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Comparative assessment of dried fish quality collected from market and drying centre at Kuakata in Patuakhali, Bangladesh

MST. NILOY JAMAN, MD. SAZEDUL HOQUE*, FARJANA YEASMIN, MD. MAHMUDUL HASAN, MD. ABU SAYED RIPON, ASMA AKTER AND MARIUM AKTER JHUMUR

Department of Fisheries Technology, Patuakhali Science and Technology University, Dumki, Patuakhali 8602, Bangladesh

*Corresponding Author: sazedul.fst@pstu.ac.bd

Abstract. The study identified the quality differences of dried Chinese pomfret (*Stromateus chinensis*), Bombay duck (*Harpodon nehereus*) and ribbon fish (*Trichiurus haumela*) from market and drying center at Kuakata, Patuakhali. The sensory, nutritional and microbial quality of collected dried samples were evaluated following organoleptic quality index, standard AOAC and aerobic plate count methods, respectively. Organoleptically no significant difference found between the samples from market and drying center. The highest moisture content value was obtained in Bombay duck (29.78%) from the market and lowest value in Chinese pomfret (20.06%) from drying center. The highest and lowest protein content was in Chinese pomfret (60.73%) and Bombay duck (47.9%) from drying center and market, respectively. The lipid and ash content varied from 2.85% to 7.20% and 13.98% to 19.57% for all the dried fish species collected from both sites. Microbiologically, higher aerobic plate count (APC), total *E. coli* count (TEC) and total *Salmonella* count (TSC) were found in Chinese pomfret at 1.96×10^6 CFU/g, 3.98×10^5 CFU/g and 1.62×10^5 CFU/g from market and lowest count found in Bombay duck at 5.05×10^5, 2.22×10^5 and 0.81×10^5 from drying center, respectively. In ribbon fish no *Salmonella* sp. was found. Based on the sensory and nutritional quality the study conclude that among three species and two sites studied, the dried Bombay duck from the fish drying center had better quality characteristics than the counter parts. However, higher microbial load especially pathogenic TSC and TEC suggests to improve hygiene and sanitary practices, better market distribution and storage facilities need to be followed by the producers for safe and quality dried fishery products.

Keywords: Dried fish, Fish drying center, Kuakata

Introduction

The dried fish and fishery products are widely regarded as a good source of protein and other essential nutrients for the maintenance of a healthy body (Arannilewa *et al.* 2005). These are generally processed traditionally at low-cost, easily transportable, marketable, storable (Nowsad 2007) and has good market demand. A sizeable quantity of fresh fish is preserved by sun drying in Bangladesh from freshwater as well as from marine fish. It is low cost dietary protein source and used as a substitute of fish at the scarcity of fresh fish in Bangladesh (Khan and Khan 2001). The southern region of Bangladesh is abundant in marine water fisheries resources. The amount of fish catches from fresh and marine water attains peak during winter season. As a result winter is considered to be the peak season for processing sun dried fish and continues till the onset of the rainy season. In the coastal villages, fish drying generally starts in October and ends in March (Nowsad 2007). A major problem associated with sun drying of fish in Bangladesh is the infestation of the product by fly and insect larvae during drying and storage. Dried fish contaminated by both insects and insecticides comprises about 60% of the total dried products and is considered to be unfit for human consumption (Nowsad 2005). Apart from these, other common sources of contamination are air and dust in and around fish processing place,

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contaminated coastal water and soil and unhygienic handling (FAO 1982, Prabhakaran and Gupta 1990). There is a tendency of fishermen to dry whatever they catch. They are dried in open space on the sand, dykes or embankments, which are sources of bacterial contamination. Fatty species are very prone to oxidative rancidity even if drying is done very carefully.

The quality and safety of fish and fishery products have become a major concern worldwide (Huss *et al.* 2003). To consumers, the most important attributes of a food product are its sensory and nutritional characteristics. Bacterial contamination in food often results in food spoilage as well as life threatening health hazards like food poisoning (Prescott *et al.* 1999). Determination of microbiological count is widely used to assess the microbiological quality of dried fish. Determination of microbiological quality of such processed fishes is very important for guarding consumer's health and hygiene (Lilabati *et al.* 1999). Also the biochemical composition of dried fish is an important aspect in dried fish processing as it influences both the keeping quality and the physical characteristics of the dried fish. The microbial load affects the composition, freshness, spoilage and nutritional quality of the fish. The presence of pathogenic bacteria in dried fish is acquiring importance from the seafood safety and quality point of view (Patterson and Ranjitha 2009). Available reports suggest that the qualities of majority of the dried products and the consumers frequently complain about their quality. Therefore, this study aims to investigate the sensory, microbial and nutritional quality of dried fish available in drying center and market in Kuakata, Bangladesh.

Materials and Methods

***Dried fish sample collection*:** Dried marine water fishes namely Chinese pomfret (*Stromateus chinensis*), Bombay duck (*Harpodon nehereus*) and ribbon fish (*Trichiurus haumela*) were collected from local market and drying centre of Kuakata during March 2018 to May 2019. Dried fish samples were packed tightly in polyethylene bags and transported to the Seafood Processing Safety and Quality laboratory of PSTU for subsequent studies.

***Sensory assessment of dried fish*:** Sensory assessment was carried out on dried fish in the laboratory by using the Quality Index method to access the degree of freshness based on organoleptic characteristics such as color, odor, texture, flavor, insect infestation, general appearance and overall acceptability carried out on dried fish generally depends on the taste of panelists. Ten (10) panelists who had been selected and trained participated in the sensory evaluation. The qualities of the fishes were scored using the score from 1 to 5 according to scoring method (Table I and II). The score of average defect points less than 2 was A grade considered as excellent, highly acceptable, 2 to less than 4 B grade was judged as Good/acceptable, 4 or above C grade was considered as rejected. Numerical grading system was developed to evaluate the judgments or results, simply in the form of excellent/highly acceptable, acceptable/good, deteriorating/not acceptable and spoiled/rejected etc. in the quality index scheme for dried fish. The organoleptic characteristics of dried fish guidelines and methods were based on organoleptic method (Howgate *et al.* 1992) with some modification as in Table I and II. Organoleptic assessment was calculated by using following formula-

$$\text{Average grade points} = \frac{\text{Total grade point}}{\text{Number of characteristics}}$$

Table I. Organoleptic assessment of dried fish based on defect characteristics

Characteristics of dried fish	Defect characters	Defect point	S-1	S-2	S-3	S-4
Color	Whitish and shiny	1				
	Off white to yellowish	2				
	Shining yellowish to brownish	3				
	Brownish outer reddish in inner	4				
	Blackish to bleached	5				
Odor	Natural dried fishy odor	1				
	Bland odor	2				
	Slightly to moderate fishy	3				
	Decomposed sour odor	4				
	Extremely decomposed sour and spoiled	5				
Texture	Firm, tender and flexible	1				
	Slightly to moderate Soft	2				
	Extremely soft and slightly juicy	3				
	Brittle near to broken	4				
	Broken, juicy and skin raptured	5				
Flavor	Natural and slight salty	1				
	Slight to moderate flavor	2				
	Strong and spoiled	3				
Insect Infestation	No infestations	1				
	Slightly to moderate infestation	2				
	Completely infested by flies and insects	3				
General appearance	Excellent	1				
	Good	2				
	Slight to moderate good	3				
	Bad	4				
	Very bad	5				
Over all acceptability	Highly acceptable	1				
	Slight to moderate acceptable	2				
	Slightly Unacceptable	3				
	Very Unacceptable	4				
	Rejected	5				
Total defect point						
Average defect point						

Table II. Grading of dried fish acceptance

Grade	Defect point	Degree of acceptance
A	<2	Excellent, Highly acceptable
B	2 to <4	Good/ acceptable
C	4 - 5	Rejected

Microbial quality assessment of dried fish: For microbial studies Nutrient agar, Eosin Methylene Blue (EMB) agar, Xylose-Lysine Deoxycholate (XLD) agar media was prepared for Aerobic Plate count (APC), Total *E. coli* Count (TEC) and Total Salmonella sp. Count (TSC) respectively by the following manufacturer's instruction (Hi-media, India). The collected dried fish samples were chopped into small pieces. The preparation of collected dried fish samples and the bacterial culture were conducted following the standard method of Schulze-Schweifing *et al.* (2014). Briefly, 1-5 grams of dried fish sample were homogenized (BK-HG160, Biobase, China) and mixed in 200ml sterile phosphate-buffered saline (PBS, 10 mmol/L PO_4^{3-}, 137 mmol/L NaCl, and 2.70 mmol/L KCl, pH 7.4) producing a 5% (m/v) sample suspension. The suspension was mixed thoroughly using a vortex mixture (VM-1000, DLII, Taiwan) before it was centrifuged (DM0412, DLAB-SI, USA). The supernatant was collected and was maintained as a stock solution.

***Total microbial counts in dried fish sample*:** The stock solution (5% suspension) was 10 fold serially-diluted up to 10^{-5} using 0.85% normal saline as diluent before 0.1 ml of each of them was spread plated onto nutrient agar media. After an incubation at 37°C for 24 hours in the incubator (JSGI-10T, JSR, Korea), the colonies developed in the media were calculated and results were recorded as cfu/gm of dried fish sample using the following formula:

$$\text{CFU / g} = \frac{\text{No. of colonies on petridish} \times 10 \times \text{dilution factor} \times \text{Volume of total solution}}{\text{Wt. of fish sample}} \times 100$$

***Microbial study on selective media*:** Aliquots of 0.1 ml from each of the sample of dried fish after serial dilutions of their respective stock solutions were spread onto the selective media: EMB (Eosin methylene blue), and XLD (Xylose Lysine Deoxycholate), TCBS (Thiosulfate-citrate-bile salts-sucrose agar) agar for *E. coli* and *Salmonella* spp colonies development in the respective selective media. After an incubation at 37°C for 48 hours in the incubator (JSGI-10T, JSR, Korea) the developed colonies in the media were calculated and results were recorded as cfu/gm of dried fish sample using the following formula:

$$\text{CFU / g} = \frac{\text{No. of colonies on petridish} \times 10 \times \text{dilution factor} \times \text{Volume of total solution}}{\text{Wt. of fish sample}} \times 100$$

***Determination of proximate compositions*:** Moisture, protein, lipid, and ash were determined by using a hot air oven (Model DO-35, Human Instrument Co. Ltd, and Korea), Kjeldahl apparatus (Model Buchi CH-9230, Switzerland), Soxhlet apparatus (Model SRICO, SMX 100, behr LABORTECHNIK GmbH Co. ltd, Germany) and muffle furnace (Faithful, SX ceramic fiber muffle furnace, Huanghua Faithful Instrument Co. Ltd, China), respectively.

***Statistical analysis of experimental data*:** The obtained data were analyzed to Mean ± SD (n=3) using Microsoft Excel 2010 software.

Results and Discussion

***Sensory quality analysis of dried fish sample*:** The quality of dried fish products were assessed on the basis of color, odor, texture, insect infestation, presence of broken pieces and overall quality and then after considering their defect point, they were graded into A, B and C which indicate excellent, highly acceptable, good/ acceptable and rejected quality, respectively. There was no significant difference in organoleptic characteristics among these samples collected from two sources (Table III). The dried Chinese pomfret, Bombay duck and ribbon fish exhibited yellowish to brownish, yellowish to light brownish and brownish color in outer and blackish color in inner, respectively.

The dried fish samples of Chinese pomfret and Bombay duck had moderate characteristic dry fish odor but in Ribbon fish decomposed sour odor was developed. Slightly to moderate soft texture was found in Chinese pomfret and Bombay duck and soft or damp texture was found in ribbon fish. Ribbon fish showed strong rancid flavor. Slightly to moderate infestation by flies and insects was observed among the samples. Considering their defect point and overall acceptability the samples were moderately good and acceptable. Previous study by Paul *et al.* (2018) shown that organoleptic characteristics in respect of color, odor, texture, insect infestation and presence of broken pieces in the products indicated poor to moderately acceptable condition. Jamil *et al.* (2017) found that organoleptically most of these sun-dried fishes were in "B'' grade that means in "Good" condition (SDP 2.33 and 2.35 respectively). In another study Hossain *et al.* (2017) found that the color of sun-dried Silver pomfret from local market as slightly brown, some were brown to dark brown compared with freshly prepared samples having an attractive cream color. Slightly rancid odor and bitter taste was developed in some samples. Texture was hard but not firm in most of the samples. Overall sensory qualities of most of the samples were of "excellent grade'', some were in "good grade''. The color, odor, texture, insect infestation, presence of broken pieces of salt and turmeric treated dried ribbon fish was good (Imtiaz *et al.* 2017). Haque *et al.* (2013) observed that the color of collected traditional sun dried fish samples were ranged from silvery to white with wide variations in different species and that of all the products were characteristics with firm and flexible texture.

Table III. Organoleptic characteristics of dried fish from market and drying center in Kuakata

Dried fish sample	Collection source	Color	Odor	Texture	Flavor	Insect Infestation	General appearance	Over all acceptability	Defect point	Grade	Grade characteristics
Chinese pomfret	Market	Yellowish to brownish in color	Slightly sour odor	Slightly soft	Slight to moderate flavor	Slight infestation	Slight to moderate good	Slight to moderate acceptable	3.07	B	Moderate good and acceptable
Bombay duck		Yellowish to brownish in color	Slightly to moderate fishy	Slightly soft	Slight to moderate flavor	Slight infestation	Slight to moderate good	Slight to moderate acceptable	2.89	B	Moderate good and acceptable
Ribbon fish		Brownish in outer and blackish in inner	Decomposed sour odor	Soft or damp	Strong flavor	Infested by flies and insects	Slight to moderate good	Slight to moderate acceptable	3.27	B	Moderate good and acceptable
Chinese pomfret	Drying centre	Yellowish to light brownish in color	Slightly to moderate fishy	Slight to moderate soft	Slight flavor	Slight infestation	Slight to moderate good	Slight to moderate acceptable	3.01	B	Moderate good and acceptable
Bombay duck		Brownish in color	Slightly to moderate fishy	Slight to moderate soft	Slight flavor	Slight infestation	Slight to moderate good	Slight to moderate acceptable	2.78	B	Moderate good and acceptable
Ribbon fish		Brownish in outer and blackish in inner	Sour odor	Soft or damp	Strong flavor	Infested by flies and insects	Slight to moderate good	Slight to moderate acceptable	3.19	B	Moderate good and acceptable

Microbiological analysis of dried fish sample

***Total bacterial load*:** The total aerobic plate count of Chinese pomfret, Bombay duck and ribbon fish from market was $1.96\times10^6\pm2.27$, $6.01\times10^5\pm1.68$ and $1.29\times10^6\pm 1.94$ CFU/g respectively. On the other hand, total aerobic plate count of the represented sample collected from drying center was $1.27\times10^6\pm1.16$, $5.05\times10^5\pm1.62$ and $1.14\times10^6\pm1.7$ CFU/g respectively. The highest APC was found in the samples collected from market than drying center. The highest bacterial load was obtained in Chinese pomfret $1.96\times10^6\pm2.27$ and lowest in Bombay duck $5.05\times10^5\pm1.62$ CFU/g (Table IV). It was observed that lowest bacterial load found in Bombay duck among three samples.

Table IV. Microbiological characteristics of dried fish from market and drying center, Kuakata

Microbial parameter (CFU/g)	Market			Drying center		
	Chinese pomfret	Bombay duck	Ribbon fish	Chinese pomfret	Bombay duck	Ribbon fish
APC	1.96×10^6 ±2.27	6.01×10^5 ±1.68	1.29×10^6 ±1.94	1.27×10^6 ±1.16	5.05×10^5 ±1.62	1.14×10^6 ±1.7
TEC	3.98×10^5 ±0.88	2.38×10^5 ±0.61	3.18×10^5 ±0.74	3.58×10^5 ±0.81	2.22×10^5 ±0.36	2.84×10^5 ±0.30
TSC	1.62×10^5 ±0.22	1.04×10^5 ±0.28	Absent	1.61×10^5 ±0.08	0.81×10^5 ±0.1	Absent

APC, Aerobic plate count; TSC, Total *Salmonella* count; TEC, Total *E. coli* count.

The higher APC for traditional dried fish samples probably due to the fact that the higher moisture content and longer storage periods and poor hygienic condition during the preparation time. Drying by heat usually destroys all yeasts and most of the bacteria, but spores of some bacteria and molds usually survive. So, if the drying process and storage conditions are adequate, there will be no growth of microorganism in dried fish. But in traditional sun drying, it is about impossible to control moisture and growth of microbes during processing and storage of dried fish. Especially during improper storage and exposed condition in the retail market, dried products absorb a considerable amount of moisture and bacterial load found higher in market than drying center. The permissible limit of APC for cooked or dried fish is 1×10^5 CFU/g at 37°C (Surendran *et al.* 2006). Here it was shown that, in case of three dried fish they exceed the permissible limit. Haque *et al.* (2013) found that in traditional sun dried fish sample the total aerobic bacterial count were in the range of 2.88×10^4 to 3.37×10^5 CFU/g for both Bombay duck and Silver pomfret collected from different region. Pravakar *et al.* (2013) observed the bacterial load of Chinese pomfret, Bombay duck and Ribbon dried products were 3.8×10^5, 3×10^4 and 2.1×10^5 CFU/g, respectively with lowest value in Bombay duck and highest value in Chinese pomfret.

Identification of Salmonella and E. coli isolated from dried fish samples: The samples collected from market found total *Salmonella sp* in Chinese pomfret was $1.62\text{x}10^5\pm0.22$ CFU/g and in Bombay duck $1.04\text{x}10^5\pm0.28$ CFU/g (Table IV). The samples from drying centre found total *Salmonella sp* in Chinese pomfret was $1.61\text{x}10^5\pm.08$ CFU/g and in Bombay duck $0.81\text{x}10^5\pm0.1$CFU/g. On the other hand in Ribbon fish *Salmonella sp* was absent both in market and drying centre. The total *E coli* found in Chinese pomfret, Bombay duck and Ribbon fish was $3.98\text{x}10^5\pm0.88$ CFU/g, $2.38\text{x}10^5\pm0.61$ CFU/g and $3.18\text{x}10^5\pm0.74$ CFU/g respectively in

market and in drying center $3.58x10^5 \pm 0.81$ CFU/g, $2.22x10^5 \pm 0.36$ CFU/g and $2.84x10^5$ CFU/g respectively. Highest *E coli* found in market Chinese pomfret $3.98x10^5 \pm 0.88$ CFU/g and lowest found in drying center Bombay duck $2.22x10^5$ CFU/g. Among both place highest *E coli* was found in samples from market than drying center. The permissible limit of TSC for cooked or dried fish is $1x10^5$ CFU/g at 37°C (Surendran *et al.* 2006). Good quality dried fish should be totally free from *Salmonella* spp. However, in the current study both market and drying yard sources dried fish had higher *Salmonella spp* content in Chinese pomfret, which is highly health and food safety concern. The higher TSC and TEC content might due to contaminated/polluted water used, poor sanitary condition and unhygienic handling practice applied during preparation of dried fish in the study site. Other studies also reported that incidence of *Salmonella spp.* in the traditional dried fish may be attributed to external contamination such as polluted water, sand and unclean place used for drying and poor handling at ambient temperature. Contamination of fish and fishery products with *Salmonella* and *Shigella* has been reported by many researchers (Sinduja *et al.* 2011). Logesh *et al.* (2012) revealed that among the coliforms, *E. coli* were dominant followed by *Vibrio* sp., *Salmonella* sp. and *Staphylococcus* sp., respectively.

***Proximate analysis of dried fish sample*:** The Moisture content of dried Chinese pomfret, Bombay duck and Ribbon fish were $25.13 \pm 1.4\%$, $29.78 \pm 1.07\%$, and $28.33 \pm 0.7\%$ respectively in market and in drying center $20.06 \pm 0.37\%$, $27.04 \pm 0.8\%$ and $23.58 \pm 0.71\%$ respectively. The highest moisture value was found in Bombay duck in market and lowest value in Chinese pomfret in drying center. The protein content found in market were $54.24 \pm 1.33\%$, $47.9 \pm 1.32\%$, $51.13 \pm 0.7\%$ and in drying center $60.73 \pm 0.86\%$, $50.63 \pm 0.38\%$ and $55.31 \pm 0.69\%$ respectively. Highest value found in Chinese pomfret $60.73 \pm 0.86\%$ in drying center and lowest in Bombay duck $47.9 \pm 1.32\%$ in market (Table V).

Table V. Proximate composition analysis of dried fish from market and drying center, Kuakata

Proximate Composition %	Market			Drying center		
	Chinese pomfret	Bombay duck	Ribbon fish	Chinese pomfret	Bombay duck	Ribbon fish
Moisture	25.13 ± 1.4	29.78 ± 1.07	28.33 ± 0.7	20.06 ± 0.37	27.04 ± 0.8	23.58 ± 0.71
Ash	16.25 ± 0.01	19.57 ± 0.7	16.25 ± 0.67	15.04 ± 0.45	19.12 ± 0.71	13.98 ± 0.83
Protein	54.24 ± 1.33	47.9 ± 1.32	51.13 ± 0.7	60.73 ± 0.86	50.63 ± 0.38	55.31 ± 0.69
Lipid	3.58 ± 0.23	2.85 ± 0.41	5.26 ± 0.4	4.17 ± 0.5	3.92 ± 0.61	7.20 ± 0.41

The lipid content found in market and drying center were $3.58\% \pm 0.23$, $2.85\% \pm 0.41$, $5.26\% \pm 0.4$ and $4.17\% \pm 0.5$, $3.92\% \pm 0.61$ and $7.20\% \pm 0.41$ respectively. Where highest lipid content $7.20 \pm 0.41\%$ found in Ribbon fish in drying center and lowest in Bombay duck $2.85 \pm 0.41\%$ in market. On the other hand, the ash content found in market and drying center were $16.25\% \pm 0.01$, $19.57\% \pm 0.7$, $16.25\% \pm 0.67$ and $15.04\% \pm 0.45$, $19.12\% \pm 0.71$ and $13.98\% \pm 0.83$ where highest ash content $19.57 \pm 0.7\%$ found in Bombay duck in market and lowest in drying center Ribbon fish $13.98 \pm 0.83\%$ (Table V). The study of Hossain *et al.* (2017) found that moisture content (%) of sun-dried in Silver Pomfret and Perch was 39.59 ± 0.34 26.74 ± 0.47, respectively. The finding of Hoque *et al.* (2018) observed that the moisture content of improved traditional dryer dried fish products ranged from 16.71% to 21.1%. The study of Hossain *et al.* (2017) found crude protein content (%) of Silver Pomfret and Perch at

32.25±1.50, and 40.31±2.13, respectively which was less similar to present findings. In other study similar findings of protein contents on wet weight ranged from 55.2% to 60.16% in case of improved traditional dryer dried Silver pomfret, Bombay duck and Ribbon fish observed by (Hoque *et al.* 2018). However, the findings of this study showed that the average protein level obtained from dried fishes were very close with the previous studies. The present study agreed with Hossain *et al.* (2017) lipid content (%) of sun-dried Silver Pomfret and Perch was 7.75±0.20 and 5.03±0.55%, respectively. Hoque *et al.* (2018) found that the lipid contents on wet weight basis for the products 12.9% to 18.80% respectively.

The present findings supported the findings of Haque *et al.* (2013) observed that the range of ash content of traditional sun dried Silver pomfret and Bombay duck was 16.95% to 21.41%, respectively. In another study Jamil *et al.* (2017) found that the ash content of sun dried Bombay duck and Ribbon fish was 16.22±0.56 %, 12.33±0.27 % respectively. The study of Hossain *et al.* (2017) found ash content (%) of Silver Pomfret and Perch at 15.75±0.39 and 11.50±0.26, respectively. In another study Hoque *et al.* (2018) found that the ash contents of the dryer were 5.18% to 7.5% respectively. Organoleptically dried fish samples collected from market and drying center were same quality, where between the species Bombay duck was better than Chinese pomfret, and Ribbon fish. Nutritionally, the highest protein 60.73 % (Chinese pomfret) and lipid 7.20 % (Ribbon fish) content in samples from drying center. The highest bacterial load was found in the Chinese pomfret from market and lowest in Bombay duck from drying center. Presences of *Salmonella sp.* and *E.coli* made the dried fish (except dried ribbon fish) poor quality, represent the poor hygienic and sanitation practices by the producers. Considering the any quality aspects, dried fish from drying center was better than market place. Microbiologically, all the dried fish samples from market and drying center exceed the recommended permissible limit where identified pathogenic microbes are highly food safety and public health concern.

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