due to improper handling, inadequate preservation and unhygienic mode of drying. The higher values of TVB-N also indicate degradation of tissue protein and might be responsible for typical flavour and odour of the products. Sen et al. (1961) reported that TVB-N value of the sun dried fish product varied from 32.5 to 41.0 mg 100 g^{-1}. Venkataraman & Vasavan (1959) reported the acceptable limit for TVB-N as 200 mg 100 g^{-1} of muscle. TVB-N values of 98 mg 100 g^{-1} and 105 mg 100 g^{-1} were reported for market samples of *M. gulio* and *P. sophore* (Karthikeyan et al., 2007).

Table 3. Biochemical and microbial quality indices of STD (solar tent dryer) products and market sample of dry fish from *Puntius sophore* and *Mystus gulio*

Indices	Product type	*Puntius sophore*	*Mystus gulio*
TVB-N (mg %, muscle)	STD product	11.73 (0.44)*	11.67 (0.46)
	Market sample	43.17 (4.38)	39.27 (6.62)
PV (m eq O_2/kg fat)	STD product	4.14 (0.13)	3.78 (0.11)
	Market sample	26.33 (2.12)	31.45 (3.23)
TBARS (mg malonaldehyde kg $meat^{-1}$)	STD product	0.72 (0.02)	0.70 (0.02)
	Market sample	3.25 (0.43)	2.76 (0.74)
Rehydration ratio	STD product	64.61 (2.11)	67.60 (0.63)
	Market sample	44.56 (3-74)	51.37 (2.78)
APC (log *cfu* g $muscle^{-1}$)	STD product	3.59 (0.06)	3.51 (0.04)
	Market sample	5.54 (0.14)	4.59 (0.23)
TFC (log *cfu* g $muscle^{-1}$)	STD product	Nil	Nil
	Market sample	4.14 (0.28)	3.20 (0.17)

* Values in parantheses denote std. dev.

Rancidity development was measured by means of primary (PV, peroxide value) and secondary (TBARS, thiobarbituric acid reactive substances) lipid oxidation compounds formation. Many 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 fish. TBA index is a widely used indicator for the assessment of degree of lipid oxidation (Nishimoto et al., 1985). The PV (millimoles O_2 kg^{-1} fat) of the STD products were 3.78 and 4.14 while in commercially dried fish products, the values were 31.85 and 26.33 for *M. gulio* and *P. sophore* respectively (Table 3). The higher PV of dried fish products might be attributed to the oxidation of lipids during the drying process (Aitken & Connell, 1979). The oxidation of fat during drying may lead to rancid flavour (Tsuchiya, 1961). The TBARS values (mg malonaldehyde kg^{-1} meat) of STD products registered 0.70 and 0.72 whereas values of 2.76 and 3.25 were found in commercially dried products respectively for *Mystus gulio* and *Puntius sophore* (Table 3.). Smruti et al. (2003) reported TBA value of enzyme tenderised and solar dried rohu steaks as 12 µg malonaldehyde/g fish. The increase of PV and TBA content could be explained as a result of the presence of pro-oxidant enzymes (lipoxygenases, peroxidases, and so on) and chemical pro-oxidant molecules (namely, hemoproteins and metal ions) (Erickson, 1997; Sikorski & Kolakowski, 2000). In this study, solar radiations and oxygen could have a more important pro-oxidant effect on fats than temperature. The higher PV and TBARS value in commercially sun dried fish might be due to the exposure of fish under direct sun light and open environmental condition in addition to initial higher PV and TBA value of the raw materials. The differences in lipid oxidation possibly resulted from initial fat content and fatty acid compositions of the product (Benjakul et al., 2005).

Rehydration is the replacement of water in dehydrated foods, but not all products reconstitute to 100% of their original state because of inherent differences in their chemical composition (Vonloesecke, 1955). The reconstitution (rehydration) property of the meat gives an index of protein quality and its ability to retain moisture. The reconstitution capacities of STD products were above 60% for both the fish. In respect of market samples, the rehydration property was found lower than the STD products. This difference in rehydration property between the STD products and market samples may be due to different degree of protein denaturation during drying and damage to cellular structure (Horner, 1992) leading to shrinkage of tissue. The moisture content of dried product is also important defining the degree of rehydration. The rehydration capacities of freshly prepared solar dried non-tenderised and tenderized rohu steaks were recorded as 39.8 and 55.8% respectively (Smruti et al., 2003). Uptake of media by the dried fish depends on the nature of reconstitution media and dipping hours but not significantly varied with the treatments (mode of drying) applied (Prodhan et al., 2011).

The STD products had APC (log *cfu* g^{-1} meat) approx. 3.5 for both the fish. Highest count was noticed in the market sample of dried products as 5.54 and 4.59 in *Puntius sophore* and *Mystus gulio* respectively.

Table 4. Organoleptic quality of STD (solar tent dryer) products and market sample of dry fish from *Puntius sophore* and *Mystus Gulio*

Parameters	Product type	*Puntius sophore*	*Mystus gulio*
Appearance	STD product	4.67 (0.33)*	5.00 (0)
	Market sample	3.44 (0.53)	3.55 (0.53)
Colour	STD product	4.67 (0.33)	5.00 (0)
	Market sample	3.50 (0.53)	3.40 (0.52)
Odour	STD product	4.33 (0.33)	4.67 (0.33)
	Market sample	3.30 (0.48)	3.50 (0.53)
Texture	STD product	4.33 (0.33)	4.67 (0.33)
	Market sample	3.50 (0.53)	3.40 (0.52)

*Values in parantheses denote std. dev.

ICMSF (1986) suggested acceptable limit of bacterial load in dry fish as < 5 log *cfu* g^{-1}. Abraham et al. (1993) and Basu et al. (1989) reported microbial load of around 5 log *cfu* g^{-1} in dried marine fishes. Although in both the drying process the final products did not exceed the acceptable limit suggested by different authors, but lower count in case of STD products could be attributed to the hygienic handling and drying besides use of quality raw materials. The quality of dried fish is often adversely affected by growth of fungi (Chakraborti & Varma, 1999) and substantial amount of fish are discarded during drying due to fungal growth (Gupta & Samuel, 1985). In the present study, solar tent dried samples were free from visible fungal colonies when plated on Rose Bengal Chloramphenicol agar (RBCA). Whereas, the total fungal counts (log *cfu* g^{-1} meat) were 4.14 and 3.20 in *Puntius sophore* and *Mystus gulio* collected from market respectively. The reason could be attributed to the higher moisture content and improper storing of materials.

The sensory quality of the dry fish depends on the quality of the raw materials. Organoleptic quality of STD products and market sample of dry fish from *P. sophore* and *M. gulio* is presented in Table 4. Sensory scores for appearance, colour, odour and texture of the STD products were above 4 in the case of both the fish. Scores for the similar quality attributes in the case of market samples were between 3 and 4 and were within the acceptable limit. The dried fish gradually lose their sensory attributes upon storage; however, good packaging can slow down the rate of deterioration with resultant increase of shelf-life. Karthikeyan et al. (2007) observed sensory score in the range of 5.7-7.3 (on 10-Point hedonic scale) of dried fish collected from the markets of Tripura. In the present study, lower scores found in the case of market sample may be due to poor quality raw materials, method of drying and uptake of moisture during post drying period besides poor packaging and storing methods.

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