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Effect of Salt and Turmeric treated smoke-drying method on the sensory, proximate, chemical and microbial quality of *G. chapra*, *X. cancila* and *M. pancalus* fish

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Abstract
Smoke-dried fishes are highly appreciated because of their characteristic taste, texture and storage stability. In present study, the combine effect of salt and turmeric powder along with smoke-drying process on the production of high quality smoke-dried fish-products from *G. chapra*, *X. cancila*, *M. pancalus* and their nutritive value was investigated. The percentage of proximate-composition such as, moisture contents was 6.21, 8.24 and 6.97; protein contents were 45.93, 63.04 and 59.22; fat contents were 30.81, 6.71 and 11.67; ash contents were 18.95, 22.52 and 22.54 respectively for *G. chapra*, *X. cancila* and *M. pancalus*. Chemical-parameters and Total Viable Counts were in acceptable limits. Minerals included calcium (705-750 mg/100g) and magnesium (25.30-152.50mg/100g) while iron, zinc, copper and manganese were present in trace amounts. The data has proved with strong evidence that Salt-Turmeric treated smoke-dried three experimental fishes are rich in most of the nutrients essential for proper health maintenance of humans.

Keywords: smoke-drying, salt-turmeric, minerals, proximate-composition, chemical-composition, microbial-quality

1. Introduction
Fish as a food is one of the most familiar, popular, tasty and nutritionally enriched item of food around the world including Bangladesh. Fisheries items are the major protein source of Bangladesh which contributing 58% of the nation's animal protein demands [1]. In terms of weight of food consumed, fish ranks third after rice and vegetables [2, 3]. Fish flesh generally contains up to 80% moisture, 15-25% protein, 1-2% mineral matter [4]. Small fishes which are eaten with bones are available source of highly bioavailability Calcium. The composition of a particular species often appears to vary from one habitat to another, and season to season, but the basic causes of change in composition are usually variation in the amount and quality of food it eats and in the amount of movement it makes [5]. The human body usually contains small amount of these minerals and the deficiency in these principal productivity and causes diseases.

Depending on consumer preference, there are several forms in which fish can be consumed; fresh, dried, frozen, fermented, brined etc. In Bangladesh majority of the people reported a preference for fresh fish but limitations such as the low keeping quality of the fish after harvest and the distances between fishing grounds and marketing outlets make this very difficult. Various factors are responsible for fish spoilage. The enzymes begin to break down fish tissues. In the dead fish, the control system fails and the enzymes begin to act on the alimentary system and fish flesh, thereby resulting in soft destructive changes. This process is referred to as autolytic spoilage. The central concern of fish processing is to prevent fish from deteriorating and to ensure that fish and fish products get to the consumer in acceptable quality. Therefore, the fish has to be processed, preserved and stored which will invariably reduce post-harvest losses. Various traditional methods are employed to preserve and process fish for consumption such as refrigeration, freezing, canning, smoking, salting, and drying [6]. Besides this, some of these techniques can also be used to enhance the value of fish, such as smoked fish. The technique has developed to a point where once common food has become a delicacy and there is need for corresponding concern for safety issues in smoked fish consumption [7]. The smoking process was basically used in the past for preservative purposes, although the changes in color, odor, flavor and texture which were provoked in foods by this process were also judged as desirable. Nowadays, due to the great advance of preservative techniques, smoking is used fundamentally for the development of sensory properties in food [8]. Ward reported that smoke-drying had been used for centuries in preserving fish, and is still widely used for this purpose among several communities in the third world where up to 70% of the catch is smoked [9].

In Bangladesh, chances of contamination and uncertainly in weather conditions affect the quality of dried fish products and thereby marketing. To enhance market acceptability & awareness about hygienic practices, new method of smoke-drying is essential. Smoking demonstrated a better efficient method of fish processing in terms of the retention of protein value and reduction in the moisture content [10].

In this study salt and turmeric were used in smoke-drying fish so that moisture removes very quickly from fish tissue with a limited time. Due to the consumer awareness of chemical preservatives, extensive studies are been made on natural preservatives for preservation of meat and fish products. In

Bangladesh, turmeric and salt is easily available and cheaper cost wise. Table salt or sodium chloride is a common preservative because it is non-toxic, inexpensive, and tastes good whereas turmeric is one of the oldest known anti-bacterial ingredients used by the ancient civilizations. Turmeric (*Curcuma longa*) has long been used as a coloring and flavoring agent for foods. In Bangladesh, turmeric is considered as one of the important ingredient for cooking any kind of dish. Even in some parts of Bangladesh, rural people usually use turmeric for short time preservation of small sized fishes.

The measurement of some proximate profiles such as proteins, lipids, energy, ash and mineral contents is often necessary to ensure that they meet the requirements of food regulations and commercial specifications [11]. A number of studies on biochemical composition of dried fishes were found in the literature but, there is very little scientific information about the use of turmeric in fish preservation especially in smoke-drying. Moreover, little is known about the nutritional quality and no work yet done in mineral composition of salt and turmeric treated smoke-dried fish products. In view of above facts, the present study was therefore initiated to produced high quality smoke-dried products of three most popular freshwater lean fish species namely *G. chapra* (chapila), *X. cancila* (kaika) and *M. pancalus* (baim) in Bangladesh treated with the combination of salt and turmeric and to assess their sensory characteristics, proximate composition, chemical compositions, mineral contents and microbial quality**.** Also the purpose of this study is to inform the consumer about the nutrient contents of these three newly processed salt and turmeric treated smoke-dried fish-products and to guarantee its optimal use as a good source of healthy food and energy.

2. Materials and methods

2.1 Sample collection

Three freshwater fish species; *Gudusia chapra* (chapila), *Xenentodn. cancila* (kaika) and *Mastacembelus. pancalus* (baim) 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 and only mineral work was done in Center for Advanced Research in Science (CARS).

2.3 Preparation of Samples

At first, the collected *G. chapra* fish was discaled while *X. cancila* and *M. pancalus* 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.

2.4 Preparation of samples for processing

Dressed fishes were then dip in freshly prepared brine, containing of 30% salt with 10% turmeric solution in 3 separate plastic buckets and kept immersed into this solution for 20 minutes followed by draining.

2.5 Fish smoke-drying

The fishes were smoked in improved traditional type of smoking kiln [12]. 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.

2.6 Sampling procedure

3 or 4 slices of experimental fishes were taken randomly which represented the parts from whole body of the fish. Then the slices were chopped with skin and bone and finally ground with an electric blender to make a homogenous sample before being sampled for analysis.

2.7 Parameters of quality assessment

The analytical methods are given below:

- Sensory evaluation was assessed by the sensory method as described by Larmond [13].
- Moisture, fat, ash and salt contents of the fish were determined by AOAC method [14].
- The crude protein of the fish was determined by Micro-Kjeldahl method [15].
- TVB-N using Conway modified micro-diffusion technique [16].
- Microbiological analysis was done according to the standard methods of AOAC [17].
- Samples for mineral analysis were prepared according to recommendations of Perkin Elmer's procedures of Atomic Absorption Spectrometer [18].

3. Results & Discussion

Study of Salt and Turmeric treated smoke-dried *G. chapra* (chapila), *X. cancila* (kaika) and *M. pancalus* (baim) in fresh process condition:

Among the freshwater small fish species *G. chapra*, *X. cancila*, *M. pancalus* fishes are very delicious, nutritious and popular to the consumers. Now it is of interest to know the nutritional quality of smoke-dried *G. chapra*, *X. cancila*, *M. pancalus* fishes by assessing their sensory characteristics, proximate composition (moisture, protein, fat ash), chemical composition (salt and TVB-N value), mineral contents and microbiological quality.

3.1 Sensory evaluation

The results from the sensory assessments corroborated the assertion of Sefa-Dedeh that differences between fish species may be reflected in the quality of the smoked fish [19]. Sowumi stated that smoked fish is highly desirable because of its enhanced flavour and texture in fish in addition to the protection offered by smoking against microbiological, enzymatic and chemical deteriorative alterations [20]. The sensory evaluation of Salt+Turmeric (S+T) treated smoke-

dried *G. chapra, X. cancila* and *M. pancalus* fish samples were evaluated on the basis of the color, odor, texture and remarks which are presented in Table 1.

Table 1: Sensory evaluation of freshly processed Salt and Turmeric treated smoke-dried *G. chapra, X. cancila* and *M. pancalus* fish-products

Experimental fishes	Color	Flavor/Odor	Texture	Remarks
G. chapra	Bright yellowish brown	Fresh smoky turmeric flavor	Firm & semi-elastic	Excellent
X. cancila	Yellowish brown	Fresh smoky turmeric flavor	Firm & semi-elastic	Excellent
M. pancalus	Yellowish brown	Fresh smoky turmeric flavor	Firm & semi-elastic	Excellent

Flavor/odor is an important quality parameter, as poor odor will discourage people from accepting food products. S+T and S+G treated smoke-dried *G. chapra, X. cancila* and *M. pancalus* fish samples showed that apart from the preservative effect of turmeric also acted as flavoring substances. However, the aroma from S+T treated smoke-dried *G. chapra, X. cancila* and *M. pancalus* fish samples were characteristically desirable. The smoke determines the color which is one of the qualities that attracts consumers. Clucas stated that the color ranges from black, dark brown, golden brown or light brown to dirty white [21]. From Table1. It is clearly shown that the texture of all the freshly processed smoke-dried samples was firm and semi-elastic. In fresh process condition the remarks of all the smoke-dried products were considered excellent. Moreover, there was found no broken parts of the experimental fish after smoke-drying process.

3.2 Proximate composition

Proximate composition of fish varying with species, body size, season, environmental factors and nutritional status [22]. Proximate composition of *G. chapra, X. cancila* and *M. pancalus* fish subjected to Salt and Turmeric (S+T) treated smoke-drying method in fresh process condition are presented in Figure 1. In present study, freshly processed Salt and Turmeric treated smoke-dried *G. chapra, X. cancila* and *M. pancalus* fish-products, moisture (%) content were 6.21%, 8.24% and 6.97%; protein (%) content were 45.93%, 63.04% and 59.22%; fat (%) content were 30.81%, 6.71%, and 11.67%; ash (%) content were 18.95%, 22.52%, and 22.54% respectively.

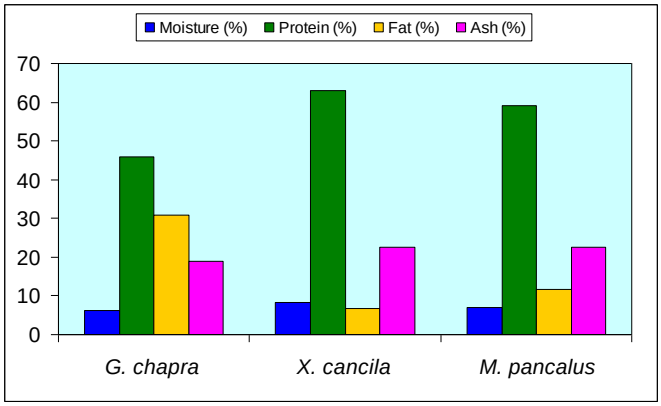

Fig 1: Proximate composition of freshly processed Salt and Turmeric (S+T) treated smoke-dried *G. chapra, X. cancila* and *M. pancalus* fish-products

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 moisture content of S+T treated three experimental smoke-dried fish samples decreased sharply after the smoking process. The low moisture content is to reduce to minimum conditions in the fish that allow for spoilage organisms and chemical activities. This decrease was caused by loss of water during smoking which was observed by Salan *et al.* [23]. Similar results were reported for smoked Atlantic salmon, hot smoked Cat Fish and smoked Nile tilapia [24, 25, 26]. Kaneko reported that a lot of proteolytic, lipolytic deterioration and microbial proliferation are encouraged at moisture levels of 15% and above [27]. In present study, the moisture levels in all the smoke-dried fishes examined were below 20% (Figure-1) which is good or acceptable for smoke-dried fishes suggested by Lilabati and similar result was also found by Hei and Sarojnalini in some smoke-dried hill stream fishes (9.36±0.01-15.77±0.02%); Adebowale *et al.*in four types of smoked *C. gariepinus* (7.16-10.71%) and Akinwumi in smoked *Clarias gariepinus* (5.885±0.034%) [28, 29, 30, 31].

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 [32]. Fapohunda and Ogunkoya reported that smoke drying methods increased the protein, ash and fat contents of *C. gariepinus* which is in line with the present research work [33]. 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 [34]. This concentration was resulted from the loss of moisture by the smoking process as opined by Koral *et al.* [35]. In this study good amount of protein value was found in S+T treated smoke dried *G. chapra, X. cancila* and *M. pancalus* fish. Thus it can be said that these smoke-dried fishes are a good source of pure protein and would be more than enough to prevent malnutrition in children and adult who feed solely on this fish as a main source of protein. Protein value of freshly processed S+T treated smoke-dried *G. chapra, X. cancila* and *M. pancalus* is more or less similar with the findings of Ezembu and Onwuka in smoked cat (*Clarias gariepinus),* croaker *(Genyonemus lineatus),* sardine (*Sardinella aurita*); Al-Reza *et al.* in smoked chela (*Laubuka dadiburjori*) fish and Adebowale *et al.* in four types of smoked *C. gariepinus* [36, 37, 30].

After smoke-drying, there was an increase in fat content could be the result of evaporation of moisture contents which is in agreement with the previous works of Chukwu and Shaba, Kabir, Islam, Daramola *et al.*, Bouriga *et al.*, Bilgin *et al.*, Ezembu and Onwuka [38, 39, 40, 41, 42, 43, 35].

Clucas and Ward reported that the inorganic content remain as ash after the organic matter is removed by incineration [44]. Salan *et al.* 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 of Bilgin *et al.*, Doe and Olley,

Kumolu-Johnson *et al*. [23, 43, 45, 34]. Smaller sized fish species has higher ash content due to the higher bone of flesh ratio [41].

3.3 Chemical composition

Changes in chemical composition (TVB-N and salt content)) of salt and turmeric treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fish in fresh process condition are shown in Figure 2.

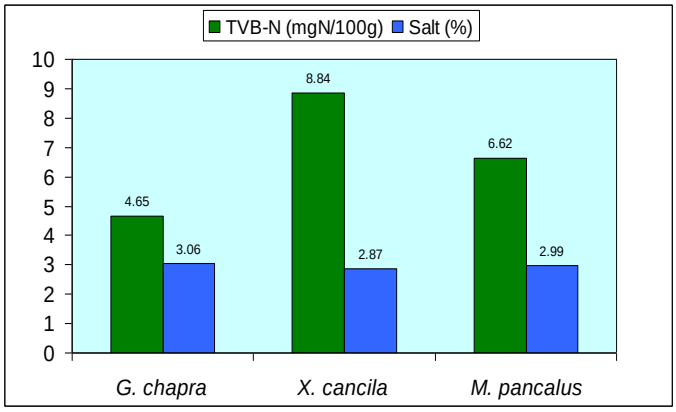

Fig 2: Changes in chemical composition (TVB-N and Salt content) of freshly processed Salt and Turmeric treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fish-products

Total Volatile Base Nitrogen (TVB-N) is one of the most widely used measurements of fish quality and appears as the most common chemical indicator of fish spoilage. TVB-N is produced by decomposition of proteins into simpler substances (ammonia, trimethylamine, creatine, purine bases and free amino acids) [46]. TVB-N expresses the degree of bacterial spoilage during processing in other word the degree of freshness. Connell reported that the acceptable limits of TVB-N were 30 mgN/100g in good quality products [47]. In the present study, the TVB-N of S+T treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fishes were within the acceptable level. Among the three Salt and Tumeric treated smoke-dried fishes highest TVB-N was detected in *X. cancila* (8.84 mgN/100g) whereas lowest was found in *G. chapra* (4.65 mgN/100g) fish products.

Salt content of freshly processed Salt and Turmeric treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* were 3.06%, 2.87% and 2.99% respectively. Borgstrom reported that salt content was 2-3% in hot smoked herring [48]. Kabir investigated that freshly processed salted smoke dried Kajuli (*Ailia coila*) fish had salt content of 4.9% [39]. Nketsia and Sefa-Dedeh determined the salt content of the smoked fish products ranging between 0.4 to 1.2% which is more or less similar with the present findings [49].

3.4 Mineral composition

Mineral ratios are often more important in determining nutritional deficiencies and excess; it is predictive of future metabolic dysfunctions or hidden metabolic dysfunction. The mineral compositions of freshly processed smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fish are given in Table 2. In case of freshly processed salt and turmeric treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fish-products, Ca (calcium) content were 750, 730 and 705 mg/100g of fish; Mg (magnesium) content were 25.30, 142.51 and 152.50 mg/100g of fish; Fe (iron) content were 5.30, 38 and 42.25 mg/100g of fish; Zn (zinc) content were 3.20,10.25 and 8.75 mg/100g of fish; Cu (Copper) content were 0.45, 0.90 and 1.10 mg/100g of fish; and Mn (manganese) content were 2.37, 1.77 and 2.60 mg/100g of fish respectively.

Table 2: Important mineral (mg/100g of fish) composition of freshly processed Salt and Turmeric (S+T) treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fish-products

Experimental fishes	Ca mg/100g	Mg mg/100g	Fe mg/100g	Zn mg/100g	Cu mg/100g	Mn mg/100g
G. chapra	750	25.30	5.30	3.20	0.45	2.37
X. cancila	730	142.51	38	10.25	0.90	1.77
M. pancalus	705	152.50	42.25	8.75	1.10	2.60

The mineral composition showed variable values in all fresh processed smoke-dried fishes analyzed; with Ca, Mg recording the most abundant while Fe, Zn, Cu and Mn recording the trace amounts. All the fish samples examined in this study contained appreciable concentrations of major elements (mineral) like Ca, Mg and minor elements like Fe, Zn, Cu and Mn suggesting that these fishes could be used as good sources of minerals in fresh process condition. As high ratio of Ca observed in all Salt and Turmeric treated fresh smoke-dried fish samples, is of nutritional benefit, particularly for children and the aged who need higher intake of Ca for bone formation and maintenance. Zaman *et al.* also stated that small fishes with bones are important source of essential minerals especially Ca which similar with present findings [50]. Variations in the concentration of minerals in fish muscles could be due to their concentration in the water bodies where they live, the fish physiological state and or the ability of the fish to absorb the elements from their diets and the water bodies [51, 52, 53].

3.5 Microbiological quality

Changes in total viable count (TVC) of salt and turmeric treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fish in fresh process condition are shown in Figure 3.

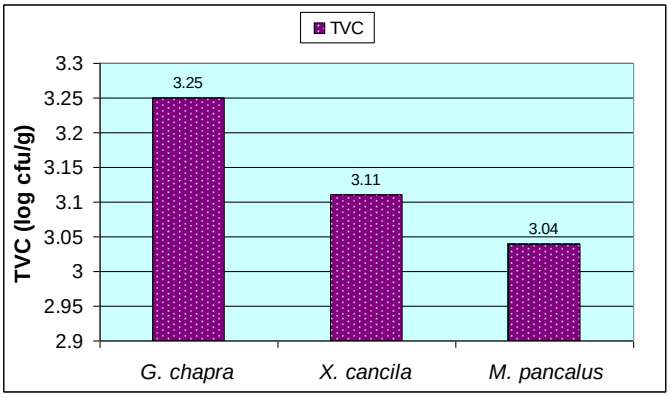

Fig 3: Total Viable Count (cfu/g) of freshly processed Salt+Turmeric (S+T) treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fish-products

The amount of bacteria in foods serves as a general indicator of hygiene. Determination of total viable count is widely used to assess the bacterial quality of fish. Kumolu-Johnson and Ndimele stated that spoilage of fish resulting from action of enzymes and bacteria can be slowed down during smoking [54]. Hilderbrand reported that the lower count in smoked fish may be due to high temperature killing the food poisoning and spoilage bacteria as well as the chemical compounds contained in smoke that can inhibit the growth of bacteria [55]. In this experiment, fresh smoke-dried fish samples had relatively lower total viable counts of bacteria which may be attributed to low moisture content and drying carried out under hygienic conditions. According to Eyo, this can be explained by the bactericidal effect of smoke constituents such as acids, aldehydes and phenols [56]. In fresh process condition, TVC of S+T treated smoke-dried *G. chapra*, *X. cancila* and *M. pancalus* fish samples were 3.25 log cfu/g, 3.11 log cfu/g and 3.04 log cfu/g respectively. The limit for TVC is 1×10^5 cfu/g in the dried product which is more or less similar with present work [57].

4. Conclusions

In Bangladesh, among the freshwater fish species, *G. chapra, X. cancila and M. pancalus* fishes are delicious and popular to the consumers as well as bear high market price. So it is necessary to take some steps for their proper preservation and marketing and during this period maintain proper quality. The present study reveals that salt and turmeric treated smoke-drying method has a positive significant role on the proximate, chemical and mineral composition of freshwater *G. chapra, X. cancila and M. pancalus* fishes and reduces bacterial load as well as makes them nutritionally suitable for all.

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