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Comparison of the Changes in Nutritional Quality of Three Important Small Indigenous Fish Species in Bangladesh at Room Temperature (27°-31°C): A Review

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Abstract

This study was conducted to change the nutritional quality of three Small Indigenous Fish Species products. Organoleptic characteristics, chemical composition and microbiological load (TPC) of fresh and sun dried fish samples- Taki (*Channa punctatus*), Puti (*Puntius sophore*) and Chapila (*Gudusia chapra*) were determined using standard methods of analysis at room temperature (27°-31°C) for shelf life. The moisture content of the sun dried products ranged from 18.32 to 26.24% with the lowest in Puti and the highest value in Chapila. The moisture content of the fresh products was in the range of 71.09 to 75.89%. The range of protein contents on dried fish products was from 42.4 to 54.65% with maximum obtained in Taki and minimum in Puti. Lipid contents of dried fish products were ranged from 5.15 to 9.21%. Maximum reconstitution of sun dried products was obtained at 60°C in all samples and was in the range of 52.51 to 55.92% where the percentage of reconstitution increases with the increase of socking time and reach maximum at the end of up to 45 min. The TVB-N content of fresh fish is low compared with sun dried one ranging from 32.45 to 34.45 mg/100 g. Peroxide value, acid value and conjugated diene of fresh fish products showed better in quality than dried fish products. The bacterial load of the sun dried products was in the range of 2.44×10^5 to 2.52×10^6 CFU/g and of the fresh products ranged from 3.9×10^4 to 3.8×10^5 CFU/g. These results showed that fresh fish products indicated excellent in quality over dried fish products at room temperature.

Keywords: Species; Organoleptic; Chemical composition; Microbiological load; Room-temperature

Introduction

Fish is one of the most important sources of animal protein available, and has been widely accepted as a good source of protein and other essential nutrients for the maintenance of a healthy body [1] of which a remarkable part comes from dried fishes. According to Rahman [2], there are 260 species of freshwater small indigenous fish in Bangladesh. Among them, which grow to a size of 25 cm or 9 inches in mature or adult stage in their lifecycle are known as "SIS" (Small Indigenous Species) [3]. However, there is some sort of contradiction exist in the above definition because there are some fishes in Bangladesh (such as *Puntius sarana, Clarias batrachus, Channa barca, Xenentodon cancila, Heteropneustes fossilis,* etc.) which are considered as SIS but their size exceeds the limits mentioned in the definition (25 cm). Fish is considered as an easily digestible food item and rich source of animal protein. SIS contains huge amount of vitamin-A and vitamin-D which are very good for human bones, teeth, skin and eyes. SIS also supply good amount of calcium, phosphorus, iron, iodine etc. These minerals are essential for developing resistance against diseases. Some SIS like Punti (*Puntius sp.*) contains double the amount of iron compared to many cultured carps like Silver carp (*Hypophthalmichthys molitrix*) and Rohu (*Labeo rohita*) and SIS Taki (*Channa punctatus*) and Chapila (*Gudusia chapra*) contain three times more calcium and fifty times vitamin-A than that of Silver carp and Rui [4].

Dried fish is a very popular food item in Bangladesh. The product is easily transportable, marketable, storable, and has good market demand in the country or abroad. The consumer preference for dried fish products is not only because of their traditionally desirable taste and flavor, but also their high content of omega-3 polyunsaturated fatty acids especially in fish lipids, which have various health benefits for human [5]. Now-a-days, people are more concern about health and nutritional issues [6-12] and they also concern about the nutritional value of food items when they buy them for their household. Biochemical analysis provides information on the nutritional value of a particular organism used as a source of food [13]. Many studies have already been performed on the proximate composition of different marine fresh/dried fishes [14-23], however, very few studies have been carried out on the biochemical composition of freshwater dried fish products.

In Bangladesh, the dried fish produced by the traditional open air drying method using sun and wind are not safe for human consumption due to high risk of insect infestation and

indiscriminate use of various types of insecticides [7]. Moreover, the development of lipid oxidation often limits the possibilities for storage and processing of the dried fish products [24]. Preliminary results showed that the degree of lipid oxidation is very high in dried fish products available in Bangladesh. Intake of such highly oxidized products may cause adverse effects on the human body such as aging, heart disease, cancer, and brain dysfunction [25]. However, quality changes especially deterioration of lipids during storage of dried fish products has not been studied so far. Therefore, the present study was aimed to compare the changes in organoleptic characteristics, chemical compositions and microbiological loads of fresh and sun-dried Taki (*Channa punctatus*), Puti (*Puntius sophore*) and Chapila (*Gudusia chapra*) fish products.

Physical and Organoleptic Characteristics of Fresh and Sun Dried Fish Product

Changes in physical and organoleptic characteristics of sun dried Taki (*Channa punctatus*), Puti (*Puntius sophore*) and Chapila (*Gudusia chapra*) were presented in **Table 1**. The color, odor, texture, insect infestation and broken pieces of these fishes revealed that the samples were excellent quality up in fresh. Then the sample was turned into different color after sun drying. Dry fish odor, and firmness and elasticity of the texture were lost in the sample after sun drying.

Table 1: Changes in physical and organoleptic characteristics of fresh and sun-dried *Puntius sophere, Gudusia chapra* and *Channa punctatus* fish products.

Fish sample	Category	Color	Odor	Texture	Infestation	Broken pieces	Overall quality
Puti	Sun dried	Whitish	Slightly sour	Soft	Slightly infestation by flies	Slightly broken	Good
	Fresh Fish	Whitish	Characteristic odor	Firm and Flexible	No infestation	Nil	Excellent
Chapila	Sun dried	Whitish	Slightly rancid	Soft	Slightly infestation	Slightly broken	Good
	Fresh Fish	Whitish	Characteristic odor	Firm and Flexible	No infestation	Nil	Excellent
Taki	Sun dried	Brownish in outer and reddish in inside	Slightly sour	Soft	No infestation	Slightly broken	Good
	Fresh Fish	Whitish/blackish	Characteristic odor	Firm and Flexible	No infestation	Nil	Excellent

However, slightly decreasing fish odor was occurred. Insect infestation and broken pieces were not seen during drying. Changes in color of the dried fish product might be attributed to non-enzymatic browning reaction, which progressed continuously during the storage period. Non-enzymatic browning is a result of reactions between products of lipid oxidation such as carbonyl compounds and amino compounds [26-32].

Changes in pH Value

The pH of freshwater fish flesh at fresh condition is almost neutral [33]. In post-mortem period, decomposition of nitrogenous compounds often tends to increase in pH level in fish flesh [34]. Increase in pH indicates the loss of quality in fishes. The pH value of sun dried fish product was significantly ($P<0.05$) increased. pH value of fresh Puti, Chapila and Taki fish were 7.3, 6.9 and 6.5, respectively in this study (**Figure 1**). The pH value was decreased due to increase of acidic compound and after that among shelf life study pH value increases in the time interval due to increase of basic compounds. pH value for sun-dried Puti, Chapila and Taki were 8.7, 8.32 and 8.19, respectively (**Figure 1**). The acceptable ranges of fish pH are 6.8 but are considered to be spoiled above 7.25. The initial pH values in the samples were similar with other researchers. The increase in pH values during the storage of room temperature (27-31°C) was higher than reported in other researches [14,16,17,35-39]. The probable reason behind these differences was due to differences in fish species and different age and sex.

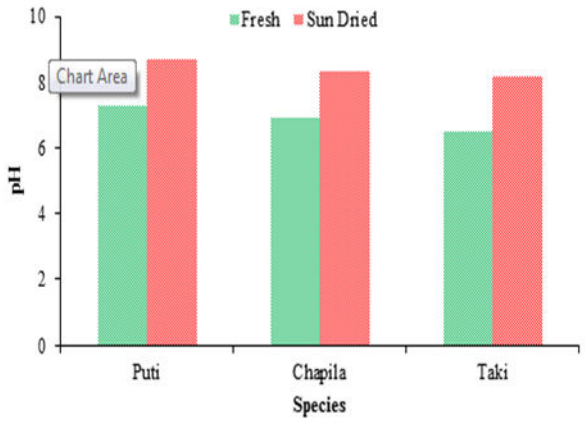

Figure 1: pH value of fresh and sun-dried fish products.

Water Reconstitution Behavior of Dried *Puntius sophere, Gudusia chapra* and *Channa punctatus* Fish Products

Water reconstitution behavior of traditional sun-dried fish products are summarized in **Table 2**. It was observed that the sun-dried fish, *Channa punctatus* absorbed 30.03% moisture within 15 minutes of initial soaking at 45 ºC. The rehydration values in all the dried fishes were higher when kept for a longer period of time. The values were increased from 40.01% to 52.60% after soaking for 30 and 45 minutes, respectively. The water reconstitution rate was also increased with the increasing of temperature. The sun-dried *Channa punctatus* was found to be absorbed 31.85% moisture within 15 minutes which was increased up to 55.55% while soaked into water at 60˚C for 45 minutes. A similar trend in water rehydration properties was also observed for other sun-dried fish products both at 45˚C and 60˚C, although no significant difference was observed among these products at both the temperatures. In contrast, all sun dried fishes showed higher rehydration capacity at the temperature of 60˚C. It was also observed that the rehydration values of all the fish products were significantly increased with increasing temperature and time.

In the present study, it was observed that the rehydration ability in all fish samples was higher when soaked in elevated temperature and longer period of time. The overall trend of the rehydration was nearly identical with the values which were reported earlier, although those studies were carried out in a variety of temperature, time and species [35,36]. It has been reported that increasing of water temperature also increases the rate of rehydration. This might be due to the fact that increased temperature of water opens the structure of fish products which maximize the scope of rapid rehydration. It has been reported that there was a positive relationship between rehydration ability and physical properties of the dried fish products [37]. Moreover, rehydration of food products depends mainly on the internal structure of the dried fish muscle [35,38-44].

Table 2: Water reconstitution behavior of sun dried fish products.

Species	Soaking Temperature	Soaking time (Minutes)	Water Reconstitution (%) Sun dried fish
Punti	45°	15	28.30 ± 0.19
		30	37.63 ± 0.59
		45	50.54 ± 0.11
	60°	15	29.26 ± 0.10
		30	40.19 ± 0.03
		45	52.51 ± 0.23
Chapila	45°	15	31.25 ± 0.27
		30	41.56 ± 0.71
		45	53.26 ± 0.27
	60°	15	32.52 ± 0.26
		30	44.60 ± 0.22
		45	55.92 ± 0.13
Taki	45°	15	30.03 ± 0.82
		30	40.01 ± 0.32
		45	52.60 ± 0.74
	60°	15	31.85 ± 0.31
		30	43.44 ± 0.29
		45	55.55 ± 0.66

Chemical Composition of Fresh and Sun-dried *Puntius sophere, Gudusia chapra* and *Channa punctatus* Fish Products

The moisture contents of that fresh fish product were ranged from 18.32% to 26.24% with the lowest in Puti and the highest in Chapila. In sun-dried fish products, the moisture contents was ranged from 71.09% to 75.89% with the lowest in Taki and the highest in Puti (**Table 3**).

The moisture content of the sun dried fish products is much lower than those found in the fresh fish. It is to be noted that there is a tendency in our country for fish processors and retailers sometimes allow more moisture in dried fish products to gain weight for economic benefit.

The other reason is that the dried products used for selling in the wholesale and retail market and during storage normally are not kept in suitable packaging material. In a tropical country like Bangladesh where relative humidity is always high, there is a chance of moisture uptake from the environment.

Excessive moisture uptake increases the water activity which facilitates the growth of micro-organisms, loss of nutrients and reduction shelf-life of dried products.

Table 3: Comparison in moisture, protein, lipid and ash content of fresh and sun-dried fish products.

Fish sample	Category	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Puti	Sun dried	75.89	15.99	3.98	4.91
	Fresh Fish	18.32	50.4	5.15	16.17
Chapila	Sun dried	73.67	16.06	4.78	6.89
	Fresh Fish	26.24	51.48	9.21	13.45
Taki	Sun dried	71.09	16.78	4.67	7.98
	Fresh Fish	21.43	54.65	6.01	15.76

The protein content of fresh *Puntius sophere* was 15.99%. The range of protein contents was 42.4% (fresh) with the highest value was obtained. The protein contents of fresh fish products were ranged from 15.99% to 16.78% with the lowest in Puti and the highest in Taki (Table 3). In contrast, protein contents of dried products which were in the range of 42.4% to 54.65% with the lowest in Taki and the highest in Puti. It is possible that the total nitrogen content in most traditional dried samples obtained from various, market sources increased compared to that in solar dried samples due to the growth of microorganisms and release of metabolites during drying.

Lipid contents of dried Puti, Chapila and Taki products were 5.15%, 9.21% and 6.01%, respectively (**Table 3**). According to fresh products, lipid contents of Puti, Chapila and Taki were 3.98%, 4.78% and 4.67%, respectively (**Table 3**). The chemical composition, the lipid contents were reported to vary greatly even within the species according to age, sex, season, feeding habit and habitat [45].

Ash content of fresh and dried fish products was summarized in **Table 3**. Ash contents of fresh Puti, Chapila and Taki were 4.91%, 6.89% and 7.98%, respectively. On the other hand, ash contents of dried Puti, Chapila and Taki were 24.17%, 13.45% and 15.76%, respectively. The high level of ash content in dried fish products might be associated with the contamination of sands and filth during drying. It is well known that traditional drying of fish are often done in the open field or on the sand particularly when large quantity of fishes are caught at a time during peak season.

The results of proximate analysis of fresh and dried fish products was indicated some variations in their composition. The most important and significant variation was observed in moisture and ash content. The results were obtained on proximate composition in the present study is more or less similar as previously reported for freshwater fishes of this region [46-48]. Ahmed et al. [49] reported that fishes dried by a solar drier contained higher percentage of protein and fat over the traditional sun dried products. This phenomenon was also observed in the present study. Cutting [50] stated that the chief alteration caused by drying was the loss of water resulting in an increase in protein, fat and mineral contents and thereby an increase in food value per unit weight of dried fish. This means food value per unit weight of tent dried fish must be higher than that of traditionally dried market samples.

Total Volatile Base Nitrogen, Peroxide value, Acid value and Conjugated Diene of Fresh and Sun Dried Products

The results of the total volatile base nitrogen (TVB-N), peroxide value (PO), acid value (AV) and conjugated diene (CD) of fresh and sun-dried products are given in **Table 4**. The TVB-N content of fresh fish ranged from 24.23 to 26.78 mg/100 g with the highest value in Puti and the lowest value in Taki. In sun dried fish the TVB-N contents ranged from 34.45 to 32.45 mg/100 g. TVB-N values were much lower than the recommended value (100-200 mg/100 g) for variety of salted and dried fish products [51]. Volatile bases (ammonia, mono-di> and tri-methylamines) are of minor significance in the muscles of living fish but most important to fish handling, as they are found in the common pattern of spoilage. Volatile bases other than TMA are formed during spoilage.

Table 4: Total volatile base nitrogen, peroxide value, acid value and conjugated diene (CD) of fresh and sun dried products.

Fish sample	Category	TVB-N (mg/100 g)	Peroxide Value (meq/kg oil)	Acid Value (mg KOH/g oil)	CD (Optical Density/234 nm)
Puti	Sun dried	34.45	36	20.83	3.54
	Fresh Fish	26.78	16.7	12.05	3.36
Chapila	Sun dried	32.8	32.6	22.25	3.63
	Fresh Fish	25.89	17.93	13.75	3.39
Taki	Sun dried	32.45	33.09	25.13	3.57
	Fresh Fish	24.23	17.66	16.24	3.43

Sen et al. [52] reported that TVB-N value of overall sun-dried product varied from 32.5 to 41.0 mg/100 g. Available reports suggest that in the case of fresh finfish such as cod, haddock, eel and sea pike, the upper limit of 30 mg TVB-N/l00 g is considered for acceptability [53]. The TVB-N value is a useful parameter to assess the degree of freshness for chilled and frozen products but not suitable for the dried products because most of the volatile bases escape from the body during the drying process.

As shown in the **Table 4**, the peroxide value of fresh samples was in the range of 16.7 to 17.93 meq/kg oil with maximum obtained in Chapila and minimum in Puti. These values were, however, the range of suggested value of 10-20 meq/kg oil [54]. Similar results were also obtained from some marine fishes where the peroxide values of the products produced from 1 day ice stored samples were in the range of 3.9 to 12.1 meq/kg oil with the lowest value in Ribbon fish and the highest value in Big-eye tuna [55]. On the other hand, the peroxide values of the traditionally dried products were in the range of 32.6 to 36 meq/kg oil with maximum in Puti and minimum in Chapila, the range which was much above the acceptable limit. Besides, strict hygienic condition was maintained during various steps of drying. As a result, the total bacterial content was within the acceptable limit and the products were safe from microbiological point of view. On the other hand, most of the traditionally sun dried product samples collected from local retail market was stored for 6-7 months in abusive condition. Enough moisture was absorbed from the air especially during the rainy season. Thus a suitable environment was created and total bacterial content exceeded the limit of acceptability.

Acid value of dried fish product was ranged from 20.83 to 25.13 mg KOH/g of lipid, which was increased significantly ($P<0.05$), maximum obtained in Taki and minimum in Puti (**Table 4**). An increased acid value suggested that free fatty acids might be released by partial hydrolysis of lipids during storage of dried fishes. Moreover, lipolysis induced by lipases and phospholipases, produces fatty acids that undergo further oxidation to produce low-molecular weight compounds that are responsible for the rancid off-flavor and taste of fish and fish products [56].

In general, after peroxides are formed, the non-conjugated double bonds (C=C-C-C=C) that are present in natural unsaturated lipids are converted to conjugated double bonds (C=C-C=C) [57]. This is accompanied by increased UV absorption at 234 nm [58]. The increase in absorbance at 234 nm is an indicator of auto-oxidation and is reported to increase with uptake of oxygen and formation of peroxides during the early stages of oxidation [59]. The changes in CD of dried Puti, Chapila and Taki fish oil occurred in the same manner (**Table 4**). The maximum values of CD in both the dried fishes were found in Chapila. For Puti, the CD of lipids was ranged from 3.369 to 3.542, which increased significantly ($P<0.05$) throughout the storage period. Similarly, CD was significantly increased in the Taki lipids during sun drying. The formation and decomposition rates of CD participated in the changes in CD value [60]. The increase in CD of dried fishes might be due to the excessive oxidation of lipid during storage of dried fishes.

The bacterial loads (Aerobic Plate Count) of fresh and sun dried samples of Puti, Chapila and Taki are presented in **Table 5**. The bacterial loads of the sun dried products were in the range of 2.44×10^5 to 2.52×10^6/g with the highest value in Puti and the lowest value in Chapila. On the other hand, Aerobic Plate Count (APC) of fresh products ranged from 3.9×10^4 to 3.8×10^5 CFU/g with maximum value obtained in Taki and minimum in Chapila. Generally, no Coliform bacteria or *Salmonella* was found in traditional dried products. It is clearly evident from the results that the APC counts were higher in sun dried than fresh samples. The results obtained from the sun dried products of the present study is more or less similar to those of some marine dried products produced in solar dryers where APC of solar tunnel dried Ribbon fish, Bombay duck, Big-eye tuna, Silver jew fish and Chinese pomfret were in the range of 1.88×10^3 to 3.06×10^4 CFU/g [15]. Most bacteria do not grow and multiply at aw values below 0.95. Frazier and Westhoft [61] stated that generally no microorganism (yeast, mold and bacteria) could grow in a fish product of moisture content less than 15%. Moisture content in most of the sun-dried products was low enough for the growth and multiplication of microorganisms. Besides, strict hygienic condition was maintained during various steps of drying. As a result, the total bacterial content was within the acceptable limit and the products were safe from microbiological point of view. On the other hand, most of the traditionally sun dried product samples collected from local retail market was stored for 6-7 months in abusive condition. Enough moisture was absorbed from the air especially during the rainy season. Thus a suitable environment was created and total bacterial content exceeded the limit of acceptability. According to Sen et al. [52], when water content of fish fell below 25% of wet weight, bacterial action stopped and when the water content further reduced to 15%, mold ceased to grow.

Table 5: APC (CFU/g) value of fresh and sun-dried fish products.

Sample Type	Puti (CFU/g)	Chapila (CFU/g)	Taki (CFU/g)
Fresh	3.60×10^5	3.90×10^4	3.80×10^5
Sun Dried	2.52×10^6	2.44×10^5	2.17×10^6

Conclusion

In Bangladesh, sun drying is mostly carried out in an unhygienic condition. Results of this study demonstrated that the dried fish produced by the sun drying method showed lower quality compared to the fresh product that is newly catch. The physical characteristics of sun dried fishes are not good as fresh fish. From viewing the proximate composition, it can say that these compositions of sun dried products are lower than fresh products. The dried fish products are oxidized during the storage period which isn't safe for human consumption. Therefore, it is necessary to maintain proper hygienic and scientific methods to produce quality dried fish products. Moreover, the quality and safety of the dried fish product is highly desirable for the health conscious people in the country and to achieve this scientific and improved sun drying method should be practiced throughout the country.

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