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Quality assessment of two smoke-dried freshwater SIS (Small Indigenous Species) fish products

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Abstract
The study was conducted to assessment the quality of two smoke-dried freshwater SIS fish kaika and baim using four different treatments such as Unsalt, Salt, Salt+Turmeric and Salt+Garlic fish-product in fresh process condition by analyzing water reconstitution time, biochemical aspects (moisture, protein, fat, ash salt and TVB-N) and microbiological quality using standard methods of analyses. In addition, yield and mineral composition after processing were also determined. In fresh process condition water reconstitution rate was faster in Salted products but slower in unsalted products. In case of four types of kaika and baim fish highest protein was found in unsalted products and lowest in Salt+Garlic and Salted products respectively. The TVC of four types of smoke-dried kaika and baim fish samples ranged from 1.1×10^3 to 3.6×10^4 and 1.1×10^3 to 3.7×10^3cfu/g. The data showed that the smoke-dried fishes are high nutritional value and good source of proteins and minerals.

Keywords: freshwater SIS fish, smoke-drying, water-reconstitution, quality-assessment

1. Introduction
Fish allows for protein improved nutrition in that it has a high biological value in term of high protein retention in the body, low cholesterol level and presence of essential amino acids [1]. In addition, fish flesh contains most of the minerals necessary for a balance diet. Fish provides food for millions of poor people in low income countries like Bangladesh, where it is regarded as "poor people's protein". In Bangladesh, fish is an irreplaceable animal-source food in the diet of millions, both in terms of quantity - accounting for approximately 60% of animal protein intake at 18.1 kg consumed per person per year and frequency of consumption, far exceeding that of any other animal-source food [2].

The country has an abundance of fisheries resources but scanty facilities for their preservation and uniform distribution. Fish is however susceptible to damage as soon as it harvested and lean fishes being small in size have a tendency to become spoiled more quickly than larger fishes. Some factors responsible for this include the prevailing high temperatures in tropical country like Bangladesh and the facilities for processing, storing and distributing the fish caught are frequently inadequate or non-existent in most cases. A decline in fish availability will have a detrimental effect on the nutritional status of the citizenry particularly in places where fish contributes significantly to the protein intake of the people. Efforts should therefore, be geared towards increased fish production through improved resource management matched with effective post-harvest handling, preservation and processing to prevent spoilage.

Proper preservation starts the moment it is harvested until reaches the consumer's table [3]. Some preservation methods used in the tropics include chilling, freezing, drying, salting, smoking, canning (wet salting), frying and glazing etc. are still widely accepted around the world because of their specific taste and aroma. Fish in any of these forms give rise to products of great economic importance and the demand for such products has been increasing. Processing is carried out with the aim of either to supply distant markets or to produce a range of products with different flavor and texture. Among the various types of preservation methods, smoke-drying of fish is one of the oldest and traditional of all processed foods and it is currently undergoing considerable growth in popularity. Smoked fish constitutes an important diet of many low income earners in the developing world, and traditional methods are well suited to local circumstances, as they are cheap and require only simple equipment or facilities [4].

Fresh water SIS fish constitute an important part of fish distribution in Bangladesh and the marketing trends predict an increase in consumer demands. It is well known that small fishes has high nutritional value in terms of both protein content and presence of micronutrients, vitamins and minerals for both young and old age consumers because these fishes can be consumed with their bones and heads [5]. These fishes are acceptable in all classes of peoples as fresh as well as dried products.

Due to high palatable, unique taste and rich in nutrients two commercially important variety of Bangladeshi freshwater small indigenous species (SIS) of fish such as kaika (*Xenentodon cancila*) and baim (*Mastacembelus pancalus*) have been selected for the present research work. There are some information on the biochemical and nutritional studies of some freshwater fish species [6, 7]. Inspite of huge amount of fish protein consumption, there are a few reports on the nutritive or caloric values of small indigenous fish as well as smoke-dried fish products. As a result, peoples are confused to take required amount of calorie from fishes. Therefore, considering the possible health risk and the nutritional benefits associated with fish consumption; this study was

carried out to complement efforts aimed at ascertaining the effect of smoke-drying on the nutritive value of two common (SIS) fishes, kaika and baim which are available and consumed in Bangladesh. Moreover nutritional studies of these fish species using traditional smoke-drying method practiced by the local fisher-folks have not been conducted elaborately in Bangladesh. In this context, the aim of the present study is to determine the effect of smoke-drying using four different treatments (Unsalt, Salt, Salt+Turmeric and Salt+Garlic) on the quality of smoke-dried kaika and baim fish in terms of water reconstitution behavior, biochemical composition, mineral content and microbiological characteristics.

2. Materials and methods

2.1 Sample collection

Freshwater fish species, 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

The experimental fish was quickly carried to the laboratory as early as possible to avoid any spoilage during that period. At first, the collected kaika and baim fish was beheaded. Then two 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

Four treatments were conducted on the dressed fish samples. In the 1st treatment, unsalted (US) fish were used in the preparation of the smoked product. In the 2nd treatment, brine containing 30% salt was used (S), whereas the 3rd and 4th treatment contained brine 30% salt with 10% turmeric solution (S+T) and brine containing 30% salt with 30% garlic solution (S+G) respectively. After that the fish samples in treatments 2nd, 3rd and 4th were kept immersed into solution for each experiment in separate plastic buckets for 20 minutes.

2.5 Fish smoke-drying

The fishes were smoked in improved traditional type of smoking kiln [8]. 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. After that cooled kaika and baim fish samples at room temperature were weighed for getting the amount of yield.

2.6 Sampling procedure

3 or 4 slice of experimental fishes was 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. Triplicate experiments were conducted for analysis.

2.7 Water reconstitution behavior

Accurately weighed 5 g of smoke-dried fish samples were taken and weighted by analytical balance and then immersed in water at 30^{0}C and 60^{0}C respectively. The fish samples were kept under water for 15, 30, 45 and 60 minutes. Any loose muscle that attached to sample was removed before dipping in water. After every 15 minutes the fish sample were removed from water and the surface water was removed with blotting paper and reweighed and dipped into water of the respected beaker. During the soaking time, the fish muscle could reabsorb maximum amount of water.

The percentage of water uptake in smoke-dried fish samples was calculated as follows

% Water reconstitution = (Wr – Wi) / Wi X 100

Initial weight of the dry fish = Wi, Weight of dry fish after reconstitution = Wr,

Water reconstitute = Wr – Wi,

2.8 Biochemical analysis

The analytical methods are given below:

1. Moisture, fat, ash and salt contents of the fish were determined by AOAC method [9].
2. The crude protein of the fish was determined by Micro-Kjeldhal method [10].
3. TVB-N using Conway modified micro-diffusion technique [11].
4. Samples for mineral analysis were prepared according to recommendations of Perkin Elmer's procedures of Atomic Absorption Spectrometer [12].
5. Microbiological analysis was done according to the standard methods of AOAC [13].

2.9 Statistical analysis

Data were analyzed by using SPSS for windows-20 statistical programme.

3. Results & Discussion

3.1 Physical proportions of four types (US, S, S+T & S+G) of smoke-dried kaika and baim fish and their different yield during smoke-drying

In present experiment percent of yield from total weight of Unsalted (US), Salted (S), Salt+Turmeric (S+T) and Salt+Garlic (S+G) treated smoke-dried kaika fish was 20.19%, 19.05%, 18.97% and 19.03%; baim fish was 25.33%, 24.49%, 24.20% and 24.15% whereas percent of yield from dressed kaika fish was 29.22%, 27.31%, 27.40% and 27.78%; baim fish was 27.02%, 26.17%, 26.64% and 26.99% respectively (Table-1). Similar experiment done by Debnath

with thai pangas (*Pangasius hypophthalmus*); Hossain with Tilapia (*Oreochromis niloticus*); Hossain with Silver Carp (*Hypophthalmichthys molitrix*) and Rayhan with Thai Pangas (*Pangasius hypophthalmus*) obtained an yield of 37.56%, 36.22%, 39.5% and 38% smoked fish from whole fish respectively which is more or less similar with the present findings [14, 15, 16, 17].

Table 1: Physical proportions of the experimental Kaika and Baim fish treated with four (US, S, S+T, S+G) different treatments during smoke-drying

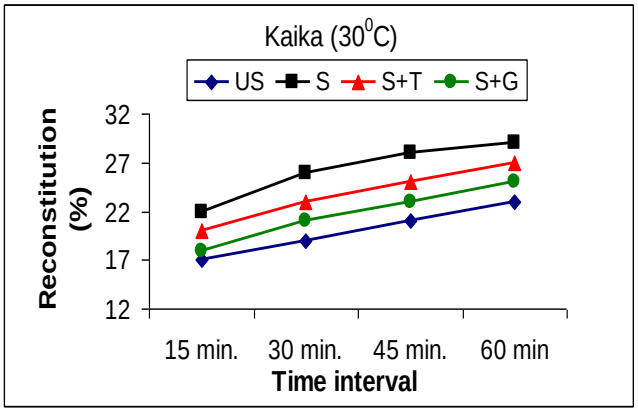
Treatment	Total weight of fish (g)	Dressed fish weight (g)	Weight after dip in 30% salt solution for 20 minutes (g)	Weight after dip in Salt(30%) + Turmeric (10%) solution for 20 minutes (g)	Weight after dip in Salt(30%) + Garlic(30%) solution for 20 minutes (g)	Weight after smoke-drying (g)	Weight loss during smoke-drying (%)	% of yield from total weight of fish	% of yield from dressed fish
US- Kaika	11000g	7600	-	-	-	2220.7	70.78	20.19	29.22
S- Kaika	12000g	8367.4	8078.1	-	-	2285.6	71.70	19.05	27.31
S+T-Kaika	11000 g	7615.1	-	7417.6	-	2087	71.86	18.97	27.40
S+G Kaika	11600g	7944.4	-	-	7624.3	2207.3	71.05	19.03	27.78
US- Baim	8000g	7500.5	-	-	-	2026.7	72.98	25.33	27.02
S- Baim	8000g	7486.3	7178.9	-	-	1959.6	72.70	24.49	26.17
S+T- Baim	11000g	9991.4	-	9771.9	-	2662.2	72.76	24.20	26.64
S+G-Baim	10900g	9749.1	-	-	9349.1	2632.1	71.85	24.15	26.99

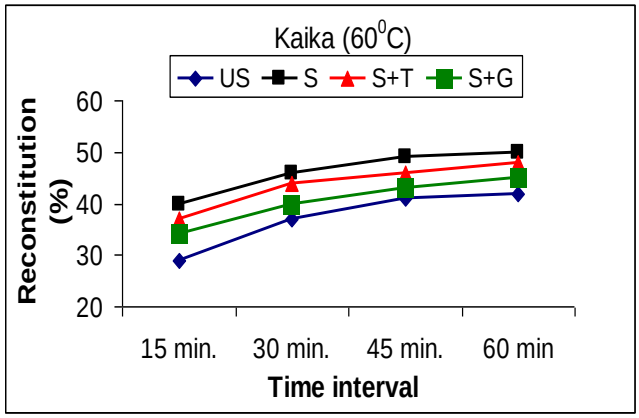
3.2 Water reconstitution behavior of Unsalted (US), Salted (S), Salt-Turmeric (S+T) and Salt-Garlic (S+G) treated smoke-dried kaika and baim fish in fresh process condition

Percentage of water absorbed by dried fish at a certain temperature and time is called water reconstitution. It is one of the most important physical parameters to assess the quality of the dried products [18]. For this reason, reconstitution properties of any processed fish food are used to monitor of its ability to go to its original form by absorbing water. In practice, the processed fish food samples which absorb maximum percent of water in the same period of reconstitution are considered to be the best possessed fish product.

Water reconstitution behavior of four (US, S, S+T and S+G) types of freshly processed smoke-dried kaika and baim fishes soaked in water temperature at 30°C and 60°C for 15, 30, 45 and 60 minutes are presented in Figure -1 respectively. It can be observed from this Figure that as the temperature of the soaking water increased, the rate of reconstitution also increased. This is might be due to the fact that increased temperature of soaking water opens the structure of fish products which favor the rapid reconstitution. This is an agreement with the findings of Saha and Hossain, who worked with dried sword fish (*Lepturacanthus savala*) [19]. Besides, initial uptake of 60^0C water was comparatively higher than that of the 30^0C water. This is because heat help in easy absorption of water in fish fiber [18]. In present study, comparatively slower reconstitution rate was observed in the later stage of reconstitution period of all four types of freshly processed smoke-dried kaika and baim fish samples. Similar trend of slower reconstitution rate in the later stage was observed by Ituen *et al*.; Mansur *et al*.; Haque *et al.* in dried products [20, 21, 22].

Present findings showed that Salted smoke-dried kaika and baim fish samples hold more water and reconstituted more rapidly than US, S+T, S+G treated fish products and four types of smoke-dried kaika fish samples exhibited an enormously rapid initial rate of reconstitution than four types of smoke-dried baim fish samples. Among the four types (US, S, S+T, S+G) of freshly processed smoke-dried products, reconstitution rate was faster in Salted smoke-dried fish samples whereas slow in Unsalted (US) smoke-dried fish samples both in kaika and baim fishes.





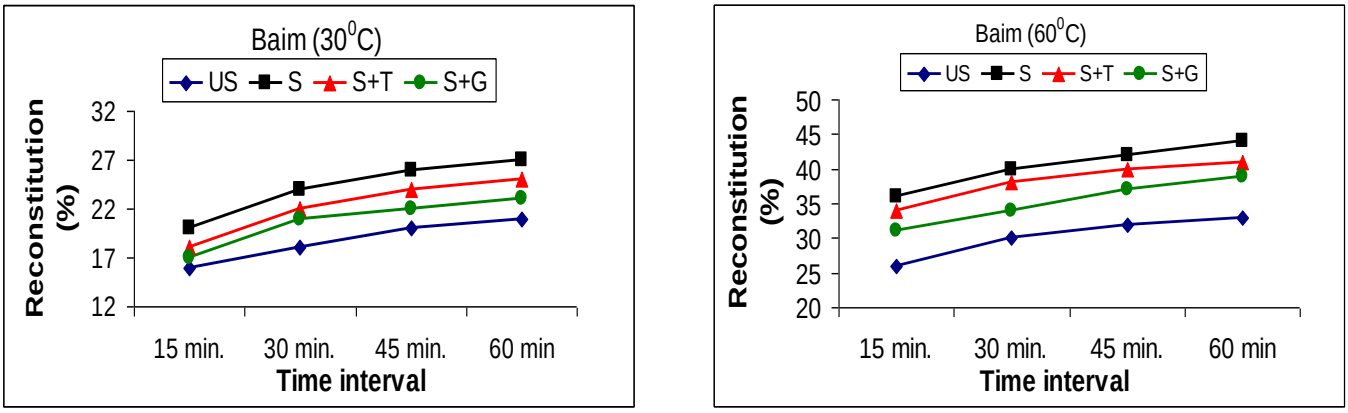


Fig. 1 Water reconstitution behavior of freshly processed Unsalted (US), Salted (S), Salt-Turmeric (S+T) and Salt-Garlic (S+G) treated smoke-dried kaika and baim fish soaked in water at 30^{0}C and 60^{0}C during different time intervals

3.3 Bio-chemical Composition

Biochemical composition of freshly processed Unsalted (US), Salted (S), Salt+Turmeric (S+T) and Salt+Garlic (S+G) treated smoke-dried kaika (*X. cancila*) and baim (*M. pancalus*) fish products are given in Table 2.

Table 2: Biochemical composition of freshly processed Unsalted (US), Salted (S), Salt+Turmeric (S+T) and Salt+Garlic (S+G) treated smoke-dried kaika (*X. cancila*) and baim (*M. pancalus*) fish products

Fish Sample	Treatments	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Salt (%)	TVB-N mgN/100g
Kaika	US	11.69±0.04	74.85±0.04	5.25±0.03	8.31±0.03	-	11.08±0.04
	S	7.15±0.05	63.56±0.05	7.12±0.04	22.31±0.03	3.30±0.01	7.44±0.04
	S+T	8.24±0.06	63.04±0.04	6.71±0.04	22.52±0.04	2.87±0.02	8.84±0.04
	S+G	9.57±0.05	62.76±0.04	5.37±0.03	22.30±0.04	2.98±0.03	5.97±0.03
Baim	US	8.22±0.05	70.82±0.04	10.78±0.03	10.74±0.03	-	9.69±0.03
	S	7.36±0.04	58.56±0.04	11.98±0.04	22.45±0.05	3.55±0.03	5.92±0.03
	S+T	6.97±0.05	59.22±0.04	11.67±0.03	22.54±0.04	2.99±0.02	6.62±0.03
	S+G	7.53±0.07	59.07±0.08	11.32±0.04	22.15±0.04	3.05±0.03	5.74±0.04

Values are shown as mean ± standard deviation of triplicate measurements

In present study, freshly processed US, S, S+T, S+G treated smoke-dried kaika and baim fish products, **moisture (%)** content were 11.69±0.04%, 7.15±0.05%, 8.24±0.06%, 9.57±0.05% and 8.22±0.05%, 7.36±0.04%, 6.97±0.05%, 7.53±0.07% **; protein (%)** content were 74.85±0.04%, 63.56±0.05%, 63.04±0.04%, 62.76±0.04% and 70.82±0.04%, 58.56±0.04%, 59.22±0.04%, 59.07±0.08%**; fat (%)** content were 5.25±0.03%, 7.12±0.04%,6.71±0.04%, 5.37±0.03% and 10.78±0.03%, 11.98±0.04%, 11.67±0.03%, 11.32±0.04**; ash (%)** content were 8.31±0.03%, 22.31±0.03%, 22.52±0.04%, 22.30±0.04% and 10.74±0.03%, 22.45±0.05%, 22.54±0.04%, 22.15±0.04**; TVB-N** content were 11.08±0.04, 7.44±0.04, 8.84±0.04, 5.97±0.03and 9.69±0.03, 5.92±0.03, 6.62±0.03, 5.74±0.04 mgN/100g of fish respectively. On the other hand, **salt (%)** content of S, S+T and S+G treated smoke-dried kaika and baim fish products were 3.30±0.01%, 2.87±0.02%, 2.98±0.03% and 3.55±0.03%, 2.99±0.02%, 3.05±0.03% respectively.

The moisture content of US, S, S+T and S+G treated smoke-dried fish samples decreased sharply after the smoking process. 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]). The moisture levels in all the smoke-dried fishes examined were below 20% (Table-3) which is good or acceptable for smoke-dried fishes suggested by Lilabati (1996) 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%) ; Oladipo and Bankole in smoke-dried *Clarias gariepinus* (18.32%) and *Oreochromis niloticus* (8.22%) and Akinwumi in smoked *Clarias gariepinus* (5.885±0.034) [27, 28, 29, 30]. 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 [31]. 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 [32]. Increase of protein may be due to the dehydration of water molecule present between the proteins thereby, causing aggregation of protein and thus resulting in the increase in protein content of smoke-dried fishes [33, 34, 35]. 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 [36, 37, 38, 39, 40, 41, 42]. Clucas and Ward reported that the inorganic content remain as ash after the organic matter is removed by incineration [43]. 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, 41, 44, 33]. Smaller sized fish species has higher ash content due to the higher

bone of flesh ratio [39]. Among the four types of smoke-dried kaika and baim fish product, S, S+T, S+G treated smoke-dried fish products recorded higher value of ash content than US products after smoke-drying (Table-2) which may be due to the crude salt. According to Salama and Ibrahim Unsalted smoke-dried grass carp fillets samples had ash content of 9.00% which is more or less similar with unsalted Smoke-dried fish products [45]. Borgstrom reported that salt content was 2-3% in hot smoked herring [46]. Kabir investigated that freshly processed salted smoke dried Kajuli (*Ailia coila*) fish had salt content of 4.9% [37]. 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 [47].

TVB-N is produced by decomposition of proteins into simpler substances (ammonia, trimethylamine, creatine, purine bases and free amino acids) [48]. 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 [49]. In the present study, the TVB-N of the four types of smoke-dried fishes was within the acceptable level. The highest TVB-N was detected in the US smoke-dried fish products followed by S+T, S and S+G.

3.4 Mineral composition

The mineral compositions of four types of freshly processed smoke-dried kaika and baim fish are given in (Table-3). In present experiment Ca, Mg, Fe, Zn, Cu and Mn were varied in a range of 477-810, 107.75-157.50, 9.50-41, 7.70-14, 0.30-0.90 and 0.77-2.70 mg/100g in US, S, S+T, S+G treated smoke-dried kaika fish Salted Smoke-dried kaika fish respectively whereas in four types of freshly processed smoke-dried baim fish, Ca, Mg, Fe, Zn, Cu and Mn were varied in a range of 325-705, 83-152.50, 5.80-42.25, 3.60-8.75, 0.35-1.10 and 0.87-2.60 mg/100g respectively.

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 calcium(ca), Magnesium(Mg) and minor elements like Iron (Fe), Zinc(Zn), Copper (Cu) and Manganese (Mn) suggesting that these fishes could be used as good sources of minerals in fresh process condition. Ca and Mg were observed to dominate other minerals in all fresh smoke-dried samples. Eyo reported that the mineral content of fish makes fish unavoidable in the diet as it is a source of different minerals that contribute greatly to good health [50]. The wide array of minerals detected from these species attest to this. However mineral composition recorded variations in their concentrations among the selected fish species used for the study. 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]. In this research work the order of mineral concentrations in smoke-dried kaika and baim fish were Ca>Mg>Fe>Zn>Mn>Cu which is more or less similar with the findings of the Kirchgessner and Schwall [54].

Table-3: Mineral composition of fresh smoke-dried kaika (*X. cancila*) and baim (*M. pancalus*) fish

Fish Sample	Treatments	Ca mg/100g	Mg mg/100g	Fe mg/100g	Zn mg/100g	Cu mg/100g	Mn mg/100g
Kaika	US	477	107.75	9.50	7.70	0.30	0.77
	S	810	157.50	41	14	0.90	2.70
	S+T	730	142.51	38	10.25	0.90	1.77
	S+G	560	127.50	12.75	9	0.87	1.10
Baim	US	325	83	5.80	3.60	0.35	0.87
	S	650	135	33.50	7.75	1.02	1.70
	S+T	705	152.50	42.25	8.75	1.10	2.60
	S+G	525	130	33.50	7.25	0.95	1.10

3.5 Microbiological analysis (TVC)

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 [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 US, S, S+T, S+G treated smoke-dried kaika and baim fish samples were 3.6×10^4 cfu/g, 1.1×10^3 cfu/g, 1.3×10^3 cfu/g, 1.5×10^3 cfu/g and 3.7×10^3 cfu/g, 1.4×10^3 cfu/g, 1.1×10^3 cfu/g, 1.2×10^3 cfu/g respectively (Table-4). The limit for TVC is 1×10^5 cfu/g in the dried product which is more or less similar with present work [57].

Table 4: Total viable count (cfu/g) of fresh and freshly processed Unsalted (US), Salted (S), Salt+Turmeric (S+T) and Salt+Garlic (S+G) treated smoke-dried kaika (*X. cancila*) and baim (*M. pancalus*) fish products

Treatments	TVC(cfu/g)
US Kaika	3.6×10^4
S Kaika	1.1×10^3
S+T Kaika	1.3×10^3
S+G Kika	1.5×10^3
US Baim	3.7×10^3
S-Baim	1.4×10^3
S+T-Baim	1.1×10^3
S+G-Baim	1.2×10^3

4. Conclusions

The present study reveals that fish smoke-drying methods treated with four different treatments (US, S, S+T, S+G) have a positive significant role on the biochemical, minerals and microbial quality of freshwater kaika and baim fish as well as makes them nutritionally suitable for all.

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