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Quality assessment of dried mrigal (*Cirrhunus mrigala*) chhari fish from different market outlets of Nepal

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Abstract
Dried chhari fish is a popular fish product with good market potential. A study was carried out to access quality of cured and uncured dried chhari fish in commercially fish processing centers in wholesale and retail markets. A total of 36 samples of cured and uncured dried fish were collected from the fish processing centers and their respective wholesale and retail markets. Samples were analyzed for proximate, chemical and microbial analysis. Wide differences in crude protein (64.3±0.7 to 73.4±0.7%) and crude fat (6.7±0.2 to 12.4±0.1%) among samples of cured dried fish were obtained. pH values of both cured and uncured samples were within the acceptable range (6.0 to 7.0). The peroxide values of both cured and uncured samples were within the permissible level (10 to 20 meq O_2/kg of oil). The total plate count ranged from $150.0x10^3±83.0x10^3$ to $12000.0x10^3±13000.0x10^3$ cfu/g in cured dried fish and from $4200.0x10^3±200.0x10^3$ to $2400000.0x10^3±1300000.0x10^3$ in uncured dried fish. Mold content ranged from $0.7x10^3±0.1x10^3$ to $3.5x10^3±1.2x10^3$ in cured dried fish and from $14.0x10^3±7.7x10^3$ to1300.0 $x10^3±1500.0$ $x10^3$ in uncured dried fish. Present analysis suggests that chhari sized mrigal fish dried by smoking at both cured and uncured processing sites and their respective market channels were less hygienic at current state of drying. However, fish preservation through curing method was comparatively better than uncured in terms of processing, preservation and storage. The study suggests that the need for improvement in fish preservation technology including processing technology and adoption of soar dryer and hybrid solar dryer.

Keywords: chhari fish, smoking, curing, processing, marketing channels

Introduction
Preference of fish consumption has been increased recently in Nepal to supplement the other source of animal protein. Fish protein is compared favorably with eggs, meat and milk in its amino acid content, and has a higher level of essential lysine and methionine both of which are lacking in a cereal-based diet [1, 2]. Most of the fresh fish markets of Nepal are in southern plain area where 90% of country's fish are produced, and the major cities where fresh fish are supplied. Transportation of fresh fish for marketing in far remote areas of Nepal is very limited because of its heaviness and perishable nature. High nutrient content, neutral pH and high-water activity makes fresh fish perishable within a short period of time and starts to deteriorate immediately after catch [3].

The dried fish is one of the alternatives sources of animal protein for people living in remote and poor physiographic areas. Enhanced self-life and lightness of the dried fish makes it easy to transport in distant market. Traditionally, fish collected from rivers, wetlands and ponds were locally preserved in the form of dry fish in order to retain quality for longer period [4]. Dried fish products are marketed where there is poor road access areas and mountainous regions where transportation of bulky commodities is difficult. As a result, the demand for dry fish has increased in recent years and the dried fish from wild capture is not enough to meet the ever-increasing demand.

Small sized whole fish of mostly mrigal (*Cirrhinus mrigala*) is commonly called chhari fish. Dried fish is a popular fish product and has a good market in Nepal. Considering the demand for small sized dry fish, fish farmers started farming of chhari fish. Farming of chhari mrigal fish is more compatible for multiple stocking and harvesting which results in high yield. The appropriate size of fish for production and drying preferred is ranged between 20 to 100 g. Dried fish of this size is believed to be stored for long period of time and consumed when desired. Market of dried chhari fish has expanded rapidly and has established network centers. Central Terai of Nepal (Bara, Parsa and Rautahat districts) is the main site for chhari size fish production. Chhari produced in central Terai are processed in different locations. Processing centers far from production site requires considerable time for fresh fish transportation. Fresh fish should be preserved as soon as possible because chemical breakdown of protein, fat and water contribute to quick spoilage [5]. Poor quality of dried fish declines in its consumption and in export [6]. The spoilage of dried fish is mainly due to bacterial, fungal or yeast action, rancidity, autolysis, browning and other reactions, all of which are temperature and water activity dependent [7]. The quality of the dried fish never receives much attention at any stage of processing, storage and marketing [8]. Little efforts were made to study the cause, nature and extent of deterioration of dried fish even though the poor quality of dried fish product is a well-known fact. Since few years, commercially dried chhari mrigal is available in the markets, which has a great consumer demand in different parts of Nepal. But the quality and food safety values of locally processed chhari sized mrigal is not yet known. Dried fish products have their oil content and moisture content considerably reduced and content more protein on weight for weight basis [9]. Nevertheless, cooking and preservation techniques could cause modifications in proximate composition, fatty acids and amino acids as well as changes in solubility and nutritional quality of fish [10-12]. Improperly or inadequately dried fish could reabsorb moisture and develop favorable condition for bacterial and mold growth. The present study was undertaken to assess the quality (proximate, biochemical and microbial) of dried mrigal chhari fish available at different market outlets and processing sites of Nepal.

Materials and Methods

A survey based on semi structured questionnaires followed by interview was carried out at commercially fish processing center, wholesale and retail markets during 2014 to 2015. A sum of 36 respondents were asked about the fish curing and drying methods, storage condition, post-harvest loss and marketing. The general conditions of the curing yards and the methods preparations were noted at each center.

A total of 36 samples of cured (partially gutted and washed) and uncured (ungutted and unwashed) dried fish were collected from the fish processing centers and their respective wholesale and retail markets. The samples were subjected to proximate, chemical and microbial analysis at Public Laboratory, Lalitpur. The proximate composition of the samples was determined following standard AOAC methods [13]. Moisture was determined by drying at 105 °C to a constant weight. Nitrogen was estimated by the Kjeldahl method (2200 Kjeltec Auto distillation, Foss Tecator, Sweden) and crude protein was estimated by multiplying the percent nitrogen by 6.25. Ether extract was measured by the solvent extraction method (1045 Soxtec extraction unit, Tecator, Sweden) using diethyl ether (boiling point 40-60 °C) as a solvent. A digital pH meter was used to measure pH. Peroxide value (PV) was determined by titration method as described by Onwuka [14]. Total plate count (TPC), cfu/g was determined by Most Probable Number (MPN) technique and pour plate method for enumeration of mold following APHA [15].

The differences in moisture content, protein content, fat content, PV, TPC and mold between cured and uncured dried fish were tested by standard t-test. Analysis of variance (ANOVA) was applied for the differences in group mean of moisture content, protein content, fat content, PV, TPC and mold between cured and uncured dried fish across the marketing channels (processor, wholesale and retail). Duncan’s Multiple Range Tests (DMRT) was applied to determine the significant differences between any two means. All statistical tests were performed using statistical software SPSS (version 20.0). Comparisons were made at 5% probability.

Results

Processing system and physical loss

Survey revealed that smoking was the only method of fish drying for both cured and uncured chhari size fish practiced in commercially fish processing centers. At the uncured fish processing centers, fish were transported from the landing centers to the drying place in jeep or riksha and heaped on the floor directly. Fish were smoked whole without washing, gutting and removal of gills in uncured fish processing centers (Fig. 1). For smoking, a bhatti (a cooking place) about 1.0 to 1.5 cubic meter size was prepared under the ground with brick and mud. Bhatti is an iron rod plate farm heated with extreme heat by wooden coal. The fish which were heaped on the ground were arranged on the iron mesh frame one by one lying the belly downward. Then the iron mesh frame with fish were kept over bhatti one above the another up to four to five layers and covered with thick paper. Smoke was prepared from wood.

At the cured fish drying centers fish from landing site were transported by preserving with ice in styrofoam box (Fig. 2). Before drying fish were cured by washing with water and split opened the ventral part, removed the gut partially. Small sized fish were dried whole and big sized fish in pieces. For smoking, a temporary bhatti was prepared above the ground with bricks. Smoke was prepared from wood.

According to the respondents the duration of fish drying period was depended on the size of fish, usually larger the size longer the duration of drying. The day required to dry 25-50g, 51-75g and 76-100g sized fish were one, two and three days, respectively. The dried fish were stored differently at cured and uncured fish processing centers. In uncured fish processing centers, dried fish were kept on iron wire mesh cage. The iron wire mesh frame with dried fish were piled one above the another and kept inside the cage made from iron wire mesh. The dried fish were also stored inside the underground bhatti by keeping on iron wire mesh frame and covered with aluminum sheet (Fig. 1). In cured fish processing centers, most of the dried fish were kept hanging in rope inside the room (Fig. 2). Dried fish were also kept in tokari (bamboo basket). At both cured and uncured fish processing centers, dried fish were stored openly without packing. In cured fish processing center, the dried fish were marketed within 4 to 5 days. Whereas in uncured fish processing centers, the dried fish were transported to Kathmandu after one week of fish drying. In wholesale and retail shops of all market channels, dried fish were stored openly in big sized plastic bags during the 15 -30 days of storage.

Fig 1: Processing and preservation steps of uncured dried fish

Fig 2: Processing and preservation steps of cured dried fish

The post-harvest losses of dried fish were due to insect infestation, mold, fragmentation and animal predation (Table 1). Survey showed the spoilage due to mold and animal predation ranged from 40 to 50% and 30 to 35%, respectively in uncured fish processing centers. The loss of dried fish in cured fish processing centers due to insect infestation and mold ranged from 30 to 40% and 35 to 40%, respectively.

Table 1: Estimated Physical loss of cured and uncured dried fish in the processing sites during storage

Cause of post-harvest loss	Uncured dried fish, % (range)	Cured dried fish, % (range)
Insect infestation	20-30	30-40
Mold	40-50	35-40
Fragmentation	10-15	20-22
Animal predation	30-35	15-20

Nutrient quality and microbial loads

The proximate compositions of cured and uncured dried fish in different market channels are presented in Table 2. The Moisture content of both cured and uncured dried fish increased significantly from processor to wholesale and to retail in the marketing channel except processor to wholesale in uncured dried fish marketing channel. The moisture content of uncured dried fish was significantly higher than cured dried fish at processor, wholesale and retail. The overall mean of moisture content of uncured dried fish was significantly higher than cured dried fish. The protein content of both cured and uncured dried fish decreased from processor to wholesale and to retail though not significant between wholesale and retail in uncured dried fish. The protein content of uncured dried fish at processor, wholesale and retail were significantly lower (p<0.05) than cured dried fish. Similarly, the fat content of cured and uncured dried fish decreased from processor to wholesale and to retail. But the decreasing trend was not significant in uncured samples. The fat content of uncured dried fish at processing center was significantly lower (p<0.05) than cured dried fish. Whereas, the fat content of uncured dried fish was non-significantly lower (p>0.05) than cured dried fish at wholesale and retail. The overall mean of protein content and fat content of uncured dried fish was significantly lower than cured dried fish.

Table 2: Proximate value of cured and uncured dried fish at different marketing channels (mean ± SD.) (n = 3)

Market channel	Moisture (%)		Protein (%)		Fat (%)	
	Cured	Uncured	Cured	Uncured	Cured	Uncured
Processor	6.9 ±0.2[a]	10.6±1.8[a]*	73.4 ±0.7[c]	67.2± 2.4[b]*	12.4±0.1[c]	9.6±1.0*
Wholesale	8.9±0.2[b]	13.0±1.7[a]*	68.5±1.1[b]	62.8±2.6[a]*	9.7±0.2[b]	8.6±3.2
Retail	9.6±0.1[c]	18.1±2.8[b]*	64.3±0.7[a]	60.4±3.6[a]*	6.7±0.2[a]	7.0±1.6
Over all mean	8.5± 1.2	14.1±3.8*	62.8±19.1	59.3±14.3	9.6±2.4	8.4±2.3

Different superscripted letters within column between processor to retail market indicates significant different (p<0.05)
***** Indicates significant different between cured and uncured within row within parameter.

The PV and pH of cured and uncured dried fish at different marketing channels are presented in Table 3. The PV of both cured and uncured dried fish were increased from processor to wholesale and to retail in all marketing channels. The PV of cured dried fish was highest at retail (9.4±0.5, mEq O_2/kg of fat) and lowest at processor (6.3±1.1, mEq O_2/kg of fat) and the difference was significant (p<0.05). The PV of uncured dried fish was lowest (8.3±3.8, mEq O_2/kg of fat) at processor and highest (16.6±11.1, mEq O_2/kg of fat) at retail and increased values were non-significant (p>0.05). There were non-significant differences between overall mean of PV value of uncured and cured dried fish.

The pH value was increased in all marketing channels of cured and uncured dried fish. The pH value was increased from processor (5.9-6.2) to wholesale (6.2 - 6.4) and to retail (6.4-6.6) in cured dried fish. Similarly, in uncured dried fish, pH increased from processor (5.8-6.2) to wholesale (6.2 - 6.5) and to retail (6.6-7.0).

Table 3: The peroxide value (PV) (mEq O_2/kg of fat) and pH of cured and uncured dried in different market channels (mean± SD.) (n = 3)

Market channel	Peroxide (mEq O_2/kg of fat)		pH	
	Cured	Uncured	Cured Mean and range	Uncured Mean and range
Processor	6.3±1.1[a]	8.3±3.8	6.0(5.9 - 6.2)	6.0(5.8 - 6.2)
Wholesale	8.3±0.2[b]	10.3±5.2	6.3(6.2 - 6.4)	6.3(6.2 - 6.5)
Retail	9.4±0.5[c]	16.6±11.1	6.4(6.4 - 6.6)	6.8(6.6 - 7.0)
Over all mean	8.0±1.5	11.8±8.0	6.2	6.3

Different superscripted letters within column between processor to retail market indicates significant different (p<0.05)

TPC was increased from processor to wholesale and to retail in both cured and uncured dried fish marketing channels (Fig. 3). The TPC content of uncured dried fish was significantly higher (p<0.05) than cured dried fish at processor center. Same was the case in wholesale and retail market. Mean comparison between cured and uncured dried fish in TPC content showed higher TPC content in uncured dried compared to cured dried fish (Fig. 4).

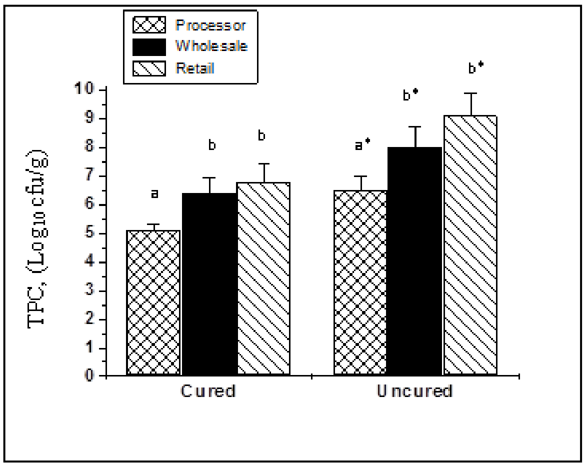

Fig 3: Comparison of TPC content of cured and uncured dried fish at different market channels. Different superscripted letters denote significant different at α 0.05 within processing method. Asterisks denotes significant difference (α 0.05) within market outlets between processing methods.

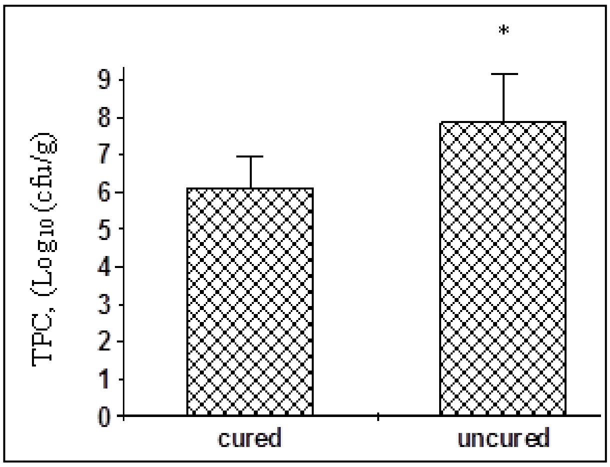

Fig 4: Comparison of mean of TPC content of cured and uncured dried. Asterisks denotes significant difference (α 0.05) within market outlets between processing methods

Mold content was increased from processor to wholesale and to retail in both cured and uncured market outlets (Fig. 5). There were significant differences in mold content of cured and uncured dried fish between processors, wholesalers and retailers. Mean comparison between cured and uncured dried fish in mold content showed higher mold content in uncured dried compared to cured dried fish (Fig. 6).

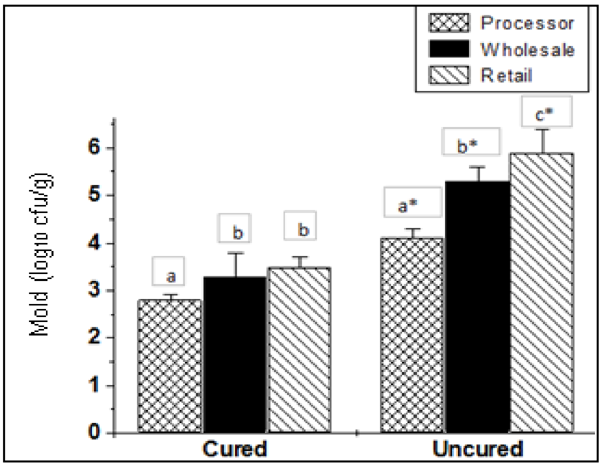

Fig. 5: Mold (Log_{10} cfu/g) of cured and uncured dried fish at different market channels. Different superscripted letters denote significant different at α 0.05 within processing method. Asterisks denotes significant difference (α 0.05) within market outlets between processing methods.

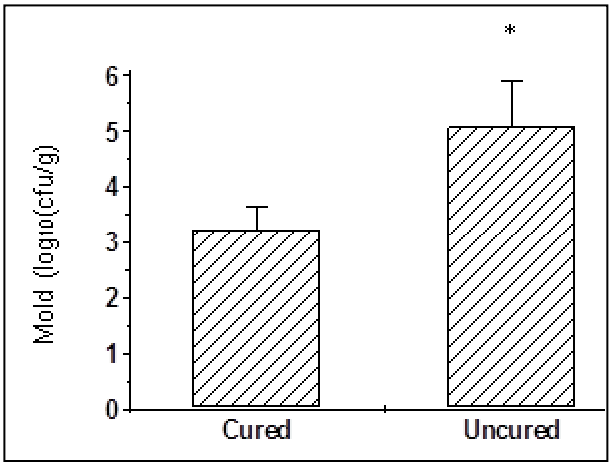

Fig 6: Comparison of mean of Mold content of cured and uncured dried fish. Asterisks denotes significant difference (α 0.05) within market outlets between processing methods.

Discussion

Post-harvest loss during processing of dried fish and quality of dried based on processing methods varies greatly. The estimated post-harvest loss of dried fish during storage in uncured fish processing center ranged from 30 to 35% which is due to animal predation (bird, cat, rat and dog) and insect's infestation during storage in the cage and inside the underground *bhatti.* In cured fish processing centers, most of the dried fish were stored inside the room hanging in rope as well as in tokari (bamboo basket), prohibiting birds and dog's predation. The loss of dried fish ranged from 15 to 20% was due to animal (rat and cat) predation inside the room. Although there was no quantifiable data available on the volume of post-harvest losses both qualitatively and quantitatively losses from 10 to 35% have been reported for marine fishes [16].

Moisture content of both cured and uncured dried fish increased (supply data) from processor to wholesale and to retail in all marketing outlets (Table 2). At both cured and uncured marketing outlets dried fish were stored openly without packaging which caused absorption of moisture from the atmosphere. Increase in moisture content could be attributed to the difference in the moisture of the smoked fish relative to the surroundings. Packaging plays a significant role as a barrier against deteriorative changes of dried fish [17]. Similar to our results, moisture content increased weekly in the five smoked fish species (Bony tongue, *Heterotis niloticus*, African carp, *Labeo coubie*, Snake fish, *Parachanna obscura*, Nile Tilapia, *Oreochromis niloticus* and African mud catfish, *Clarias gariepinus*) from the initial average of 10.41±0.02% to 10.62±0.05% by packing in black polythene bags and kept in perforated plastic containers within 8 weeks of storage [5].

The decline in protein levels observed during this study is similar to the findings of Abolagba and Melle [18] which reported that protein levels decrease with an increase in storage time. Protein were found to vary from 45.25% (0 day) to 44.81% (4 month), 74.85% (0 day) to 74.12% (4 month) and 70.82% (0 day) to 68.89% (6 month) for smoke-dried Chapila (*Gudusia chapra*), Kaika (*Xenentodon cancila*) and Baim (*Mastacembelus pancalus*), respectively, during storage at room temperature [19]. This decrease of protein could be due to reasons such as the degradation of protein molecules to more volatile compounds like Total Volatile Bases (TVB) and the leaching out of soluble protein molecules [20, 5, 21]. Similar drop in protein concentration was reported for *Heterobranchus longifilis* [22]. The decrease of fat levels from processor to wholesale and to retail could be due to the reason of oxidation of poly-unsaturated fatty acids of fish tissue to products such as peroxides, aldehydes, ketones and the free fatty acids [23]. The fat content varied in a range of 32.05-31.28%, 5.25-4.27% and 10.78-7.66% respectively, for smoke-dried Chapila (*Gudusia chapra*), Kaika (*Xenentodon cancila*) and Baim (*Mastacembelus pancalus*), respectively, during storage at room temperature [19].

The pH of the dried fish increased from processor to wholesale and wholesale to retail in the marketing channels of both cured and uncured dried fish (Table 2). The pH in fresh condition of fresh-water fish flesh is almost neutral [24]. In the post-mortem period, decomposition of nitrogenous compounds leads to an increase in pH in the fish flesh [25]. The increase in pH indicates the loss of quality. Most microorganisms grow the best at pH values between 6.6 and 7.5, whereas only a few grow at a pH below 4. Kolodziejska *et al.* [26] found the pH levels of hot smoked mackerel slightly changed from 6.1 to 6.2 after 21 days of storage at 2 ºC. pH value increased significantly in sundried and smoked *chela* spp. at the end of 60 days of storage [27]. The PV which is used as primary indicator of oxidation of fat (rancidity) increased during marketing process from dry fish processor to wholesale and wholesale to retail with storage time in both cured and uncured dried fish. Fat oxidation is a self-catalyzing reaction, which is affected by the age of the raw material as well as oxidation of fats during processing and storage. This explains the reason why the peroxide values were higher (p<0.05) during marketing process in both cured and uncured dried fish products. The higher PV contents may be due to exposure of the product to atmosphere throughout the storage period. Similar increase in PV was found by several research workers [28-32]. The lipid quality of the anchovies (*Stolephorus* sp.) showed gradual increase in PV from 3.2 to 24.5 mEq of O_2/kg of fat during 5 weeks of storage period [33]. PV values have been reported for a number of species: 0.8 to 1.2 mEq of O_2/kg of fat for herring (*Clupea harengus*) [34], 5.60 mEq of O_2/kg of fat for wild turbot (*Scophthalmus maximus*) [35] and 27.6 mEq of O_2/kg of fat for fresh sardine *pilchardus* [36]. The PV value observed in both cured and uncured dried fish were above than reported by Smith *et al.*, [34] and Ozogul *et al.*, [35] but lower than reported by Cho *et al.*, [36]. However, Connell [37] reported that when peroxide value is above 10-20 mEq of O_2/kg of fat, fish develop rancid taste and smell. But in this study, the value was within the acceptable limit of 10-20 mEq of O_2/kg of fat as suggested by Connell [37] in all cases.

In fresh fish, the acceptable limit of Total Plate Count (TPC) is 5 x10^5 cfu/g at 37°C but for cooked or dried fish, the permissible limit is 1x10^5, cfu/g at 37°C [38]. The TPC, cfu/g in all market channels from processor to wholesale and to retailer increases in both cured and uncured dried fish products due to growth and multiplication of the microbes [39]. This view is supported by Clucas and Sutcliffe [40]. Microbial load increases with duration of storage [41]. As the duration of storage increase, processed fish samples may absorb small amounts of moisture from surrounding atmosphere providing enabling for microbial growth [42]. The microbial and fungal load were higher in uncured dried fish than cured dried fish which may be due to contamination from the surrounding as all the activities of fish processing was done on the floor at uncured fish processing centers. Proper washing of the dressed fish was not found to be done since most of the uncured fish processing centers were without good running water. Proper waste disposal facilities also were not available. Fecal contamination near the landing center was also responsible for this [43]. Drying in an unhygienic way also adds fecal bacteria to the fishes [44].

Conclusion

Dried fish increase shelf life where fresh fish transport and storage facility is unavailable. Mean comparison between cured and uncured dried fish showed significantly higher moisture content in uncured dried fish (p<0.005) than cured fish. The protein and fat content of uncured dried fish were lower than cured dried fish but there was no significant difference. The PV value of uncured dried fish was also higher in uncured dried fish. The TPC and mold content were significantly higher in uncured dried fish than cured dried fish (p<0.05). The TPC content of both cured and uncured dried fish exceeded permissible limit. However, the mold of the cured dried fish did not exceed the permissible limit, while uncured dried fish were heavily contaminated with mold, and exceeded permissible limit. Although, chhari sized fish preservation through curing method was comparatively better than uncured in terms of processing, preservation and storage, fish dried by smoking at both cured and uncured processing sites and their respective market channels were less hygienic at current state of drying. This study suggests that the need for improvement in fish preservation technology including processing technology and adoption of soar dryer and hybrid solar dryer. It is recommended that more research should be carried out to determine the time lapse between processing and sale of smoke-dried fish in open markets in order to give a better idea of the length of storage of these products.

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