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Full Length Research Paper

Study on the quality and safety aspect of three sun-dried fish

Hasnain O. Altaf, Farhanullah k. and Fahim Jahanzeb

Department of Fishery, Faculty of Agricultural Sciences, Allama Iqbal Open University, Islamabad, Islamabad CT, Pakistan. *E-mail: hasto@gmail.com

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Market samples of three sun-dried freshwater fish species namely Indian major carp (*Labeo rohita*), snake headed fish (*Channa striatus*), and a type of eurasian catfish (*Wallago attu*) were included in this study. The quality of the sun-dried fish samples were evaluated by examining physical properties, biochemical composition, and reconstitution behaviour. The safety aspect of the sun-dried fish samples were studied by the detection of heavy metal, total viable bacterial count (TBC), aerobic plate count (APC) and Total volatile base-Nitrogen (TVB-N). According to the physical characteristics such as colour, odour, texture, it appeared that the *L. rohita* and *C. striatus* were of better quality than that of the *W. attu* which had already developed rancid odour, and bitter taste. The examined samples were brownish to light brown compared to the attractive cream colour of a freshly prepared samples. The products had moisture content ranging from 19.17 to 23.12%. The protein content ranged from 49.23 to 62.85%. Lipid and ash content were in the range of 4.92 to 11.0% and from 11.11 to 18.89%, respectively. *C. striatus* contained the highest protein content (62.85%) and *W. attu* contained lowest protein (49.23%) on moisture free basis. The result of heavy metal analysis of the sun-dried fish samples showed that, in sun-dried *L. rohita*, Arsenic (As) was 0.001 µg/g, Cadmium (Cd) was 0.53 µg/g, and Chromium (Cr) was 0.025 µg/g. In the sample of sun-dried *C. striatus* As was 0.003 µg/g, Cd was 0.089 µg/g and Cr was 0.054 µg/g; while in the sample of sun-dried *W. attu* As was 0.004, Cd 0.097, and Cr 0.068, which were within the acceptable limit for human consumption. The TBC of the experimental samples ranged from 1.84×10^4 to 5.3×10^6 per g of the dried samples. The total volatile base Nitrogen (N) content of the dried fish samples ranged from 7.54 to 8.32%. Reconstitution rate was found to be faster in *C. striatus* and *L. rohita* but slower in *W. attu*.

Key words: Total volatile base-Nitrogen, sun-dried, trace elements, fish.

INTRODUCTION

Drying along with salting and smoking as a fish preservation technique had been practiced perhaps longer than any other food preservation technique. Drying and other two curing methods have all continued as preservation techniques virtually unaltered from prehistory to the present day.Modern developments have centered around understanding and controlling the process to achieve the standard product demanded by today's market (Horner, 1992). Drying is one of the important methods of preserving fish throughout the world. It is still a vital method in the developing regions of the world.

Fish is the major source of animal protein in the diet of the people of Bangladesh contributing 58% of the total animal protein supply (DoF, 2008). It contributes 3.74% of the Gross Domestic Product (GDP) and 4.04% of the foreign exchange earnings. A sizeable quantity of fish is preserved by sun drying in Bangladesh from inland water fish as well as from sea fish. Domestic consumers as well as the ethnic community in developed countries eat dried fish. Bangladesh earns a good quantity of foreign exchange by exporting dried fish every year. The food value of dried fish is well established by the scientists (Cutting, 1962; Qudrat-I-Khuda et al., 1962; De, 1967; Bhattacharya et al., 1985; Humayun, 1985). A major problem associated with sun drying of fish in Bangladesh is the infestation of the product by fly and insect larvae during drying and storage (Ahmed et al., 1978).

In general, bacteriological problem associated with quality loss is not significant in properly dried and well-packaged fish products. The problem is the contamination during different stages of handling and improper packaging. Connell (1957) reported that, fresh fish species dried in sun reabsorbs water to comparatively small extent and once reconstituted, are very tough, almost rubber-like, fibrous, compact, and dry in mouth. Freshly prepared dry fish will have an attractive cream colour. On long storage, they become brownish yellow or brown which indicates varying degree of spoilage (Connell, 1957). It is highly desirable that, the requirement of a safe dried product should be available to all those who are concerned with the expansion and development of fish processing and preservation particularly in those regions of the world where an improvement in the fishery can have a marked effect on the standard of living of the people. Poulter et al. (1988) described losses of fish, which have been cured by salting, drying, smoking or a combination of these processes. Undue delay in processing and poor processing methods may lead to low value poor quality products; this represents a financial loss to fishermen or processor. The causes and extent of different types of quality reduction is described. Excessive heat treatment is known to impair the availability of amino acids such as lysine in fish protein (Carpenter and Booth, 1973). Hoffman et al. (1977) found a significant reduction in lysine availability and net protein utilization in tropical fish dried at 75°C and smoked at 100°C. Post harvest loss in dried fish product is estimated as 25% in Bangladesh (Doe et al., 1977).Under very humid conditions cured fish reabsorb moisture. Rao et al. (1962) found that, a relative humidity of over 70% was conductive to mould attack. Fish damaged by mould has a lower price thereby resulting in economic loss.

Good quality raw material supply is essential for both domestic consumption and value-added product development for export market. It needs proper research support to produce safe and quality product for export. Global climate change has lead to an increasing concern in recent years regarding the abundant entry of heavy metal into the water and their probable adverse effect that might be reflected on aquatic animal like fish, and finally, on human health through the food chain.

Attention to environmental pollution in Bangladesh was not adequate which is now affecting its fisheries resources. Fish living in the polluted water may accumulated toxic trace metals via their food chain. High level of As, Lead (Pb), Copper (Cu), and Iron (Fe) have been found to cause rapid physiological changes in fish (Tarrio et al. 1991). As is identified as a toxic environmental pollutant because, it causes chronic and epidemic effects on human health through widespread water and crop contamination due to the natural release of this toxic element from aquifer rock in Bangladesh (Fazal et al., 2001). Cd is a known teratogen and carcinogen, probable mutagen and has been implicated as the cause of serious deleterious effect on fish. Trace elements can be accumulated by fish, both through the food chain and water (Hadson, 1998). Mercury (Hg), Cd, Cr, Pb, Selenium (Se), are known to be potentially harmful pollutants contaminated in fish, but so far only Hg has been implicated in disease to consumers caused by eating fish. Hg above 0.5 to 1.0 mg/kg cause a disease in human which affects central nervous system (Connell, 1980). For a sufficient margin of safety and a fairly high level of weekly fish consumption is 4 to 8 meals of 150 g each.

In Bangladesh, very little work has been done on the presence of heavy metals in freshwater fish, despite such data are important to assess the quality and safety of fish and fishery product for domestic consumption as well as for export. Some research, on the As on ground water relevant to human health are done by foreign scientists. But research on As, Cd, and Cr detection in fish and fishery products is still imperative for human health concern. Examination of fish and fishery products on specific metal and elements (heavy metal) may be necessary because sometimes fish are caught from suspected area as for example near effluent discharges or waste dumps. These heavy metals are cumulative poison that cause injury to health through progressive and irreversible accumulation in the body as a result of eating repeated small amounts. In the present study, we have attempted to create data information, which will be helpful in producing a quality product as well as a safe product for domestic consumption as well as for export.The present study was undertaken with the aim to have a clear idea about the quality and safety aspects of sun-dried fish. The nutritive value of dried fish is already established. Quality of dried fish in term of physical properties, bio-chemical composition and reconstitution behaviour was studied.At the same time the safety aspect in terms of heavy metal, total viable bacterial count, Aerobic plate count and Total volatile base Nitrogen was studied.

A better knowledge on quality and safety of sun-dried fish is important because a reasonable quantity of sun-dried fish is exported to International market every year. To continue export of this fishery product the quality and safety of the product should be assured. At the same time, the product should have desired quality and it should be safe for health of the domestic consumers. At the first step, the result of the present investigation is expected to provide a clear idea on the quality and safety of the sun-dried fish under present study.

MATERIALS AND METHODS

Species selection, sample collection, and storage

Three traditionally sun-dried freshwater fish species namely *Labeo rohita*, *Channa striatus,* and *Wallago attu* were included in this study. These sun-dried fishes were purchased from the local market of Mymensingh town and brought to the Laboratory of the Department of Fisheries Technology, Bangladesh Agricultural University, Mymensingh, Bangladesh. Dried fish samples were packed tightly in polyethylene bags and stored at -20°C until further analysis for subsequent studies. A quantity of 2 kg sun-dried fish of each species were been purchased for the study. The samples were been subjected to laboratory analyses within 2 weeks of purchase.

Physical characteristics

Physical characteristics such as colour, odour, and texture of the traditionally sun-dried fishes were examined by organoleptic test/sensory test on the basis of the method described by Howgate et al. (1992). All determinations were done in triplicate and the mean value was reported.

Biochemical composition

Biochemical composition of the traditionally sun-dried fishes were determined according to the methods proposed by Analytical Methods Committee AMC (1979). Biochemical analysis included determination of crude protein, lipid, ash, and moisture determinations. All determinations were done in triplicate. The mean values have been reported.

Total volatile base-Nitrogen (TVB-N)

Total volatile base-Nitrogen (TVB-N) was determined by steam distillation method proposed by Analytical Methods Committee AMC (1979). All determinations were done in triplicate and the mean value was reported.

Quantitative bacteriological analysis

Aerobic plate count (APC) was done by consecutive decimal dilution technique. Sample for the APC was accurately weighed and added with required amount of water and liquefied in a sterilized blender jar and consecutive tenfold dilution were prepared in test tubes. From all of the dilutions spread plate, cultures were made in duplicate and incubated at 35°C for 24 to 48 h. Colonies developed on the plates having 30 to 300 colonies were selected for APC. APC was calculated by the following formula:

$$APC / g = C \times D \times 10/S \ CFU/g$$

Where C = number of colonies found, D = dilution factor, S = weight of sample in grams, CFU = colony forming unit.

Experimental media

The media used in this experiment were as follows

Plate count agar

Plate count agar was a commercial preparation (Hi media, India) that was used for enumeration of viable bacterial count in sample. Accurately weighed 23.5 g media was suspended in 1000 ml distilled water and boiled until the ingredients were completely dissolved. The media was then sterilized at 121°C for 15 min under 15 lb/inch^2 pressure in an autoclave.

Peptone diluents (0.2%)

Peptone diluents were used as diluents in determining APC.

Calculation of microbial load

The microbial load of dried fish product was calculated by using the following formula:

$$\text{Colony Forming Unit (CFU/g)} = \frac{\text{No. of Colony} \times 10^n \times 10 \times \text{Vol. of Soln.}}{\text{Weight of Sample}}$$

Detection of heavy metal

The collected sun-dried fish samples were subjected to analysis for the detection of heavy metals namely As, Cd, and Cr. A known quantity of dried fish sample was weighed by an electronic balance and 5 ml of diacid mixture (5 ml conc. HNO_3; 3 ml 60% $HClO_4$) was added to each sample. The content was mixed for overnight. Samples were then digested initially at 80°C temperature and later at 150°C for 2 h. The completion of digestion was indicated by almost colourless condition of the material. The brown fumes also cease to exist at completion of digestion. The samples were separately filtered by using an ash less filter paper and volume made up to 25 ml with 0.5% HNO_3 prepared for the determination of As, Cd and Cr (Eboh et al., 2006). The samples were subjected to analysis by Atomic Absorption Spectrophotometer (HG-AAS, PG-990, PG Instruments, UK) at Professor Muhammad Hossain Central Laboratory, Bangladesh Agricultural University, Mymensingh according to the method of Clesceri et al. (1989). The wave length of As, Cr, and Cd were 193.7, 127 and 217 nm, respectively. The concentration of As, Cr, and Cd were calculated by

Table 1. Physical characteristics and organoleptic characteristics of sun-dried fishes

Species	Colour	Odour	Texture		Taste	Overall quality
C. striatus	Brown	Good	Tough and springy	Fibrous	Slightly salty and bitter	Satisfactory
L. rohita	Brown	Good	Tough and springy	Fibrous	Good	Satisfactory
W. attu	Dark brown	Rancid	Soft	Slightly fibrous	Bitter	Poor

Table 2. Biochemical and bacteriological characteristics of sun-dried fishes.

Species	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	TVB-N mg/100 g	TBC cfu/g
C. striatus	19.17	62.85	4.92	11.11	7.54	1.84×10^{4}
L. rohita	20.27	59.32	10.83	12.89	7.73	2.32×10^{4}
W. attu	23.12	49.23	11.00	18.89	8.32	5.3×10^{6}

the following formula:

$$\text{Metal concentration} = \frac{\text{ppm conc. observed} \times \text{final vol. of sample in ml}}{\text{Weight of tissue taken in g}}$$

Water reconstitution behaviour

Accurately weighed 5 g of dried fish flesh/tissue was kept soaked in 1 L of water at room temperature for 150 min and in hot water at 80°C for 60 min with occasional stirring. Then water was dried off. All the flesh were then transferred to the strainer and the water on surface was wiped off by a piece of blotting paper and the flesh tissue was weighed again. During the soaking time, the flesh could reabsorb maximum amount of water. Result in this respect has been expressed in terms of weight of water absorbed by 5 g of moisture frees sample (Jason, 1965).

RESULTS AND DISCUSSION

The physical (organoleptic) characteristics of the sun-dried fish samples are presented in Table 1. The colour, odour, texture, and taste revealed that the *C. straitus* and *L. rohita* were comparatively of good quality, while the *W. attu* had already lost the shelf life. Rancid odour and bitter taste was developed in the dried *W. attu* samples. It appears that, if moisture content of the product is comparatively high, then the deteriorative changes may result in browning reactions and development of rancid and off odour. The samples examined were slightly brown, brown or dark brown compared with freshly prepared samples which were expected to have an attractive cream colour. Rancid odour and off odour was developed in some of the samples. Some of the samples contained high quantity of broken pieces, which might be the result of using poor quality raw material, excess drying or improper drying and handling or due to moisture reconstitution.

The result of biochemical analysis on the sun-dried fish samples are presented in Table 2. Moisture content of *L. rohita* and *C. straitus* was 20.07 and 19.17%, whereas the moisture content of *W. attu* was 23.12%. The protein content which is most important from nutritional point of view ranged from 49.23 to 62.85%. Lipid and ash content were in the range of 4.92 to 11.01% and 11.11 to 18.89%, respectively. For better evaluation of data, the content of protein, total lipid and ash of all the samples have been recalculated on moisture free basis. There was an inverse relationship between protein and fat content of the dried fish products where the relationship is markedly evident by the data calculated on moisture free basis. As shown in Table 2, the sun-dried *C. straitus* contained the highest protein content (62.85%) while the sundried *W. attu* contained the lowest (49.23%) protein content. From the analytical data, it is evident that, the proximate composition of fish varies with some factors of which species of fish is an important factor.

TVB-N of the sun-dried fish samples was comparable among the species under present study. The range of TVB-N in the sundried fishes was from 7.54 to 8.32 mg/100g (Table 2). TVB-N express the degree of bacterial spoilage during processing in other word the degree of freshness. In the present study, the TVB-N of the sun-dried fish was within the acceptable level. The highest TVB-N was detected in the dried fish produced from *W. attu* followed by *L. rohita* and *C. striatus*. Despite this minor difference in TVB-N content in the sun-dried fishes, the overall result on TVB-N is comparable among the sun-dried fishes and the result is within allowable limit that is, acceptable.

TBC of the sun-dried fishes was also conducted during the present research study. The TBC of the sun-dried fish samples was also highly varied among the species probably indicating the different degrees of spoilage by bacteria. The result of TBC in the sun-dried fishes were 1.84×10^{4} per g in *C. striatus*, 2.32×10^{4} per g in *L. rohita* and 5.3×10^{6} per g in *W. attu*. A correlation was found between TBC and TVB-N. The sample with high TVB-N content showed maximum bacterial load while comparatively low TVB-N content had minimum bacterial

Table 3. Detection of heavy metal in the sun-dried fishes.

Species	Arsenic (µg/g)	Cadmium (µg/g)	Chromium (µg/g)
C. striatus	0.003 ± 0.001	0.089 ± 0.004	0.045 ± 0.003
L. rohita	0.001 ± 0.001	0.053 ± 0.003	0.025 ±0.002
W. attu	0.004 ± 0.002	0.097 ± 0.003	0.068 ± 0.002

count. On the other hand, higher moisture content promoted the growth of bacteria and accelerated the TVB-N content irrespective of the samples analyzed. Most of the samples with increased TVB-N and TBC contained around 20% moisture. Although there is a close relationship observed between the higher TBC and the corresponding high level of TVB-N content, when initial moisture level was close to 20%, the samples picked up sufficient moisture. Sen et al. (1961) reported that, when water content of the fish fall below 25% of the wet weight, bacterial activity stops; when the water content is further reduced to 15% mould ceases to grow. This indicates that, moisture level of 20% was quite unsuitable for the growth of bacteria. It is of little use of insisting production of sun-dried fish with water content below 20% when there is no option but to store it even in a climate of 90% humidity.

Result of heavy metal concentration (pollution by metal and element) in the sun-dried fishes of this research study is shown in Table 3. The sun-dried fishes contained very low concentration of As, Cd and Cr. The range of the heavy metal concentration was within the acceptable limit for human consumption. Even this concentration of heavy metal accumulated in dried fish flesh was less than that of acceptable range recommended for drinking water. A large number of potentially harmful metals and elements are known as pollutants despite Hg has been implicated in disease to man caused by eating fish and fish product. Pollution from any metal or element may cause unsuspected hazards to man. The elements of most concern are cumulative poisons, that is, those that cause injury to health through progressive and irreversible accumulation in the body as a result of ingestion of repeated small amounts. These include Hg, Cd, Pb, Se, and As (Connell, 1975).

Many countries are now taking voluntary or mandatory action to reduce pollution of the aquatic environment with heavy metal for the food safety of aquatic food particularly fish. Considering the affect of heavy metal on fish quality and safety the food regulatory and health authorities in some developed countries have taken serious view and adopted maximum allowable limit of harmful metals and elements. Usually pollutants of metal and element category contaminate the raw fish. The concentration of harmful metal and element is much higher (calculated value) in the processed fish as moisture percentage is reduced considerably. As a result of this, the concentration of pollutants in per unit weight/mass is increased remarkably. But in the present study, the concentration of As, Cd, and Cr in the final product that is, the sun-dried fish was very low. The range was from 0.001 to 0.09 µg/g. It clearly indicates that, the raw fish was caught from unpolluted water and the sun-dried fish quality was good, it is safe to eat when pollution by metal and elements is considered.

Water reconstitution behaviour of the dried fishes soaked in water at room temperature (30°C) and in hot water (80°C) are presented in Figures 1 and 2, respectively. Among the three sun-dried fishes, reconstitution rate was faster in *C. striatus* and *L. rohita* but slow in the other dried fish *W. attu*. A close relationship was observed between reconstitution behaviour and physical properties of the samples. The overall reconstitution power of the sun-dried fish samples was comparatively slow with poor texture such as tough, rubbery and compact structure with few interfibrillar spaces. This was especially true for *C. straitus* and *L. rohita*. The reasons for the failure of these dried products to attain perfection are the irreversible changes which took place during sun drying, and severe damage suffered by the cellular structure. The real reconstitution of sun-dried fish is impossible.

The best way of reconstitution is to conserve a porous structure by a suitable method which absorbs and retain sufficient water. Compressed products absorb slowly and this is usually incomplete. The fibres of these sample muscles appeared to be cemented together and suffered severely. The large difference in rehydration rate which existed among the sun-dried fishes is due to their micro-structural differences. The *C. straitus* and *L. rohita* exhibited an enormously rapid initial rate of rehydration. This is due to water being carried into the deep part of the piece by a porous structure which absorbed and retained sufficient water by capillary. With a tough and rubbery tissue water penetrates mostly to the centre of large pieces by diffusion through the protein of the fibre itself and the process is very slow (Sen et al., 1961; Connell, 1957; Lahiry et al., 1961).

On the basis of the results of the present study, it can be concluded that, the sun-dried *C. striatus* and *L. rohita* is better than that of *W. attu*, when quality and safety is considered. It can also be concluded that, the heavy metal concentration in the sun-dried fishes was within the safe level.

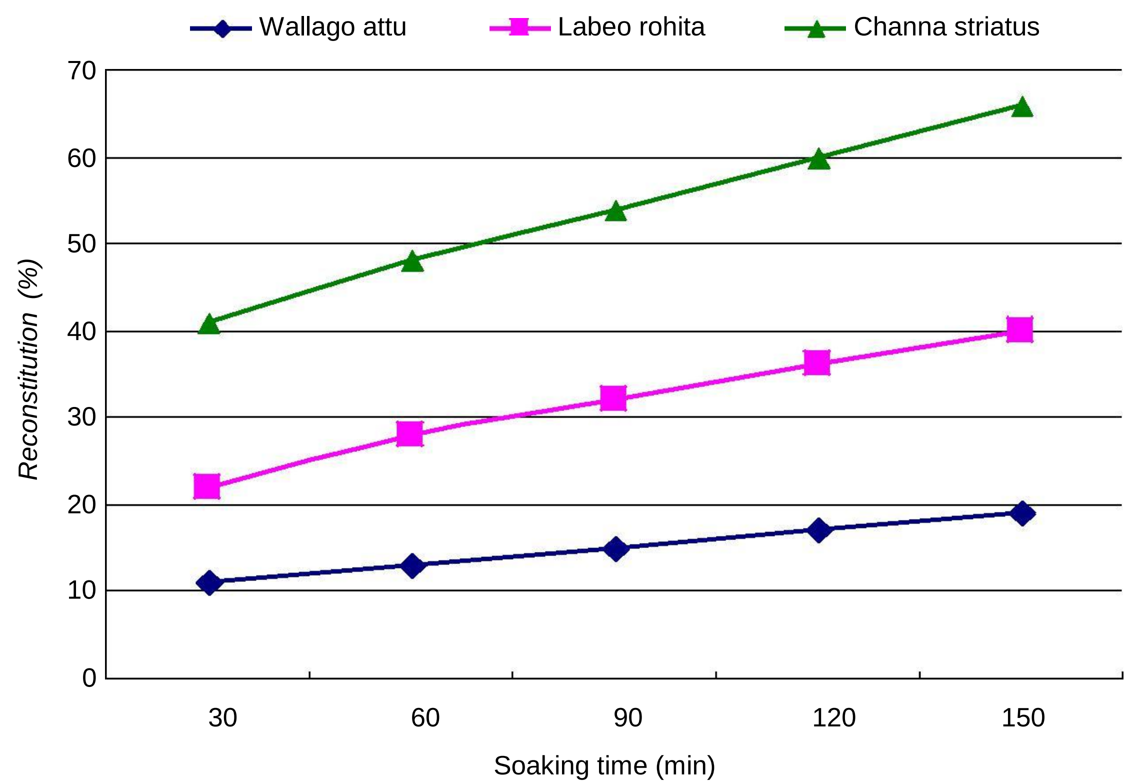

Figure 1. Reconstitution behaviour of the sun-dried fishes soaked in water at room temperature for 150 min.

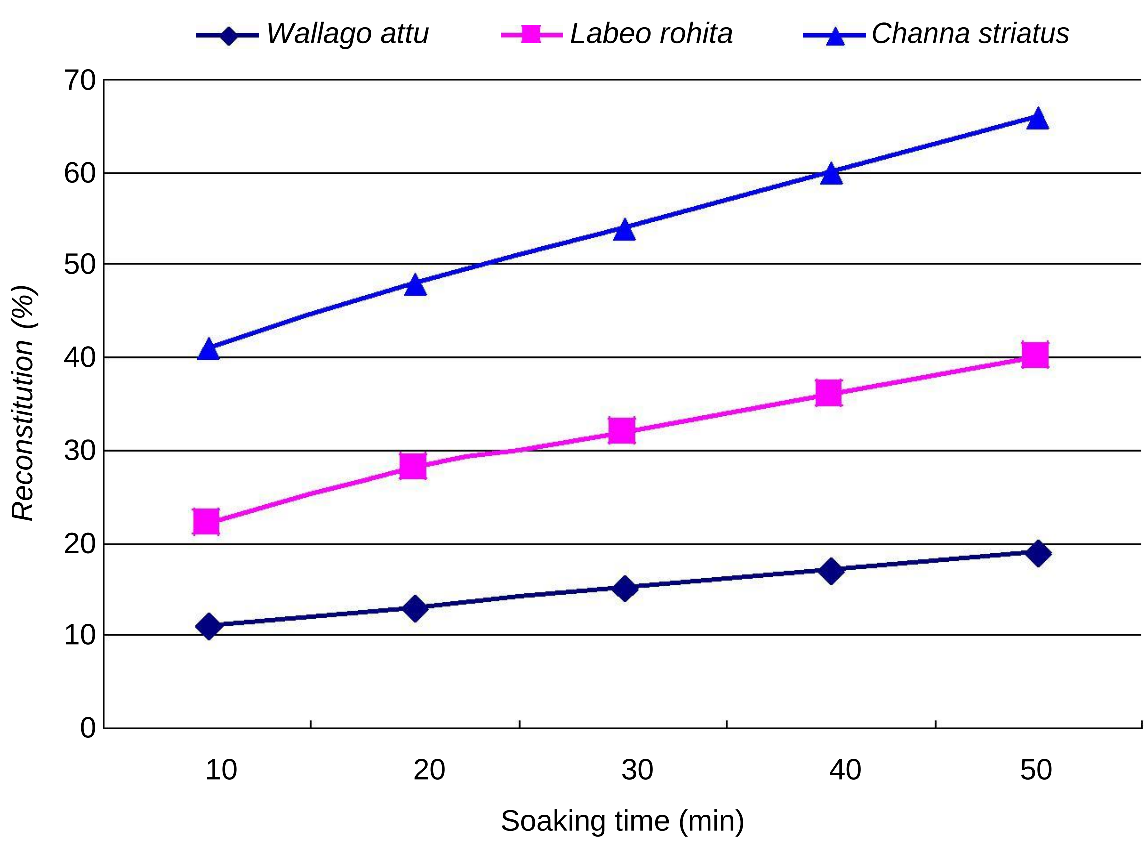

Figure 2. Reconstitution behaviour of the sun-dried fishes soaked in hot water at 80°C for 50 min.

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