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RESEARCH PAPER

Quality Assessment of Dried Striped Dwarf Catfish, *Mystus vittatus* in the North-eastern Region of Bangladesh

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Abstract

Dried fish is a popular and in-demand fish food item in Bangladesh, and it is regarded to be the most cost-effective form of nutritional protein, which helps to alleviate malnutrition among the disadvantaged people. A consumer survey reported a slew of concerns regarding the physical, visual, and organoleptic aspects of market available sun-dried fish. The current study evaluated the organoleptic, nutritional, and microbiological quality of dried striped dwarf catfish, *Mystus vittatus*, which is one of the most popular dried fish in Bangladesh. To highlight the quality disparities among the samples, an experimental sample was made in the laboratory with the utmost hygiene and sanitation. Experimental samples had the highest features score than marketed ones, according to organoleptic analysis. Except for moisture and ash content, the experimental sample had greater mean lipid, protein, crude fiber, and nitrogen-free-extract (NFE) values. The mean (±SD) moisture content of the experimental, drying yard and market sample were 19.82±1.7, 21.44±2.7 and 24.3±1.4%; lipid content were 12.30±2.12, 10.54±1.76 and 9.04±2.41%; protein content were 43.01±.10, 41.74±.79 and 39.67±3.18%; ash content were 16.11±1.70, 17.91±3.70 and 20.77±3.24%; crude fiber content were 1.78±.08, 1.56±.08 and 1.54±.13% and NFE content were 7.01±1.08, 6.80±.77 and 4.67±1.01%, respectively. The mean Total Plate Count (TPC) of dried *M. vittatus* from the experiment, drying yard, and market samples, respectively, was 4.51±0.11, 5.33±0.25, and 6.39±0.18 log cfu g^{-1}. The results show that commercially manufactured dried striped dwarf catfish has low organoleptic, nutritional, and microbiological quality. Commercially manufactured dried fish requires improved hygiene and good manufacturing practices (GMPs) to ensure consumer safety and health.

Introduction

Dry fish (shutki in Bengali) is one of the most popular food items in Bangladesh. Sun drying accounts for 20% of total fish caught each year, with the majority of fish being consumed domestically (DoF, 2011). Dry fish has a good market demand and regarded as a valuable source of animal protein. People all around the country enjoy the flavor and aroma of dry fish.

Dry fish of both fresh and marine origin are available in almost every fish market and supermarket all the year round. Dried fish is widely consumed by people of all socio-economic backgrounds since it is readily available, low in cost and can be stored for longer periods of time without any preservation. These are particularly popular among low-income people as it is inexpensive and quite tasty. There are enormous numbers of dry fish consumer across the country and they frequently express dissatisfaction with the quality of dried fish products on the market. Insect infestations of dried fish products in local markets are common, resulting in significant quality loss. According to several studies, the physical and organoleptic properties of most conventional sun-dried items on the market are unsuitable for human consumption (Reza *et al.,* 2005).

In general, conventional drying is done in an open area under direct sunlight, with poor hygiene and sanitation (Hussain *et al.,* 2016). Sometimes low-quality fish are used for drying. When the humidity is high during the monsoon, appropriate drying cannot always be achieved using the traditional drying method, in which the fish absorbs moisture and serves as a habitat for microbial populations (Azam, 2002). The fish is readily contaminated by dust, dirt or sand, as well as pathogens and insect infestation, when dried using traditional methods. Traditional fish drying is typically done by poor and often illiterate fishermen (Azam *et al.,* 2003). Furthermore, drying is a slow process that contributes to the partial destruction of the fish's protein content through oxidation and bacterial or enzymatic degradation, making the product unhygienic. As a result, the physical and organoleptic attributes of most conventional sun-dried fish on the market failed to meet the consumer's quality expectations.

Even consumers in rural areas are becoming more aware of health and food quality issues as a result of rising educational standards. They frequently produce the required dried fish products for their own use. On the other hand, people with better incomes in urban areas choose to buy dried fish from supermarkets that have already earned people's trust in terms of quality. Consumers are also becoming more concerned about the nutritional value of dried fish, as well as deterioration, microbiological contamination, and insect infestation. Therefore, it is necessary to assess the quality of these items in order to protect consumers' health and hygiene, as well as to fulfill their satisfaction. The nutritional value of food can be determined through proximate biochemical analysis (Zafar *et al.,* 2004). The determination of microbiological and organoleptic quality, is also critical in terms of quality assessment.

Dwarf catfish species, locally known as tengra, are commonly found and collected all the year round in Bangladesh's North-Eastern districts, particularly Sylhet, due to the existence of a major river, Surma, a broad range of haor regions, and other submerged wetlands. Dried fish produced from this catfish species is considered one of the most popular, delicious, demandable, and widely produced dry fish in the North-Eastern region of Bangladesh. Although a good number of works on the biochemical composition of dried fishes in Bangladesh have been done by many researchers, no work has been done to the best of our knowledge on the comparative study of dried fish considering the different sources except Begum et al., (2011). The prime purpose of this study was to evaluate the food quality of dried striped catfish (*Mystus vittatus*) from different sources considered as a vital factor of consumer health and safety. Therefore, assessment of the organoleptic, microbiological, and nutritional quality of dried *M. vittatus* was examined. A comparative study was also conducted to obtain a complete picture of food quality between commercially and experimentally processed dried *M. vittatus*.

Materials and Methods

A considerable number of dried tengra fish (sutki) is produced every year from mid-October to April in the North-Eastern part of Bangladesh. In this study, three types of dried tengra samples (drying yard sample, market sample, and experimental sample) were evaluated. Drying yard samples were collected from the Lamagaji fish drying yard in Sunamgonj, market samples from the fish markets in Sylhet Sadar, and for experimental samples fresh tengra fish were processed into dried samples. On a monthly basis, all three types of samples were collected, prepared, tested, and analyzed. From November 2016 to March 2017, the research was conducted over a 150-day period.

Experimental Sample Preparation

Raw tengra fish at their peak freshness were transported to the experimental site in an insulated ice box to keep the fish fresh. After that, the fish were gently rinsed with clean water to remove blood, slime, unwanted adherence, and other debris. They were then died for 5 to 6 days in the sun on a wooden basket wrapped in a clean polythene sheet. During the sun-drying period, fishes were kept covered with a tiny mesh net to prevent external contamination and to protect the sample from bird attack and fly infestation.

Before any kind of laboratory experiment, all the collected and prepared samples were stored in air tight polythene bags at 4°C.

Experimentation Laboratory

Experiments were conducted in the Microbiological Laboratory of Department of Microbiology and Immunology, Faculty of Veterinary, Animal and Biomedical Sciences of Sylhet Agricultural University, Sylhet and in the Fish Nutrition Laboratory of Bangladesh Agricultural University, Mymensingh, Bangladesh.

Sample Analysis

Proximate Composition Analysis

Proximate composition was analyzed according to the methods of Association of Analytical Chemists (AOAC, 2000). The determined parameters were moisture, crude protein, crude lipid, ash, crude fiber and nitrogen free extracts (NFE). Moisture content was determined by using a hot air oven at 105°C for 24 hours. Crude fat was extracted using petroleum ether by Soxhlet method with Soxhlet apparatus. Kjeldhal method was used to determine the nitrogen content and then the crude protein level was subsequently calculated using a nitrogen to protein conversion factor 6.25. Ash content was determined in a muffle furnace at 550°C. Crude fiber was analyzed by acid and alkaline extraction. Nitrogen free extract (NFE) was calculated by subtracting the percentages calculated for each nutrient from 100 % [100 % – (% Crude Protein + % Ash + % Crude Fat + % Crude Fiber)].

Microbiological Analysis

Total Plate Count (TPC) for heterotrophic bacteria was determined using APHA (1992) methods. Plate count agar (PCA) was used to determine bacterial load by spread plate technique. A tenfold volume of physiological saline (0.85% NaCl) was serially mixed ten times with ten grams of each sample. Appropriate dilutions of fish homogenate were spread on plate count agar. The colonies were counted for total plate count having plates 30-300 colonies and the count was expressed as log cfu g^{-1} after incubation at 37°C for 24 hours.

Sensory Evaluation

Selected panel members assessed the product's sensory features using a 9-point hedonic scale, with scores ranging from 9 (strongly like) to 1 (strongly dislike) (Siddaiah *et al.*, 2001). During sensory evaluation, appearance, color, odor, texture, and general acceptability were assessed. The indifference area of the judge's emotive relationship to the product was defined as a score of 5 (neither liked nor hated). Scores from 6 to 9 were considered acceptance, whereas scores from 1 to 4 were considered rejection.

Statistical Analysis

The data were expressed as mean with their standard deviation (*SD*). All data were analyzed using IBM SPSS Statistics Version 20. All data were normally distributed and variance were approximately equal. Data were tested through one way ANOVA. Duncan's Multiple Range Test (DMRT) was used to see if there was a significant difference between the means at P<0.05. All bacteriological counts were converted to log cfu g^{-1} for statistical analysis. Graphs and charts were generated using Microsoft Excel 2013 version 15.

Results and Discussion

Proximate composition analysis

Moisture Content

The moisture content (%) of dried tengra in experimental, drying yard and market sample were observed in the range of 17.59±.47 to 21.33±.26; 18.12±.43 to 24.33±.28 and 22.42±.73 to 26.34±.41%, respectively (Figure 1). In each month investigation, significant differences were found among the samples which might be due to differences in temperature and humidity of the air in different months (Nahar *et al.,* 2017) as well as for the duration of the drying period.

Normally the sun-dried fishes contain an average of 10 to 20% moisture (Haque, 2004). In this study, the average moisture content (%) in experiment, drying yard and market tengra shutki sample were 19.82±1.7, 21.44±2.7 and 24.3±1.4%, respectively (Figure 2) which are slightly higher than the referred values. Hasan *et al.* (2006) estimated moisture contents in the range of 26.02% to 27.33%, 16.23% to 22.84% and 13.71% to 19.30% for traditional, rotary and solar tunnel dried products (mola, katchki and tengra products) which are in agreement with the present study. In five dried fish samples of *Mystus vittatus, Channa punctatus, Chanda nama, Corica soborna and Trichuirus haumela,* Flowra *et al.* (2012) found the moisture content ranged from 14.06% to 24.58% which resembles the findings of the present study.

In this study moisture content (%) was reported comparatively higher in market sample than drying yard and experimental sample. The present findings agree well with the findings of Begum *et al.* (2011) who also observed higher moisture content in commercially sun dried Tengra (21.05-23.50%) collected from the local market than the laboratory produced experimentally sun dried tengra fish (15.10-16.90%). Higher moisture content in market sample was also reported from the study of Hasan *et. al* (2018). Generally traditional dried fish products are marketed and stored without packaging materials which facilitates moisture uptake from the environment for which moisture content of traditional dried fish products is high (Hasan *et al.,* 2006). Rasul *et al.* (2018, 2020) concluded that the high moisture content in traditional dried product is due to improper drying and the absorbance of atmospheric water from the surrounding environment during inappropriate packaging and storage.

Lipid Content

The lipid content among the studied dried tengra fish samples ranged within 4.77±.39 to 15.75±.25% (Figure 1), with highest value obtained from experimental sample in the month of January and lowest value from market sample in the month of March. In each month, significant differences were observed among the samples. The average lipid content (%) of tengra shutki collected from experimental, drying yard and market samples were 12.30±2.12, 10.54±1.76 and 9.04±2.41%, respectively (Figure 2). Begum *et al*. (2011) estimated 8.01-10.50% fat in experimentally sun dried tengra and 9.02-12% fat in commercially sun dried tengra collected from the local market which is in agreement with the present study. Similar finding was reported by Hasan *et al.* (2006) who observed lipid content ranged from 8.91% to 16.63% in traditionally dried small indigenous species (SIS) products. Lipid content varied from 4.20% to 13.03% in ten indigenous dried fish is also stated by Rana *et al.* (2020) which goes well with our findings. Higher lipid value than the present study was reported by Rana and Chakraborty

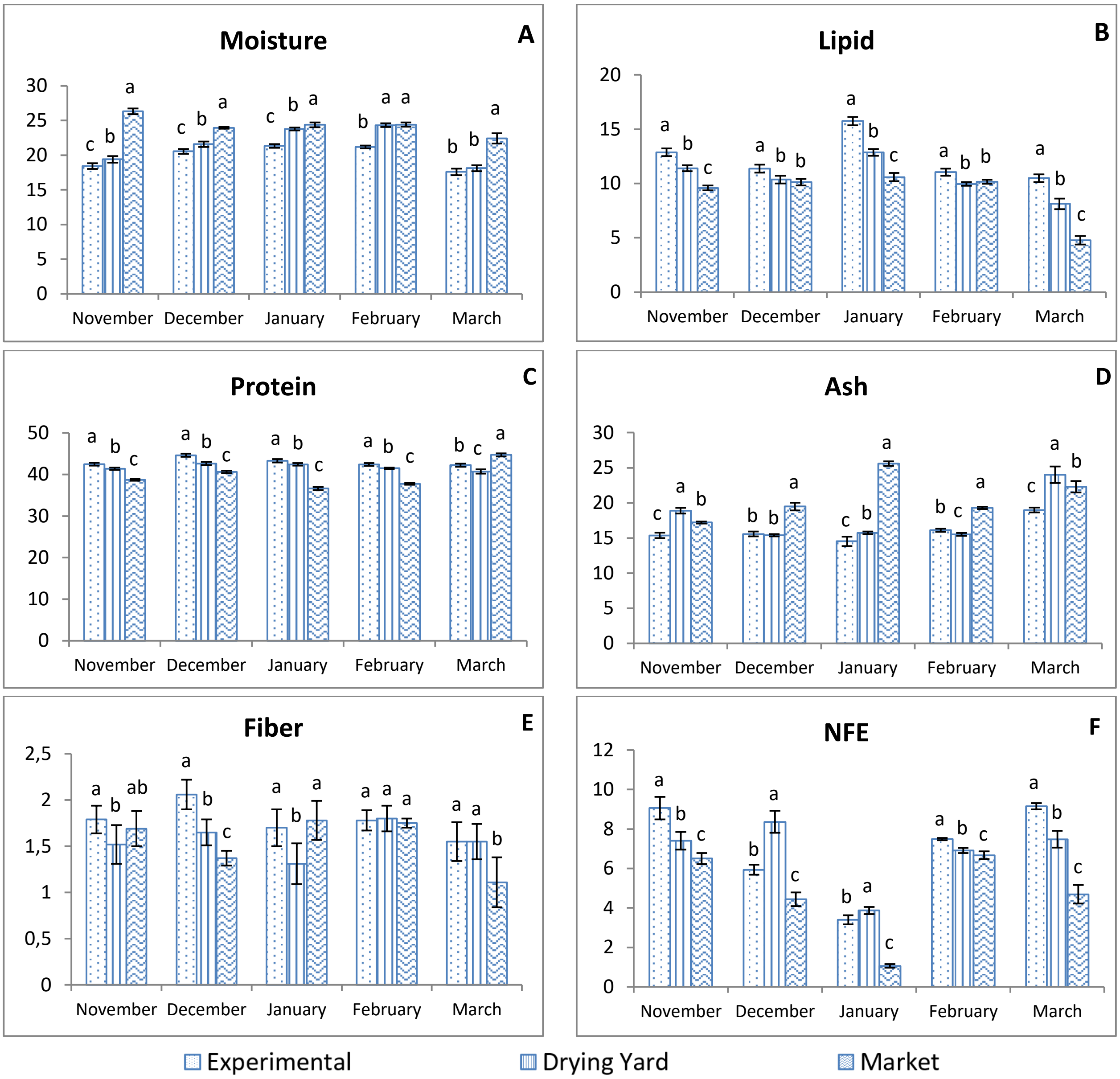

Figure 1. Proximate composition (%) (±SD) of dried striped dwarf catfish samples obtained from different sources; (A) Moisture, (B) Lipid, (C) Protein, (D) Ash, (E) Fiber, (F) Nitrogen free extract (NFE).

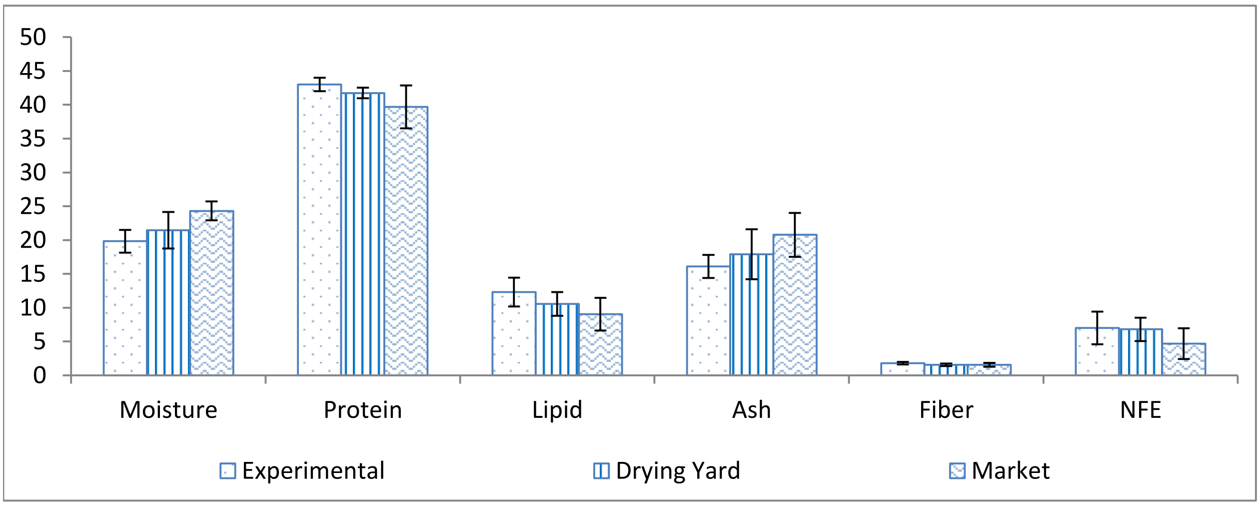

Figure 2. The mean (±SD) value of analyzed parameters of dried striped dwarf catfish collected from different sources during the study period.

(2017) in salt-smoke dried (19.95 ±.14 %) and control dried tengra fish (20.48±.38%). Flowra *et al.* (2012) also estimated higher lipid content in dried *M. vitatus* (17.76%) collected from the local market.

Comparatively higher lipid content (%) was obtained from experimental sample than from drying yard and market. Higher lipid content (%) in experimental sample was also observed in cheap shutki and dried baim respectively from the findings of Nahar *et al.* (2017) and Hasan *et al.* (2018). This is well known that there is an inverse relation of fat with moisture content. The increase rate of lipid in the control product is obvious due to reduction of moisture content (Nahar *et al.,* 2017). Nayeem *et al.* (2010) reported that the poor content of lipid in the product obtained from retailers and wholesalers are probably due to loss of quality at different stage of marketing chain during handling, transportation and preservation.

Protein

Percentage (%) of protein content of dried tengra varied from 36.61±.39 to 44.71±.39% (Figure 1). The average protein content (%) of tengra shutki from five months investigation was 43.01±.10, 41.74±.79 and 39.67±3.18%, respectively in experimental, drying yard and market sample (Figure 2). Hussain *et al.* (1992) reported 17.2 to 78% protein content in 23 different dried species which supports the present study. The protein content was found in the range of 32.02% to 41.38% in dried *Puntius sp.* (puti), *Amblypharyngodon mola* (mola), *Channa punctatus* (taki) and *Glossogobius giuris* (bele) (Islam *et al.,* 2013) resembles the findings of this study. Hasan *et al.* (2006) analyzed 44.72, 48.64 and 47.76% protein value respectively in traditional, solar tunnel dried and rotary dryer dried tengra fish which is higher than our findings. Higher protein value than the present finding was also analyzed by Rana and Chakraborty (2017) in salt-smoke-dried (63.40±.07%) and in control dried (62.52±.13%) Tengra. Begum *et al.* (2011) reported 58.02-63.21% protein in experimentally sundried tengra fish (*Mystus vittatus*) and 52.10-55.31% in commercially sun dried tengra collected from local markets which also differ from the present study.

From this study, it is evident that protein content (%) was comparatively higher in experiment samples than from the samples of drying yard and market. Ahmed *et al*. (2013) and Begum *et al.* (2011) also reported higher values of protein in the samples obtained from control/experiment as compared to samples from producer. Lower level of protein content in the products obtained from retailers could be probably due to the loss of quality at different stages of marketing chain (Ahmed *et al*., 2013).

Ash Content

Ash content (%) in experimental, drying yard and market tengra shutki sample were observed in the range of 14.52±.66 to 18.98±.34; 15.40±.16 to 24.01±1.17 and 17.20±.13 to 25.58±.32%, respectively (Figure 1). In each month investigation, significant differences were found among the samples.

The average ash content (%) of tengra shutki was estimated as 16.11±1.70, 17.91±3.70 and 20.77±3.24%, respectively in experimental, drying yard and market sample during the study period (Figure 2). Flowra *et al.* (2012) estimated ash content varied from 9.63% to 22.73% in the dried fish samples of *Mystus vittatus, Channa punctatus, Chanda nama, Corica soborna and Trichuirus haumela* which is in agreement with the present findings. The present study also agrees well with Hussain *et al.* (1992) who stated that the ash content varied over a large range 1.4-21.6% in 23 different dried species. More or less similar result was obtained by Rana and Chakraborty (2017) in salt smoked dried (16.55±0.07) and in control dried (15.99±0.34) tengra products. Different result was reported by Begum *et al.* (2011) who observed 8-10.50% ash in the experimentally sun dried tengra fish and 12.50-14% ash in the commercially sun dried tengra collected from the local market.

In this study, ash content (%) was found comparatively higher in market sample than the others. This may be due to contamination of the market samples with filth, sand, dust etc. which might occur during handling, transportation and preservation in the marketing chain (Ahmed *et al*., 2013).

Fiber Content

The fiber content (%) of tengra shutki were observed in the range of 1.55±.21 to 2.06±.16, 1.31±.22 to 1.80±.14 and 1.11±.27 to 1.78±.21%, respectively in experimental, drying yard and market sample (Figure 1). In each month investigation, no significant difference was found only in the month of February among the samples.

The average fiber content (%) in experimental, drying yard and market sampled dried tengra during the five months investigation was 1.78±.08, 1.56±.08 and 1.54±.13%, respectively (Figure 2). From the observed results, it is evident that fiber content (%) was comparatively higher in experimental sample than drying yard and market sample. Nahar *et al.* (2017) and Hasan *et al*. (2018) also found higher fiber content in experimental sample in dried chepa and Tengra, respectively but the value of their studies was lower than the present findings. Lower fiber content was also reported in smoked *Clarias gariepinus* (0.25-0.60%), in electric oven dried *Clarias gariepinus* (0.98±0.01%) and in both solar dried *C. gariepinus* and *O. nicotilus* (<1.00%) from the study of Okereke *et al.* (2014), Chukwu and Shaba (2009) and Mustapha *et al.* (2014), respectively. On the other hand, higher fiber content (4.79%) than the present study was estimated in dried *O. niloticus* by Oladipo and Bankole (2013).

Nitrogen Free Extract

The NFE content was varied from 1.06±.10 to 9.15±.16%, with highest value obtained from experimental sample and lowest value from market sample (Figure 1). Significant ($P<0.05$) differences were found among the samples in each month's investigation. The average NFE content (%) estimated in dried Tengra during the five months investigation was 7.01±1.08, 6.80±.77 and 4.67±1.01%, respectively (Figure 2). NFE content (%) was comparatively higher in experimental sample than drying yard and market sample. This agrees well with the findings of Nahar *et al.* (2017) and Hasan *et al.* (2018). Iheanacho *et al.* (2017) found 18.30% NFE in solar dried African catfish (*Clarias gariepinus*) which is higher than the present study.

Nitrogen Free Extracts (NFE) composed mainly of digestible carbohydrates, vitamins and other non-nitrogen soluble organic compounds reduced with the time of storage in case of dried and fermented products. The lower NFE content in the market samples are probably due to reduced carbohydrate content during long time handling, transportation and preservation (Nahar *et al.,* 2017).

Microbial Load Analysis

Total plate count (TPC) of dried tengra fish samples collected from experiment, drying yard and market were observed in the range of 4.40±.14 to 4.68±.25; 4.93±.24 to 5.59±.27 and 6.18±.17 to 6.63±.19 log cfu g^{-1}, respectively (Figure 3). Significant differences were observed among the samples in each month investigation which might be due to the differences in moisture and temperature in different months (Akter *et al.,* 2018).

The mean bacterial load of dried tengra collected from three different sources (experiment, drying yard and market) during the five months investigation were 4.51±.11, 5.33±.25 and 6.39±.18 log cfu g^{-1}, respectively (Figure 4). Mansur *et al.* (2013) estimated total bacterial count of some sun-dried fishes range between 1.84 and 5.3 log cfu g^{-1} which is similar to the present finding. The observations from the present study are in agreement with the opinion of Majumdar (2017) who examined the microbiological load (TPC) in the range of 5.39 to 6.40 log cfu g^{-1} in sun dried taki (*Channa punctatus*), puti (*Puntius sophore*) and chapila (*Gudusia chapra*). Rana and Chakraborty (2017) reported SPC as 4.01 log cfu g^{-1}

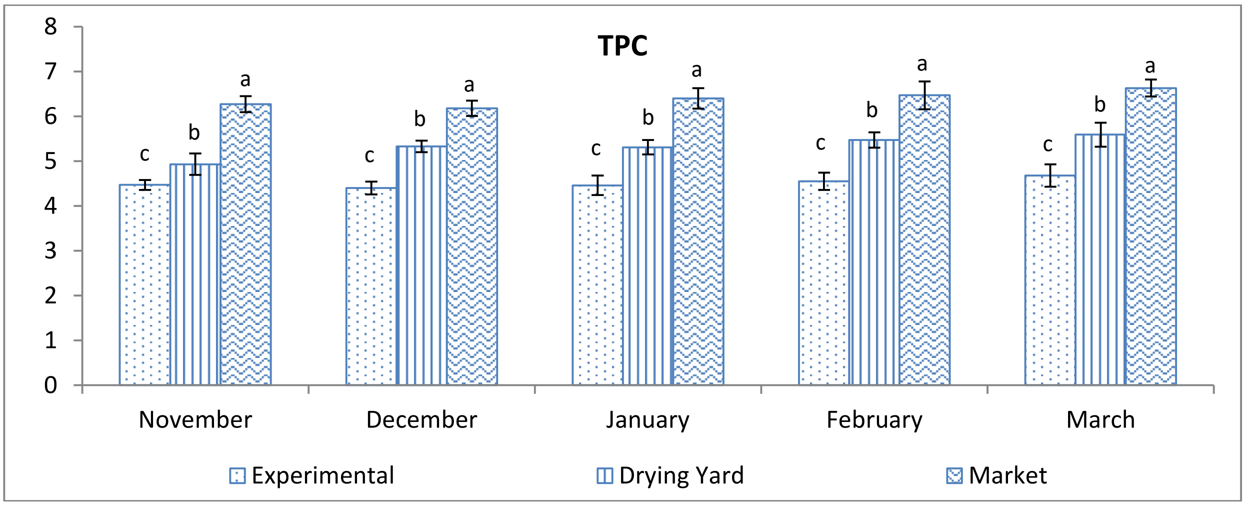

Figure 3. Total plate count (log cfu g^{-1}) of dried striped dwarf catfish samples collected from different sources (n=3) in different months.

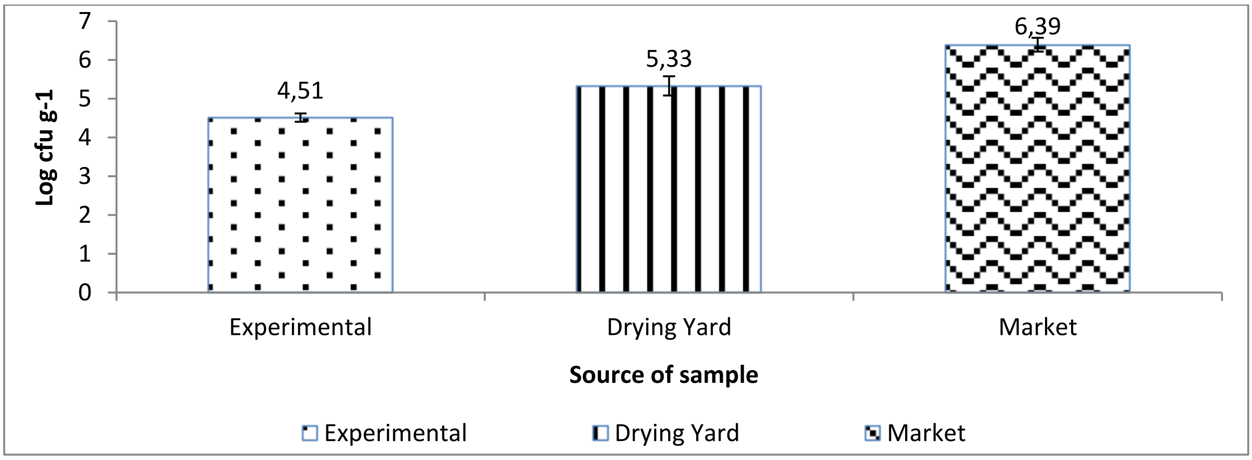

Figure 4. Mean (±SD) bacterial load of dried striped dwarf catfish of different sources.

and 4.26 log cfu g^{-1}, respectively in salt-smoke-dried and control dried tengra which also supports the present study. Slightly lower value than the present study was reported by Farid *et al.* (2017) fin sun-dried salted *M. tengra* (3.45 log cfu g^{-1}).

Total plate count was observed comparatively higher in samples from market than from drying yard and experiment. This result concurs with the findings of Akter *et al.* (2018) who observed comparatively higher bacterial load in market sample than from drying yard and control. Ahmed *et al.* (2013) also reported higher TPC in retailer market sample than the producer sample. Patterson and Ranjitha (2009) enumerated that total plate count (TPC) seemed to be high in the commercially dried fishes than the experimentally dried fishes.

From this study, it is revealed that TPC of tengra shutki from experimental and drying yard sample were found good in quality. According to BSTI (2016), in Bangladesh, the recommended limit of SPC of processed fish to be not more than 6 log $cfug^{-1}$. Besides, the acceptable limit for cooked fish and dried fish is 5 log $cfug^{-1}$ (Sulieman *et al.,* 2014). On the other hand, TPC was found slightly higher in the market sample than the recommend level but didn't exceed 8 log $cfug^{-1}$ bacterial counts thought to cause spoilage of any product (Ojagh *et al.,* 2010). Therefore, it can be considered as in marginally accepted quality.

The occurrence of high TPC might be due to use of low-quality raw fish, poor sanitation practices during processing, inadequate packaging and storage, absorption of moisture from the environment and different stages of marketing chain during handling, transportation and preservation (Nayeem *et al.,* 2010, Ahmed *et al*., 2013 and Khanum *et al*., 2001). In contrast, the low bacterial counts in the products might be attributed due to reduced water activity, which did not favour microbial growth (Smruti *et al.,* 2003). Lilabathi *et al.* (1999) reported that there is a direct relationship between the total microbial count and water content of the dried fish sample.

Sensory Analysis

Sensory quality plays a major role in determining the quality of any products. The sensory evaluation of the product helps in ensuring that the consumers get consistent, non-defective and enjoyable foods (Civille & Carr, 2015). For consumers, the perceivable sensory attributes act as the deciding factors in food acceptance. Likeness score of sensory attributes (appearance, colour, odour, texture, and overall acceptability) for various sources are shown in Figure 5. In each month investigation, sensory scores (except texture) were found significantly ($P<0.05$) different between experimental and market samples and between drying yard and market samples. Only sensory scores of textures were observed varied significantly among the samples of the three different sources in each month investigation. The products were found to have overall acceptability score in the range of 6.0±0.23 to 8.1±0.27 and the present study revealed that all the products were in acceptable limit. Experimental dried Tengra products obtained highest score from the panelists (like very much) and dried Tengra products which were collected from the local markets obtained the lowest score and marked as like slightly. The difference in the sensory quality and overall acceptability of the product might be attributed due to the different degree of biochemical and microbiological changes the dried fish may have undergone during drying and subsequent storage (Kakati *et al.,* 2017).

Conclusion

The food quality of tengra shutki was found higher in experimental sample prepared with maintaining proper hygiene and sanitation. On the other hand, tengra shutki of market sample was found inferior quality for both nutritional and food safety aspects. This may be due to use of low-quality raw fish for drying purpose, lack of hygiene and sanitation, lack of proper packaging system, poor marketing channel and as well as lack of adequate knowledge. The quality and safety of the dried fish product is highly desirable for the health-conscious people in the country. Therefore, it is recommended to use premium quality raw material by the producer as initial quality is essential for the final product. Besides, care should be taken for strict hygienic measures right from the preparation of raw materials, use of utensils, handling practices, processing, drying, during packaging and storage in order to offer quality products to the consumers. A massive awareness building activities and training is also recommended for the retailers as well as for the producer.

Ethical Statement

No animals were harmed during the study period.

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Author Contribution

Md. Mehedy Hasan: Data curation, Formal analysis, Investigation, Methodology, Software, Validation, Visualization, Writing - original draft, Writing - review & editing. **Md Jakiul Islam & Md. Abu Sayeed:** Conceptualization, Data curation, Methodology, Software, Project administration, Resources, Supervision. **Mohammad Abu Jafor Bapary, Md. Atick Chowdhury & Md. Ashraf Hussain:** Writing - review & editing.

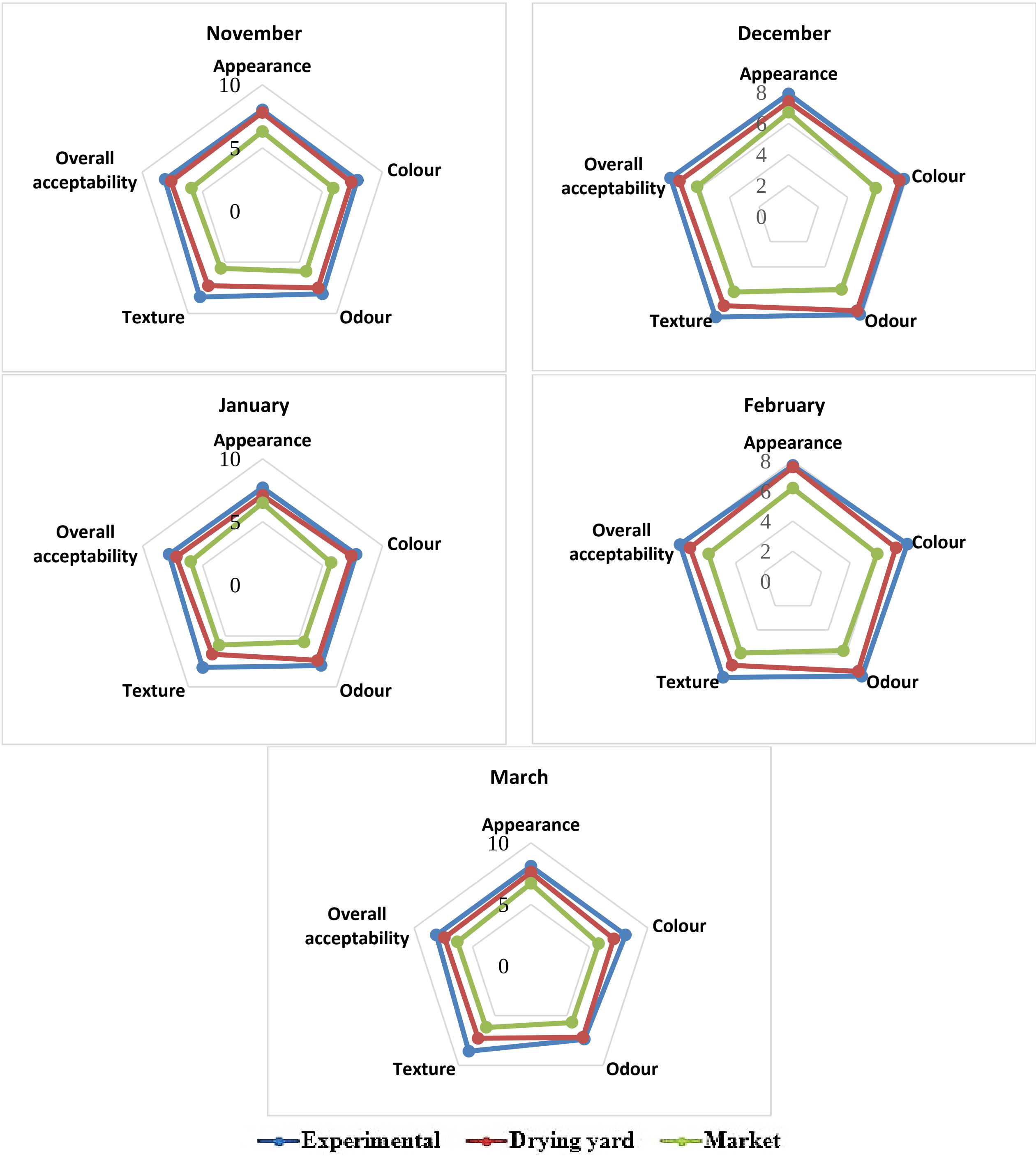

Figure 5. Sensory attributes of dried striped dwarf catfish of different sources in different months.

Conflict of Interest

This article has not published yet and it is not under consideration for publication elsewhere. Its publication is approved by all the authors. If accepted, it will not be published elsewhere in any form. We also have no conflicts of interest to disclose.

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