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Comparison of shelf life quality of salted smoke-dried freshwater fish; Chapila (Gudusia chapra) Kaika (Xenentodon cancila) and Baim (Mastacembelus pancalus) at refrigeration storage (4^0C)

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Abstract: *The purpose of this research was to determine the better shelf life of salt treated smoke-dried freshwater SIS fish, chapila, kaika and baim. This study assessed the comparative changes in sensory characteristics, biochemical components and microbiological quality of three salt treated smoke-dried fish during refrigeration (4^0C) storage using standard methods of analyses. During storage period, the percentage of moisture, TVB-N value (mgN/100g) and TVC (cfu/g) were increased whereas protein, fat and ash contents were considerably decreased. However, there was also a general decline in mean of general acceptability score of smoke-dried fish products during storage. From the overall performance, salted smoke-dried chapila fish (24 month) have better shelf-life than smoke-dried kaika (18 month) and baim (21 month) fish. This study clearly indicated that the proximate values obtained could be of help in choosing salted smoke-dried fish based on nutritional values.*

Keywords: *Bio-chemical composition, freshwater-fish, microbial-quality, smoke-drying*

I. Introduction

As compared to red meat, fish protein is considered slightly superior than any other land animal proteins and is nutritionally equivalent. The enhanced digestibility is mainly because of the fact that most fish muscles are devoid of strong collagenous fibers and tendons common in any other land animals. According to Adekoya and Miller, globally fish and fish products constitute more than 60% of the total protein intake in adults, especially in the rural areas [1]. It also has a high economic value for many countries because it represents the largest share among agribusiness products on the global market [2]. At present the Fisheries Sector in Bangladesh represents as one of the most productive and dynamic sectors in the country which play a major role in employment, nutrition, foreign exchange earnings and other aspects of the economy. The demand for fish in International market had increased substantially in recent years. All- out efforts are being made for increased production of fish, so that more fish are available for export. As fish is highly perishable material, so whatever may be the amount of harvest, it has no value until it reaches the consumer as food. Proper pre-treatment or processing of premium quality fresh fish can minimize the post harvest loss and thus reduced the amount of fish spoilage. Spoilage of fish occurs concurrently and independently, their relative importance varying with species of fish (size, lipid content, stage of maturation etc.), environmental conditions (feed availability, temperature, microbial load etc.), method of slaughter and post-mortem handling, storage procedures and processing conditions [3].

Various food preservation techniques have been utilized to improve the microbial safety and to extend the shelf life of fish in general, including icing, freezing, chemical preservation, salting and smoking. Besides this, some of these techniques can also be used to enhance the value of fish, such as smoked fish. . The advantages of exposing food to smoke are several; it preserves food, enhance flavor and protects against infestation by insects. Originally, smoking of fish was an incident occurrence when in period of wet or humid weather; fishermen had to resort to the use of open fires, rather than sun and wind, to dry their surplus catch. It was much later that the microbiocidal and antioxidant effects of smoke processing came to be appreciated. But fish smoking especially smoke-drying of small indigenous species (SIS) of fish is very limited in Bangladesh. Therefore, this study has been carried out to see the feasibility and suitability of fish smoking particularly for SIS of fish in Bangladesh.In this research three small indigenous freshwater fish species; chapila kaika and baim were used for study which is in high demand in many part of the country due to high palatable, unique taste and rich in nutrients. Very little information is available on literature regarding the preservation aspects of these fishes. Fish is normally salted before smoking. Different salting methods are being practiced by the smoked fish industry in different parts of the world [4, 5]. Salt has been used as a preservative since ancient times, to protect food against bacteria, mold, and spoiling. Basically, salt works by drying food. Salt absorbs water from foods, making the environment too dry to support harmful mold or bacteria. Table salt or sodium chloride is a common

preservative because it is non-toxic, inexpensive, and tastes good. Thus, this research is aimed at studying the effectiveness of dry salt for extending the shelf-life by analysis of sensory evaluation, biochemical composition (proximate composition and TVB-N value) and microbiological quality in smoke-dried chapila, kaika and baim fish during storage at refrigeration temperature (4°C).

II. Materials And Methods

2.1. Sample collection

Three freshwater fish species; chapila *(Gudusia chapra)*, kaika (*Xenentodon cancila*) and baim (*Mastacembelus pancalus*) were collected from the Meghna River early in the morning. Fresh mature fish samples were transported to laboratory in sterile polythene bag to avoid any type of microbial contamination.

2.2. Place of experiment

The whole experiment was carried out at the laboratory of Fish Technology and Food Microbiology Section of the Institute of Food Science and Technology (IFST) of Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhanmondi, Dhaka.

2.3. Preparation of Sample for processing

At first, the collected chapila fish was discaled while kaika and baim fish was beheaded. Then three fish samples were gutted and washed properly with clean water. The dressed fish samples were then weighed and prepared for further processing. Then brine containing 30% salt solution was prepared in 3 separate plastic buckets and the fish samples were kept immersed into this solution for 20 minutes.

2.4. Fish smoke-drying

The fishes were smoked in improved traditional type of smoking kiln [6]. The fish smoking kiln was operated by first loading tamarind wood chips and rice-husk into the heat chamber, preheating for some minutes and then loading the fish-samples onto removable wire mesh trays in its central chamber for the smoking process. The desired temperature (70-75^{0}C) was maintained manually. Smoking was done approximately for 4 hours. During the smoking fish samples were turned upside down in the middle period, to make the sample smooth and steady in texture and appearance. The smoked fishes showed characteristic attractive golden brown color and acceptable texture with smoky flavor, which was followed by cooling for 20-30 minutes at ambient temperature to make fish muscle compressed and facilitate to prevent breaking of smoked products.

2.5. Storage for shelf life study

The marked, cooled salt treated smoked-dried fish samples were then packed in transparent polythene bags. Bags were then sealed by using an electrical sealing machine (PFS-300). After that, three groups of smoke-dried fish product were then kept for storage at refrigeration (4^{0}C) temperature for further analysis.

2.6. Sample preparation

Salt treated smoke-dried fish samples were fairly minced and homogenized in a blender for the analysis.

2.7. Analysis

For quality analysis-Sensory evaluation, biochemical and Microbial analysis were done. Sampling was done on every 3rd month for fish kept at refrigeration (4^{0}C) temperature. The analytical methods are given below:

- Sensory score value were assessed by the sensory method as described by Larmond [7].
- Moisture, fat and ash contents of the fish were determined by AOAC method [8].
- The crude protein of the fish was determined by Micro-Kjeldahl method [9].
- TVB-N using Conway modified micro-diffusion technique [10].
- Microbiological analysis was done according to the standard methods of AOAC [11]

III. Results And Discussion

3.1. Sensory score value

Sensory methods are considered to be the most useful and dependable criteria for assessing the degree of freshness for quality determination. Human being is capable to detect defects from visual signs of deterioration such as loss of freshness and changes during storage period. Sensory quality assessment is an easy, quick and efficient method of getting idea about the quality of the product. This method is based on the response or tendency of sense organ for accepting the food products. The quality assessment as well as sensory evaluation (score) was carried out every three months intervals for samples stored at refrigeration temperature (4^{0}C) using trained panel of four judges following 9-point ascending scale to evaluate changes in color, odor, texture, general appearance and mean of general acceptability score until it was an acceptable condition [12]. Smoked fish is highly desirable because of its enhanced flavor and texture in fish in addition to the protection offered by smoking against microbiological, enzymatic and chemical deteriorative alterations [13]. The aroma from all these smoke-dried fish samples was characteristically desirable. The smoke determines the color which is one of the qualities that attracts consumers. The color ranges from black, dark brown, golden brown or light brown to dirty white [14]. The shelf-life of these three types of salted smoke-dried fish products were found to be related to the temperature and the length of storage. At the beginning of storage all the sensory parameters of these

three salted smoke-dried fish samples were rated as good based on the grading scale. Moreover, there was found no broken parts of three experimental fishes after smoke-drying process. The highest mean of general acceptability score was found 8.80, 8.86 and 8.88 in fresh process salted smoke-dried chapila, kaika and baim fish products respectively (Fig. 1).

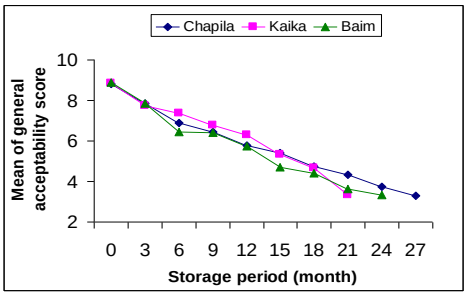

Fig. 1 Changes in mean of general acceptability score of Salted smoke-dried chapila, kaika and baim fish during storage at refrigeration temperature (4°C)

The mean of general acceptability score decreased as storage-duration increased and the acceptability score <3.5 is considered as rejected or spoiled for all the salted smoke-dried products. The mean of general acceptability score of the end product of smoke-dried chapila, kaika and baim was 3.73 (24 month), 4.65 (18 month) and 3.64 (21 month) respectively (Fig. 1). The results of the sensory analysis indicated that the storage lives of these smoke-dried fishes were different. At the end of 21 (3.33) month, salted smoke-dried kaika fish products became spoiled whereas salted smoke-dried chapila and baim fish products were still remain in good condition. Salted smoke-dried chapila and baim fish products became spoiled at the end of 27 (3.28) and 24 (3.34) months of storage period. This agrees with the results of research into storage of smoke dried fish and crustaceans (Oyster and shrimps) which revealed quality loss during storage both at ambient temperature and chilling [15,16,17].

3.2. Biochemical analysis

In the present study the values obtained from the analysis of biochemical composition includes proximate composition (moisture, protein, fat, ash) and TVB-N value. During salted smoke-drying, the percentage of moisture content decreased and protein, lipid and ash content increased due to water loss. This observation is in agreement with the findings of Atlantic mackerel and European eel, pike perch and rainbow trout [18, 19]. Similarly, smoke drying methods increased the protein, ash and fat contents of *C. gariepinus* [20].

3.2.1. Moisture (%) Content: The moisture content can be used as a pointer to the rate at which deterioration occurred in fish samples resulting in the early decomposition. The initial (0 day) percent of moisture were found 5.31%, 7.15% and 7.36% for salted smoke-dried chapila, kaika and baim fish respectively (Fig. 2 , Fig. 3 and Fig. 4). There was a gradual increase in the moisture content of these three types of salted smoke-dried fish samples with increasing storage period. In the present study, the moisture content of salted smoke-dried chapila, kaika and baim fish rose to 10.04 % (24 month), 8.36% (18 month) and 9.15% (21 month) respectively during storage at refrigeration temperature (Fig. 2, Fig. 3 and Fig. 4). The increase can be attributed to absorption of moisture from the surrounding since there was no re-drying during storage [15]. The gutted smoke dried fish samples of African cat fish (*Clarias nigrodigitus*) had moisture content as 6.27 to 10.92% which is more or less similar with present study [21]. The shelf-life of three types of smoke-dried fish samples were more or less similar with the observation of Jallow who stated that fish at 10-15% moisture content reportedly had a shelf-life of 3-9 months when stored properly [22].

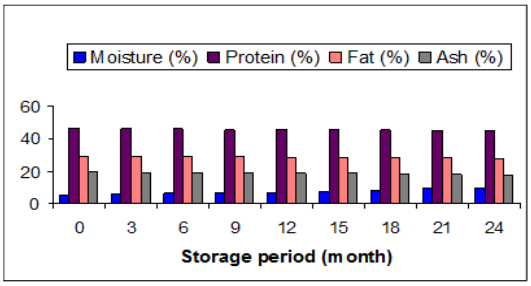

Fig. 2 Changes in Proximate Composition of Salted smoke-dried chapila (*G. chapra*) fish during storage at refrigeration temperature (4^0C)

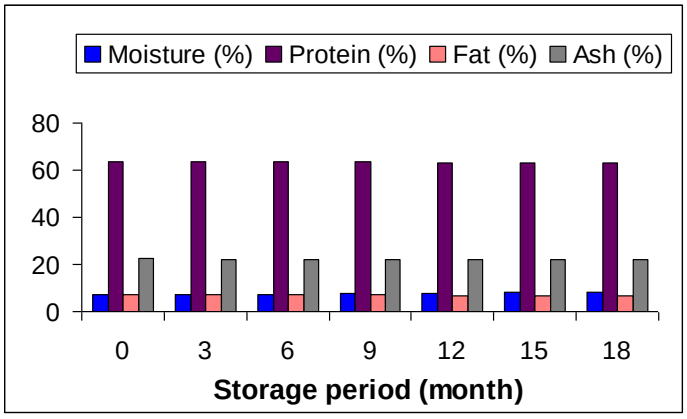

Fig. 3 Changes in Proximate Composition of Salted smoke-dried kaika (*X. cancila*) fish during storage at refrigeration temperature (4^0C)

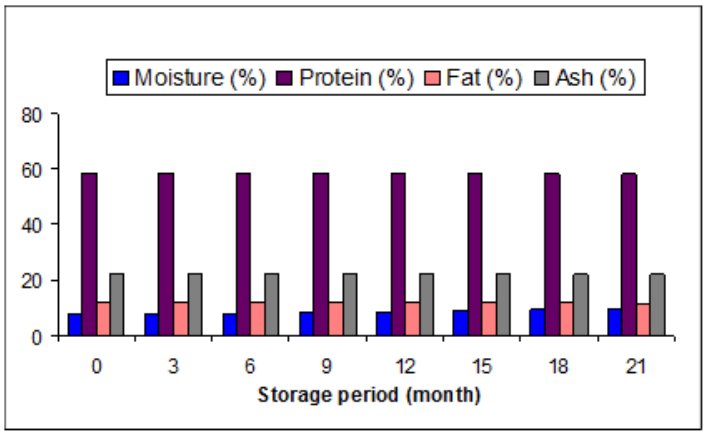

Fig. 4 Changes in Proximate Composition of Salted smoke-dried baim (*M. pancalus*) fish during storage at refrigeration temperature (4^0C)

3.2.2. Protein (%) Content: Fish protein is of high quality and contains sufficient amounts of all the essential amino acids required by the body for growth, maintenance of lean muscle tissue and active metabolism [23]. In this study, the protein content increased in smoked chapila, kaika and baim fish , when compared with the fresh fish, suggested that protein nitrogen was not lost during smoke-drying [24,25]. Also this is in harmony with the findings of Ogbonnaya and Shaba [26]. The increase in crude protein level can be explained by Kumolu-Johnson *et al*. who stated that smoking resulted in concentrating crude protein components of fish [27]. This concentration was resulted from the loss of moisture by the smoking process as opined by Koral *et al.* [28]. Highest protein value was found in salted smoke dried kaika fish (63.56%) while least was found in salted smoke-dried chapila fish (46.47%) in fresh process condition. Protein decomposes with passing time [29]. Protein (%) were found to vary from 46.47% (0 day) to 44.72% (24 month), 63.56% (0 day) to 63.12% (18 month) and 58.56% (0 day) to 58.07% (21 month) for smoke-dried chapila, kaika and baim fish respectively during storage at refrigeration temperature (Fig. 2 , Fig. 3 and Fig. 4). In storage condition, the protein content decreased significantly with the time due to water soluble protein diffused out to the surrounding for exosmosis [30]. This could be due to gradual degradation of initial crude protein to more volatile products such as total volatile bases, hydrogen sulphide and ammonia [31]. Similar drop in protein concentration was reported for *Heterobranchus longifilis* [32]. Also Daramola *et al*. was found the decreasing trend of protein content in hot smoked *C. gariepinus* during storage period which is in line with the present findings [33].

3.2.3. Fat (%) Content: After smoke-drying, there was an increase in fat content and this variation could be the result of evaporation of moisture contents which is in agreement with the previous works of Ogbonnaya and Shaba; Daramola *et al*.; Bouriga *et al*. and Bilgin *et al.* [15,26,34,35]. During storage at refrigeration temperature the fat content varied in a range of 29.05-28.05%, 7.12-6.73% and 11.98-11.38% in salted smoke-dried chapila, kaika and baim fish respectively (Fig. 2, Fig. 3 and Fig. 4). Usually moisture and fat contents in fish flesh are inversely related and there sum is approximately 80% [36]. This inverse relationship was also well defined in this experiment.

3.2.4. Ash (%) Content: Ash content of smoke-dried fish samples was higher than that of fresh fish. Clucas and Ward reported that the inorganic content remain as ash after the organic matter is removed by incineration [37]. Salan, Juliana and Marilia observed increase of ash content in smoked *C. gariepinus* and the authors further noted that the increase in the ash content in the smoked fish was due to the loss of humidity and that the significant reduction in the moisture content when the fish was smoked as a result of the loss in moisture during hot smoking which was in agreement with the present study and also similar result for ash content of smoked fish have been reported in previous study [38, 35, 39]. Also Doe and Olley reported that smoking resulted in the concentration of nutrients, such as, protein and ash [40]. Ash (%) content was found to vary from 19.92% (0 day) to 17.72% (24 month), 22.31-% (0 day) to 21.90% (18 month) and 22.45% (0 day) to 21.83% (21 month) for salted smoke-dried chapila, kaika and baim fish respectively during storage at refrigeration temperature (Fig. 2, Fig. 3 and Fig. 4). The ash content changes with the time of storage due to absorbance of moisture and loss of protein [30]. Smaller sized fish species has higher ash content due to the higher bone of flesh ratio [15].

3.2.5. TVB-N value: Total Volatile Base Nitrogen (TVB-N) levels were monitored as the main parameter of fish muscle freshness. It helps to measure the level of fish spoilage and to explore the shelf life of fish. TVBN are produced by decomposition of proteins into simpler substances (ammonia, trimethylamine, creatine, purine bases and free amino acids) [41]. In this study the higher value of TVB-N were reported in fresh smoke-dried chapila, kaika and baim fish compared with fresh fish. An increase of TVBN after smoking was most likely caused by an autolytic process which produces volatile amine compounds [42]. This agrees with the report of Adeyemi *et al.* which stated that the TVBN of *T. trachurus* before smoking was 28.12±0.38mg N/100g and rose to 31.90±0.3mgN/100g after smoking [43]. Vasiliadou *et al.* also observed an increase in the TVB-N value after smoking [44]. The initial (0 day) TVBN values obtained from salted smoke-dried chapila, kaika and baim fish were 4.29 mgN/100g, 7.44 mgN/100g and 5.92 mgN/100g (Fig. 5).

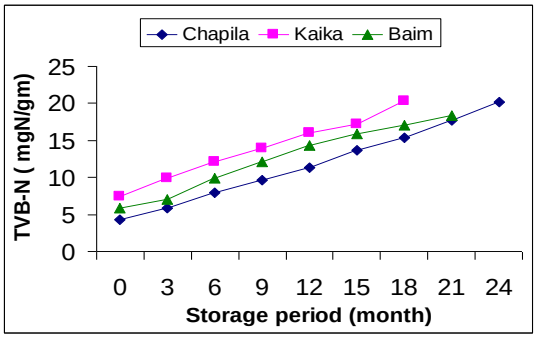

Fig. 5 Changes in TVB-N value of Salted smoke-dried Chapila, Kaika and Baim fish during storage at refrigeration temperature (4°C)

There was continuous increase in the TVB-N value of all the salted smoke-dried samples all throughout the period of storage (Fig. 5)) which could be due to gradual degradation of the initial protein to more volatile product such as total volatile base nitrogen [15]. The increase in TVB-N throughout the storage period may be due to microbial activity, storage temperature, absorption of moisture .Pearson recommended that the limit of acceptability of fish is 20-30 mg N per 100g [45]. While Kirk and Sawyer suggested a value of 30-40mg N/100g as the upper limits [46]. Increase in final values of TVB-N in this study is similar with other researchers [32, 47]. During hot smoking fish are exposed to heat and atmospheric oxygen. These factors can accelerate the oxidation of the fish lipids resulting in an increased in TBA [35].

3.4. Microbiological analysis: The total viable counts (TVC) of salted smoke-dried chapila, Kaika and baim fish samples are presented in (Table-1).

Table-1. TVC (cfu/g) of salt treated smoke-dried chapila (*G. chapra*), kaika (*X. cancila*) and baim (*M. pancalus*) fish during storage at refrigeration temperature (4°C)

Storage period (month)	Chapila	Kaika	Baim
0	3.7×10^{3}	1.1×10^{3}	1.4×10^{3}
3	5.3×10^{3}	3.6×10^{3}	4.4×10^{3}
6	6.6×10^{3}	1.9×10^{4}	1.1×10^{4}
9	2.5×10^{4}	5.3×10^{4}	2.0×10^{4}
12	4.2×10^{4}	2.6×10^{5}	5.1×10^{4}
15	7.0×10^{4}	4.8×10^{5}	2.4×10^{5}
18	3.3×10^{5}	1.9×10^{6}	6.6×10^{5}
21	8.8×10^{5}	-	2.1×10^{6}
24	2.0×10^{6}	-	-

Results showed that freshly processed salted smoke-dried fish samples had relatively lower total viable counts of bacteria. This can be explained by the bactericidal effect of smoke constituents such as acids, aldehydes and phenols [48]. In view of present study, Total Viable Counts (TVC) of salted smoke- dried chapila, kaika and baim fish samples ranged from 3.7×10^3 (0 day) to 2.0×10^6 cfu/g (24 month), 1.1×10^3 (0 day) to 1.9×10^6 cfu/g (18 month) and 1.4×10^3 (0 day) to 2.1×10^6 cfu/g (21 month) respectively (Table-1). Total Viable Counts (TVC) of smoke-dried fish samples were increased with increase in the duration of storage due to growth and multiplication of the microbes [35]. As the duration of storage increased processed fish samples may absorb small amounts of moisture from surrounding atmosphere providing enabling environment for microbial growth [48]. Smoking inhibits microbial growth in stored fish products [38]. It is generally accepted that fish with microbial load $>10^6$cfu/g is likely to be at the stage of being unacceptable from the microbiological point of view and unit for consumption which agrees with the present research work [49].

IV. Conclusion

The present study provides a possible application of salt treated smoke-drying as an efficient drying process for fish especially in developing countries where all the required sophisticated storage equipment is not available. Smoke-drying process have a positive significant role on the biochemical composition of salt treated smoke-dried chapila *(Gudusia chapra)*, kaika (*Xenentodon cancila*) and baim (*Mastacembelus pancalus*) fish products and reduces bacterial load as well as makes them nutritionally suitable for all. Smoke-drying methods are efficient in the post harvest management of fishery products which could be improved the preservative strategies of dried fish and thus prolong the shelf life of one of the commercially important food commodities in the tropics.

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