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Quality Assessment of Traditionally Dried Marine Fish of Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author PCP conducted the experiment, managed the literature searches, performed the statistical analysis and wrote the first draft of the manuscript. Authors MSR and MNI managed the analyses of the study and edited the manuscript. Author MK designed the study and wrote the protocol. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted to assess organoleptic, biochemical and microbiological quality aspects of traditionally dried marine fish products of one of the largest fish drying zones of Bangladesh viz., Cox's Bazar and Teknaf. It was found that eight species viz., *Stromateus chinensis*, *S. cinereus*, *Riksha* sp., *Johinus argentatus*, *Trichiurus haumela*, *Harpodon neherus*, *Lutianus johnii* and *Penaeus* sp. were commonly used as raw materials to produce traditional dried fish. Organoleptic characteristics in respect of colour, odour, texture, insect infestation and presence of broken pieces in the products indicated poor to moderately acceptable condition while water reconstitution rate was found to be slower in majority of the traditional sun dried products. Results of the proximate composition such as moisture, crude protein, lipid and ash content of these products ranged from 18.56% to 24.20%, 33.56% to 58.22%, 2.74% to 15.44% and 15.87% to 32.22% respectively. Total volatile base nitrogen (TVB-N) and peroxide value (PV) were 28.46 ± 0.5 to 42.88 ± 4.9 mg N/100g and 46.80 ± 1.9 to 82.70 ± 3.8 m.eq/kg oil respectively, both of which were higher than the

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recommended values for dried fish. Microbial load, on the other hand, ranged from 0.95 × 10^4 to 1.9 × 10^5 CFU/g indicating varying levels of viable bacteria in those products while no coliform bacteria were detected in these samples. These data provide valuable information on these highly relished dried fish for domestic consumers in order to choose them based on their quality aspects.

Keywords: Dried fish; coliform; organoleptic character; quality assessment; water reconstitution.

1. INTRODUCTION

Fish is the primary source of animal protein in the diets of the most Asian people [1]. It provides quality protein and other essential micro-nutrients for the maintenance of a healthy body [1,2]. In fact, fish proteins are considered vital in the diet of this densely populated part of the world, particularly for the coastal communities. Like many other Asian countries, fish and shrimp sectors are holding a key position in food and nutrition, meeting the demand of animal protein, job creation opportunities, foreign exchange earnings and GDP growth in Bangladesh [3]. However, due to higher spoilage rate compared to other animal meats, fish require appropriate preservation method to enhance its shelf life for subsequent usage. Among the various methods of fish preservation, sun-drying is one of the most ancient methods [4]. It is regarded as an efficient and cheap method for preserving fish for years and the product plays an important role particularly in providing nutrition to the poor and economically disadvantaged people in Bangladesh [5,6]. The method is widely practised in the coastal regions and in the floodplains to prepare dried fishery products from marine and freshwater fishes, respectively. In the coastal region, fish drying yards are located at Kutubdiapara, Dhalghata, Matarbari and St Martin's Island in Cox's Bazar, Charfasson in Vhola, Alipur, Mohipur, Kuakata and Rangabali in Patuakhali, Dublar Char in Bagerhat, and in the inland region, Mahatbpur, Tuker Bazar and Amtoli in Sylhet, Ibrahimpur and Jamalganj in Sunamganj, Tarash in Sirajgong, Kuliarchar in Kishoreganj are the most dominant fish drying yards [7]. Dublarchar of Sundarbans is the largest marine fish drying center of the country [5].

Apart from export data, there is no production statistics of dried and dehydrated fishery products in Bangladesh. Ahmed [8] estimated that 15% of the total fish produced in Bangladesh were used as raw material for the production of dried and salted-dehydrated fishery products while Hussain [9] estimated it to be 25%. It is possibly an overestimation as the household survey conducted by International Food Policy Research Institute, IFPRI [10] showed per capita dry fish consumption in Dhaka, Chittagong, Rajshahi, Khulna, Rangpur, Sylhet, Barisal divisions stood to 713, 1045, 178, 11, 822, 1179 and 297 g / annum respectively. Considering these estimates, we predict that the production of dried and dehydrated fishery products in Bangladesh lies somewhere between 107,000 to 120,000 mt. These products also brought significant amount of foreign exchange amounting 3.76 million USD for 2,229 mt dried fish [11], indicating their large role in the country's economy.

The dried fishery products are prepared from a large number of fish species including marine water jewfish, pomfret, snapper, ribbon fish, Indian salmon, Bombay duck, mackerel, catfish, tuna, shrimp to freshwater barb, carp, carplet, minnow, catfish, snakehead, eel, goby, loach, prawn etc. Available reports suggest that the quality of majority of the traditional sun dried products available in the market are not satisfactory for human consumption [12,13,14] and the consumers frequently complain about their quality. Therefore, there is a need to regularly monitor quality and safety of dried fish available in the domestic market. Studies were, therefore, conducted to assess organolepltic, biochemical and microbiological quality aspects of traditional dried fish available in coastal Cox's Bazar and Teknaf regions, Bangladesh. These areas were selected as study area as they are regarded as one of the largest dry fish producing zones of the country.

2. MATERIALS AND METHODS

2.1 Raw Materials

Traditionally dried fish samples of Chinese pomfret (*Stromateus chinensis*), silver pomfret (*S. cinereus*), Ricksha fish (*Ricksha* sp.), silver jewfish (*Johinus argentatus*), ribbon fish (*Trichiurus haumela*), Bombay duck (*Harpodon neherus*), red snapper (*Lutjanus johnii*) and tiger

shrimp (*Penaeus* sp.) were collected from the local market at Taknaf Bazar and Kutubdiapara of Cox's Bazar, Bangladesh during November 2017 to April 2018. About 2.5 kg of dried fish sample for each species had a total length of 19±2 cm, 21±1 cm, 14±3 cm, 21±3 cm, 31±2 cm, 25±3 cm, 36±5 cm and 4±1 cm for Chinese pomfret, silver pomfret, Ricksha fish, silver jewfish, ribbon fish, Bombay duck, red snapper and tiger shrimp, respectively were collected, packed in pyrogen-free polyethylene bag and transported to the Laboratory of Fish Processing, Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh. The quality of dried fish samples were evaluated by determining organoleptic, biochemical and bacteriological aspects as described previously [6].

2.2 Sampling Procedure and Sample Preparation

Samples were transported to the laboratory and separated into 2 categories: one for organoleptic and the other for biochemical and microbiological analyses. For biochemical and microbiological analyses, sample of each species were separated from bones and passed through food chopper for homogenisation. They were stored at 4˚C until analysis.

2.3 Determination of Organoleptic Characteristics

A sensory evaluation of flavor, color, texture, insect infestation, presence of broken pieces and overall acceptance of dried fishes was performed using 9-point hedonic scale (1 = extremely dislike to 9 = extremely like) by a trained panel of expert members [15].

2.4 Determination of Moisture, TVB-N and PV

Moisture content was determined by air drying of a given sample in a thermostat oven (Gallenkamp, HOTBOX, Manchester, UK) at 105℃ for 24 hours until constant weight. All values were expressed on wet basis. TVB-N (mg N/100g) values were determined as described by Antonacopoulos and Vyncke [16]. For determination of PV, the lipid fraction was extracted according to Bligh and Dyer [17] method and the peroxide value was determined according to the method described by Lima et al. [18].

2.5 Determination of Aerobic Plate Count and Coliform Count

About 10-15 g of whole fish sample was blended with an appropriate volume of 0.2% peptone water in a sterilised blender for few minutes until homogeneous slurry was obtained. APC expressed as colony forming units per gram of muscle (CFU/g) of the representative samples were determined by standard plate count methods on plate count agar (Hi-media, Mumbai, India) according to Collins and Lyne [19]. For the determination of total coliform count, 3.5 g of Mac Conkey's medium was first dissolved in 100 ml of distilled water. Ten (10) g of ground dried fish sample was taken and transferred to a 90 ml sterile distilled water and shaken well. Appropriate dilutions were done and tubes were incubated at 37˚C for 24-48 hr. Most probable number (MPN) by multiple dilution technique was used to determine the total coliform/g of sample with Mac Conkey's medium.

2.6 Determination of Rehydration Ability/Water Reconstitution Properties

The dried samples were rehydrated by immersing them in water bath at constant temperature, which was agitated at constant speed (100 rpm). The samples were taken from the bath at different immersion periods and were weighted after being blotted with tissue paper in order to remove excess solution and its volume was measured. The effect of water temperature was investigated using three temperatures namely 40, 60 and 80˚C up to 60 min. By the given soaking time, percentage of rehydration was calculated according to Niamnuy et al. [20]. All tests were performed in triplicates.

2.7 Statistical Analysis

Data from different parameters were subjected to *t* - test ($P < 0.05$). The statistical analysis package SPSS version 16.0 (SAS Institute Inc., NC, USA) was used to explore the statistical significance of results. One-way ANOVA was used to compare differences in the means of the moisture, protein, lipid and ash content of different species of fish. This was followed by Tukey post-hoc analysis to determine in more detail how different species of samples differed. Correlation between moisture content, aerobic plate count, and PV of the dried fish were analysed using R software [21].

3. RESULTS AND DISCUSSION

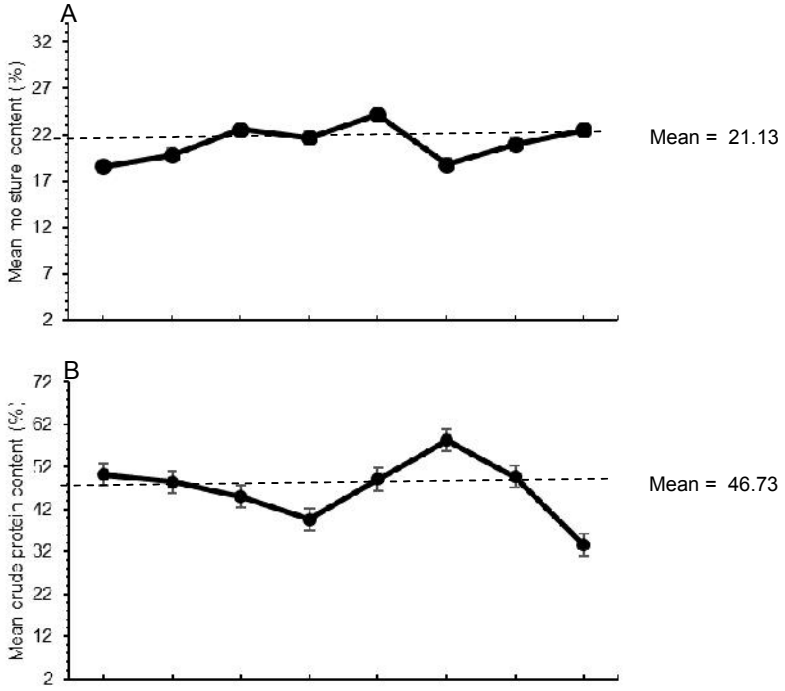
A quality assessment survey was conducted on major traditionally dried fish products in Cox's Bazar and Teknaf regions in Bangladesh. Table 1 shows the organoleptic properties of those products. It was revealed that they had characteristic odour and colour with Chinese pomfret, Bombay duck and red snapper showing strong rancid odour primarily due to oxidation of lipid. Generally, these three fish species are considered medium to high fatty fish [6,22], and polyunsaturated nature of their fatty acid makes them vulnerable to oxidation. Colour and texture of the traditional dried products varied considerably from light yellowish to blackish and highly fragile to tough elastic and flexible respectively. Most of the products were found to contain sand and filth and were infested with blowfly, beetle eggs and larvae. Fungal growth and discolouration were also observed in some samples such as Chinese pomfret and red snapper. The overall organoleptic quality of all the products was rated as poor to the moderately acceptable condition. We previously observed that the traditionally dried fish products in the coastal region of Bangladesh were of poor quality, which was possibly linked to the initial quality of the raw materials where in most cases fishes not sold as fresh in the market were used [23,24]. More or less similar results were also reported for dried samples collected from Kuakata, Bangladesh by Azam et al. [25] and West Bengal coast of India by Payra et al. [26].

The results of the mean percentage of moisture, protein, lipid and ash contents of 8 types of marine dried fish products are shown in Fig. 1. For moisture and protein contents, there were no significant differences among all the 8 fish products. Moisture content of these products ranged from 18.56 – 24.20% with highest in red snapper and the lowest in Chinese pomfret. This wide variation of moisture content is possibly related to uptake of moisture from the environment as the products are kept in jute gunny bags during storage. This phenomenon is highly pronounced in dried fish samples collected during monsoon where moisture content may reach as high as 33.28±1.89% in dried Bombay duck [27]. Crude protein content of these products ranged from 33.56 – 58.22% with highest in shrimp and lowest in red snapper. The lipid and was significantly lower in silver jewfish (Tukey Post-Hoc Test, $p<0.05$) as can be observed in Fig. 1. The lipid content in silver jewfish was approximately 4 – 6 times lower than other products ranging from 2.5 to 2.8%. This is possibly related to variation in initial lipid content of raw materials used for processing [28] as fat content in fish may vary according to seasons, species, and age and maturity of the respective species [29]. Oxidation of lipids is another reason of variation in lipid content as the degree of lipid oxidation was reported to be high in traditional dried fish products available in Bangladesh [30]. For ash content, red snapper contained significantly higher levels among 8 fish products (Fig. 1). The values ranged from 15.87 – 32.22% with lowest in Bombay duck and highest in red snapper. Such high variation in ash content among 8 dried fish products is not well understood, but may be related to the pre-treatments of raw materials with salt and herbal substance during drying. We previously reported that salt pre-treatment is a common practice in drying of many majority of fish species like pomfret, Ricksha fish, jewfish, ribbon fish, snapper and thread fin in fish yards of Cox's Bazar, Moheshkhali, Sonadia and Teknaf regions where processors use 10-15% NaCl to enhance drying [5,13]; while herbal preservatives like turmeric and chili powder were used in fish drying yards of Cox's Bazar and Sonadia regions of Bangladesh [31]. Considering the results of proximate analyses, these dried fish products were identified to be high in protein, fat and mineral contents, indicating their higher food value [32].

Rehydration property (also known as reconstitution property) of a dried product is the ability of moistening, and generally used as a quality indicator. It specifies the rate of cellular and structural disintegration that occurs during the dehydration process [33]. Generally better reconstitution property is observed for products where the porous structure has been conserved by a suitable method. In the present study, we investigated time and temperature function on rehydration property of 8 traditional dried marine fish products and results are shown in Fig. 2. It was observed that the rehydration rate was highest in dried shrimp compared to rest of the samples where the values ranged from 71 to 92% while soaking at 40°C for 15 min and 80°C for 60 min respectively. The lowest values, on the other hand, were observed for dried silver pomfret and Riksha fish which ranged from 20 to 40% while soaking at same condition (Fig. 2). The samples of shrimp, ribbon fish and Bombay duck exhibited a rapid initial rate of rehydration which was no doubt due to water being carried deep into the pieces by a porous structure which absorbed and retained

Table 1. Organoleptic quality of traditional dried marine fishery products

Fish sample	Organoleptic quality	Overall acceptance
Chinese pomfret	Brownish colour on the outer surface but reddish in inner side; characteristic dry fish odor; firm and flexible texture; infestation by fly eggs and larvae; no broken pieces	5.53 ≈ 6
Silver pomfret	Brownish colour on the outer surface reddish in inner side; slight decrease of dry fish odor; firm and flexible texture; infestation by fly eggs and larvae; no broken pieces	6.06 ≈ 6
Riksha fish	Blackish to brownish in the outer side and yellowish to reddish in the inner; characteristic dry fish odor; slightly softened texture; infestation by blow flies; some broken pieces	7.20 ≈ 7
Silver jewfish	Characteristic colour. slight decrease of dry fish odor; firm and flexible texture, no infestation; a few broken pieces	6.90 ≈ 7
Ribbon fish	Slightly whitish colour, characteristic odour; firm and flexible texture; no infestation; a few broken pieces.	7.51 ≈ 8
Shrimp	Fade colour; slight rancid odour; firm and flexible texture; infestation by blow flies and other insects; many broken pieces	5.52 ≈ 6
Bombay duck	Characteristic colour; slight rancid odour; presence of broken pieces, infestation by flies and filth; a few broken pieces.	7.11 ≈ 7
Red snapper	Brownish colour on the outer surface but reddish in the inner side; characteristic odour; firm and flexible texture; no infestation; no broken pieces.	5.80 ≈ 6



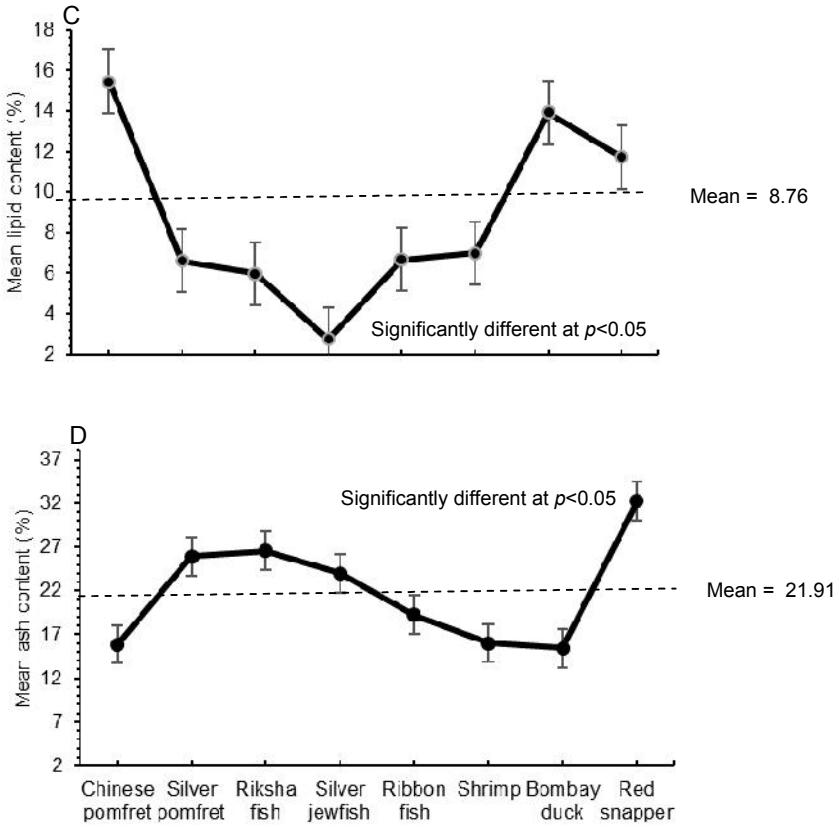


Fig. 1. Proximate composition (A, moisture; B, protein; C, lipid and D, ash) of traditional dried marine fishery products

sufficient water by capillarity [34]. However, water retention was decreased to 89% and 80% at higher temperature when soaked for longer duration of 45 min and 60 min in shrimp and silver jewfish respectively. These results suggest that optimum rehydration of dried products occurred at lower temperature rather than higher temperature. Significant differences for these rehydration values were observed for shrimp and Bombay duck among the 8 dried fish (p<0.05). As expected, 100% reconstitution of the dried fish was not possible. This is possibly due to no pre-treatment of salt for Bombay duck and shrimp during drying process. Organoleptic properties of the dried fish were also found to have some correlation with rehydration properties where products having firm and flexible texture showed higher reconstitution properties (Table 1).

Results of TVB-N analysis of dried products are shown in Table 2. TVB-N is a breakdown product of proteins by the action of microorganisms in wet fish and generally used as a quality indicator. Although these volatile bases may escape during the process of drying, this parameter was used to check the degree of bacterial spoilage of the dried products [6,35]. The TVB-N values for the traditionally dried marine fish samples ranged between 28.46 to 42.88 mg N/100 g with lowest in Chinese pomfret and highest in shrimp. These values were slightly higher than the limit of acceptance. Values between 35-40 mg N/ 100 g are usually regarded as the limit beyond which round, whole marine dried fish can be considered to be spoiled for most uses [6,36]. In the present study, we observed all the products were more or less in acceptable condition.

The PV of the traditional dried products exceeded a higher acceptable limit of 10-20 m.eq/kg oil [6,36]. The values in all the samples ranged from 46.80 to 82.70 m.eq/kg oil. It is well known that the sensory properties of dried products may deteriorate during storage due to oxidation of lipids. Fish oils, as well as other edible oils and fats, if conditions are favourable, spontaneously oxidise in the presence of

atmospheric oxygen. The amount of lipid was found to be well correlated with the PV of the dried products (Fig. 3B). At or near the ordinary temperatures the rate of autoxidation of oils is dependent on various factors. One of key factors is the degree of unsaturation which is most common as marine fish containing large quantity of unsaturated fatty acids. Temperature is the factor influencing the rate of oxidation and it is of common knowledge that the rate of oxidation increases with the increasing temperature. The rise of temperature activates reaction molecules and at the same time promotes the decomposition of peroxides. Light and the moisture in the oil also influence the rate of oxidation [37]. Therefore, the increased peroxide value in the traditional dried products is expected because they were susceptible to rapid oxidation during processing, drying and storage under abused influencing conditions including inappropriate packaging [23].

The viable bacterial count of traditional dried marine fishery products collected from Cox's Bazar and Teknaf regions, Bangladesh was studied and the results are presented in Table 2. The count of aerobic bacteria in dried fishery products such as Chinese pomfret, silver pomfret, Ricksha fish, silver jewfish, ribbon fish, Bombay duck, red snapper and tiger shrimp were 1.8×10^4, 5.8×10^4, $5\ 4 \times 10^4$, 0.95×10^4, 0.95×10^5, 3.5×10^4, 1.3×10^5 and 1.1×10^4 CFU/g respectively. The results of the study on bacterial load in dried fishery products showed that total bacterial load were comparatively low and within acceptable limit for six species except ribbon fish and Bombay duck. The relative moisture content in the dried products was found to be the major factor affecting the SPC as higher values of SPC obtained for ribbon fish and Bombay duck was correlated well with higher levels of moisture among the eight dried samples collected from the markets (Fig. 3A). The values were slightly

Table 2. Total volatile base nitrogen (TVB-N), peroxide value (PV), standard plate count (SPC) and total coliform count for eight traditional dried marine fishery products

Fish sample	TVB-N (mg N/100g)	PV (m.eq/kg oil)	SPC(CFU/g)	Total coliform count (CFU/g)
Chinese pomfret	28.46± 0.5	48.67± 2.5	1.8×10^4	Nil
Silver pomfret	32.16± 1.2	72.50± 1.8	5.8×10^4	Nil
Riksha fish	35.46± 1.7	54.40± 3.5	5.4×10^4	Nil
Silver jewfish	29.88± 1.8	72.50± 1.2	0.95×10^4	Nil
Ribbon fish	36.74± 2.5	74.60± 1.5	1.95×10^5	Nil
Shrimp	42.88±4.9	82.70± 3.8	3.5×10^4	Nil
Bombay duck	41.76±4.3	72.70± 3.1	1.3×10^5	Nil
Red snapper	39.88±0.3	46.80± 1.9	1.1×10^4	Nil

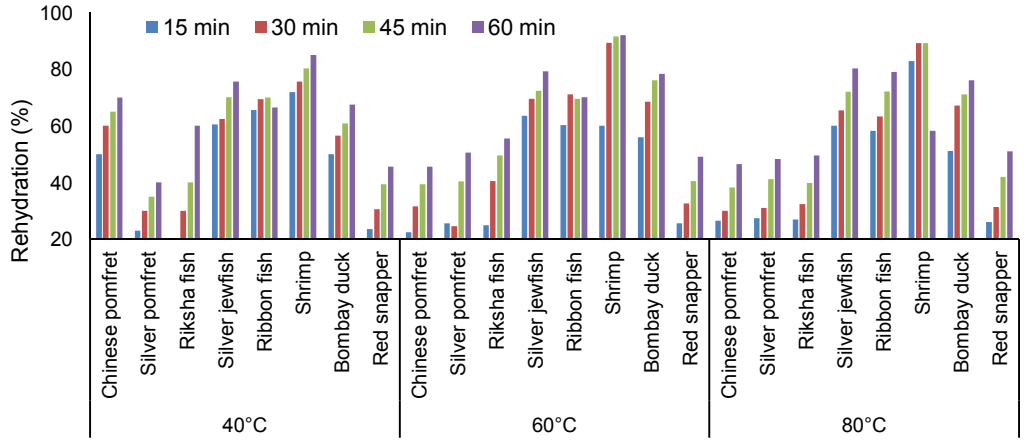


Fig. 2. Rehydration properties of eight traditional dried marine fishery products at 40°C, 60°C and 80°C

higher than the permissible limit of 1×10^4 CFU/g for these two samples [38]. Other factors include improper handling, storage and sanitary conditions during the preparation of dried products [39]. Generally marine fish contain a high level of non-protein nitrogen (NPN) content and generally samples with high NPN content to contain high bacterial load. But there is a positive relationship between moisture content and bacterial growth in dried fish (Fig. 3A). Although there is a close relationship observed between the high bacterial load and the corresponding high level of NPN content [40], when the initial moisture content was close to 20% or below this, the samples did pick up some moisture content before any microbial attack was possible. Sen et al. [41] reported that when water content of the fish fell below 25% of the wet weight, bacterial action stopped and when the water content was further reduced to 15%, mold ceased to grow. Frazier and Westhoff [42] stated that generally no microorganism (yeast, mold and bacteria) could grow in a fish product with moisture content of less than 14%. This indicated that moisture content of 20% was quite unsuitable for the growth and multiplication of bacteria. As a result, the bacterial load was in low and acceptable condition for Chinese and silver pomfret, Riksha fish, silver jewfish, shrimp and red snapper. For presence of coliform, no sample was found to be positive for this pathogen indicating maintenance of hygienic condition of these products during processing and storage.

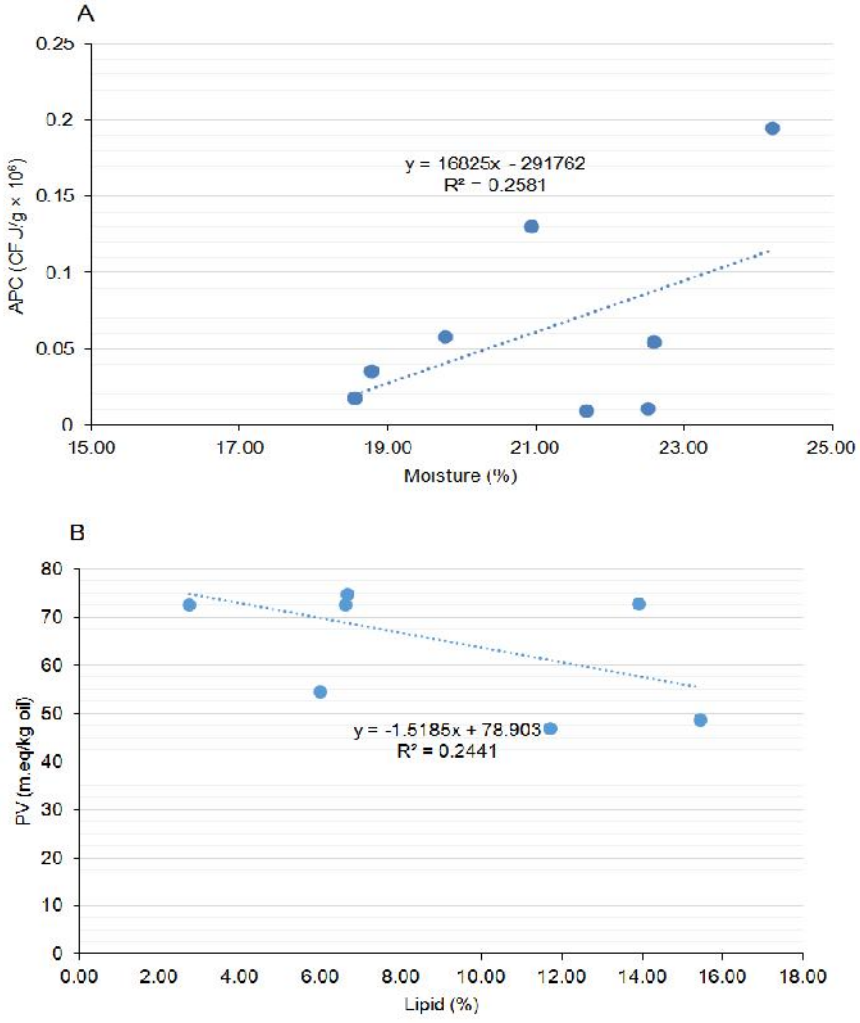


Fig. 3. Correlation between (A) moisture content - aerobic plate count, and (B) lipid content - PV in eight traditional dried fishery products

4. CONCLUSION

Generally, it is assumed that the traditional dried processed fish products are produced under unhygienic conditions. This concept is partially true for those traditionally dried marine fish products which are prepared for local consumption but not in case of those products which are prepared only for export purposes. Due to the increasing demand and higher consumer preference towards these products, special care is now being taken and hygienic conditions improved during processing, handling and storage to sustain goodwill in the competitive market.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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