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Organoleptic, biochemical and bacteriological aspects of the low cost tunnel dried fish products

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Abstract

Studies were conducted on the organoleptic, biochemical and bacteriological aspects of three dried fish products produced from two different model of low cost solar tunnel dryer. The overall quality of the products obtained from both dryers was excellent. Sixty minutes soaking showed the maximum water reconstitution of the products with values between 66.82 to 75.28 % and 71.98 to 78.09% in dryer 1 & 2 respectively. The highest reconstitution was obtained from Silver Jew fish (75.28-78.09 %) and lowest from Bombay duck (66.86-71.98 %) from both dryers. The average moisture, protein, lipid and ash content of the dried products were 11.8-15.0%, 57.32-68.49 %, 6.08-8.62 % and 12.25-14.88 % respectively in fish in dryer 1 and dryer 2. The TVB-N values were in the range of 24.3 to 30.9 in dryer 1 and 22.1 to 28.2 mg/100 g samples in dryer 2. The highest values were obtained from Bombay duck and lowest value in Silver Jew fish in both dryers. The peroxide values varied from 14.1 to 16.9 % in dryer 1 and 13.3 to 16.4 % in dryer 2. The highest peroxide value was obtained from Ribbon fish and lowest from Silver Jew fish. Total bacterial load varied in the range of 6.6×10^4– 8.6×10^4 CFU/g in dryer 1 and 2.54×10^4 to 4.9×10^4 CFU/g in dryer 2. The highest value was obtained from Ribbon fish and lowest from Silver Jew fish.

Key words: Organoleptic, Biochemical, Bacteriological, Quality, Dried fish

Introduction

In Bangladesh, the physical and organoleptic qualities of most of the traditional sun dried products available in the market are not satisfactory for human consumption (Kamruzzaman 1992, Khan 1992, Saha 1999). There are frequent complaints from the consumers about the quality of the products and the major constraints associated with sun drying of fish are infestation of the products by the fly and insect larvae, contamination and spoilage during drying and storage. The problem markedly evident with dried products in Bangladesh is the contamination during different stages of handling and indiscriminate use of various types of insecticide such as DDT, Nogos and Rubral to avoid infestation as reported during market survey in Cox's Bazar (BFRI 1998).

The quality of the dried fish produced by the *Hohenheim* type dryer was good in terms of organoleptic characteristics, infestations and contaminations, as it has been reported earlier by many authors (Ahmed *et al.* 1979, Islam 1982). In Bangladesh, *Hohenheim* type of solar tunnel dryer firstly developed in the Department of Farm Power and Machinery at Bangladesh Agricultural University, Mymensingh. The design of which was modified and constructed at low-cost using locally available bamboo and wooden materials. These solar tunnel dryers are simple and useful for higher drying capacity. These dryers essentially consist of a flat plate air-heating collector and bamboo and wooden made tunnel dryer unit. Normally black surface is used as a collector. This is working on the principle that a black surface absorbs sun's energy far more effectively than any light coloured surface. The two sides of the dryer having small meshed net are open to provide the required airflow over the product to be dried. Both the collector and the drying unit are covered with transparent polythene. Solar radiation passes through the transparent cover and heat absorbs in the collector. The heated air from the collector passes over the product to absorb moisture.

This paper reports the physical, organoleptic, biochemical and bacteriological aspects of dried products of some commercially important marine fish species produced from two different model of low cost solar tunnel dryer.

Materials and methods

Dried samples of three species of marine finfish species named Bombay duck (*Harpodon nehereus*), Silver Jew fish (*Johnius argentatus*) and Ribbon fish (*Trichiurus haumela*) were used for the investigation. The samples were produced in low cost solar dryer of two different models. These two models of dryers essentially consist of a flat plate air-heating collector and bamboo and wooden made tunnel dryer unit. A corrugated iron sheet (tin) having black paint (10´x3´) was used in both dryers as a heat absorber and placed in one end of the drying unit normally at the side of direction of airflow which blow absorbed heat over the product to be dried. The two sides of the dryers having small meshed net were open to provide the required airflow over the product to be dried. Both the collector and the drying unit were covered with transparent polythene. In dryer-1, the products to be dried were placed in thin layer on a bamboo splitting net inside the tunnel dryer. But in dryer-2, the products were placed in thin layer on chatai (bamboo mat) and also in hanging bar inside the tunnel dryer. The size of dryer-1 and dryer-2 were 20×4×3 feet, 30×3×3 feet respectively.

The products were packed tightly in separate polyethylene bags on the basis of the type of species and then brought to the laboratory. These were packed in polyethylene bags and stored at room temperature until used for experiment. For preparation of samples, whole dried fish samples were comminuted in a meat grinder and ground in a blender (Waring, USA, model no.35BL64) to produce a homogenous one before being sampled for analysis. Samples of each species were kept in a separate airtight container during study period.

Organoleptic quality assessment

A large number of schemes have been proposed for sensory evaluation for various types of fish and fishery products. The evaluation methods used in this study were based on the one that is currently used in various institution of the world. Representative whole sample of dried products were taken on a tray to assess the characteristics such as colour, odour, texture, broken pieces and insect infestation by organoleptic method.

Physical study (water reconstitution behavior)

Percentage of water absorbed by dried fish at a certain temperature and time is called water reconstitution. It is one of the most important physical parameter to assess the quality of the dried products. Five gram of fish sample was kept soaked in one litre of water at a temperature of 80°C up to 60 minutes with occasional stirring. Water was drained off through a coarse nylon cloth. All the flesh was then transferred to the strainer and extraneous water was wiped off by a piece of blotting paper and flesh was weighed again. By the given soaking time, flesh could reabsorb maximum amount of water. Results have been expressed in terms of weight of water absorbed by the sample.

Determination of proximate composition

Determination of moisture, ash, lipid and crude protein were carried out according to the methods given in AOAC (1980).

Determination of total volatile base nitrogen (TVB-N)

Total Volatile base nitrogen was determined according to the methods given in AOAC (1980) with certain modifications.

Preparation of sample: Ten grams of ground samples were weighed, mixed with 90ml of 6% perchloric acid and homogenized for two minutes with a blender under cooled condition.

Steam distillation and titration: Hundred ml of extract with 4-6 drops phenolphthalein indicator were put in a Kjeldahl flask and then some glass-beads and 20ml of 20% NaOH were added to the flask after placing it on the distillation unit. The distillate was collected in the conical flask containing 50ml of 3% H_3BO_3 and 1 drop of mixed indicator. Distillation was continued at 70°C and confirmed through changing the colour of mixed indicator, i.e. violet to greenish.

The collected distillate was titrated with 0.01 N HCl. Regaining of the violet colour of mixed indicator confirmed the end-point of titration. The results were expressed as mg of TVB-N/100g sample while calculated according to the following formula:

$$\text{TVB}-\text{N (mg/100gms Sample)} = \frac{\text{ml of titrant} \times 0.14 \times 1 \times 100}{\text{Sample Wt.}}$$

Peroxide value estimation

The method of Wood and Aurand (1977), modified by Egan *et al.* (1981) was used for the determination of per-oxide value.

One gram of sample oil was weighed accurately into a stoppered 250ml conical flask and 20ml of chloroform was added to dissolve the lipid. The flask was shaken for 30 seconds. A volume of 50ml of a mixture of acetic acid and chloroform in the ratio of 3:2 was added. One ml of saturated aqueous potassium iodide was added and the flask was swirled for about 20 seconds and kept in the dark for 30 minutes. A 100ml of distilled water and 4-6 drops of starch indicator were added to the mixture and liberated iodine filtrated against 0.002M $Na_2S_2O_3$, $5H_2O$. Freshly prepared 1% starch solution was used as an indicator. The per-oxide value was calculated as follows:

Per-oxide value = 2 (S-B)/W, m.eq/kg of oil
Where, 'S' is sample titre
'B' is blank titre
'W' is weight of sample oil in g.

Bacteriological examination

In this study, total aerobic plate count expressed as colony forming units (CFU/g) of the representative samples were determined by standard plate count method on plate count agar following the dilution technique described by Seeley and Vandemark (1972).

Results and discussion

Organoleptic characteristics

Organoleptic and physical characteristics of three dried fish products produced from dryer 1 and dryer 2 were investigated by determining colour, odour, texture, insect infestation, presence of broken pieces etc. The colour of solar dried Silver Jew fish, Bombay duck and Ribbon fish became whitish to light brown with little difference among three fish species in both dryers. Texture was firm and flexible and odour was very natural in all samples. No insect infestation or broken pieces were found around the products. The overall quality of the products obtained from both dryers was excellent for all three marine fish species. The results obtained in the studies are summarized in Table 1.

Table 1. Organoleptic characteristics of solar tunnel dried fish

Dried fish	Organoleptic characteristics	
	Dryer 1	Dryer 2
Bombay duck	Whitish colour Characteristic odour Firm and flexible texture No infestation No broken pieces found	Whitish colour Characteristic odour Firm and flexible texture No infestation No broken pieces found
Silver Jew fish	Silvery colour Characteristic odour Firm and flexible texture No infestation No broken pieces found	Silvery colour Characteristic odour Firm and flexible texture No infestation No broken pieces found
Ribbon fish	Yellowish and reddish colour and shining Characteristic odour Firm and flexible texture No infestation No broken pieces found	Yellowish and reddish colour and shining Characteristic odour Firm and flexible texture No infestation No broken pieces found
Overall quality	Excellent	Excellent

Water reconstitution properties

The reconstitution properties of the dried fish muscles at 80°C were investigated for the products obtained from both the dryers and the results are presented in Table 2. The samples were soaked in water at 80°C for one hour and ability of the samples to absorb moisture was investigated every 15 minutes intervals. The reconstitution of the samples at 80°C increased as the soaking time increased and at 60 minutes time the maximum reconstitution of the products was in the range of 66.82 to 75.28 for dryer 1 and 71.98% to 78.09% in dryer 2 was obtained after one hour of soaking. The highest reconstitution was obtained from Silver Jew fish (75.28-78.09 %) and lowest from Bombay duck (66.86-71.98) from both dryers.

A close relationship was observed between the reconstitution power and physical properties of the samples. The quality of dried fish is also related to final a_w. At low a_w values, water uptake proceeds more quickly. Denaturation of protein may cause decreased ability of rehydration.

Reconstitution power was found to be slow with the poor texture such as tough, rubbery and compact structures with few interfibrillar spaces. This was especially true for Bombay duck fish produced at 40-45°C. The reasons for the failure of these dried products to reach perfection are not hard to find. In the first place, for irreversible change (denaturation) that takes place during drying and severe damage suffered by cellular structure, the real reconstitution is impossible. The best way of reconstitution is to conserve a porous structure by a suitable method which absorbs and retains sufficient water by capillary. Compressed products absorb slowly and less completely (Jason 1965). The fibres of these samples appeared to be cemented together and suffered hardly any of the separation induced by shrinkage.

Table 2. Reconstitution percentage of solar tunnel dried fish produced at 80^{0}C temperatures and time interval

Dried fish	Soaking time (m)	Reconstitution percentage	
		Dryer 1	Dryer 2
Bombay duck	15	33.58	37.07
	30	43.12	48.12
	45	56.15	60.11
	60	66.86	71.98
Silver Jew fish	15	35.69	39.38
	30	50.98	56.21
	45	61.25	67.77
	60	75.28	78.09
Ribbon fish	15	34.15	36.21
	30	45.25	49.88
	45	60.36	65.06
	60	72.96	76.60

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 (Connell 1957, Sen *et al.* 1961, Lahiry *et al.* 1961).

Proximate composition of dried products

The results of the proximate composition of the dried products obtained from dryer 1 and dryer 2 are presented in Table 3. The average moisture content of the dried products was in the range of 11.8-15.0% with highest value obtained from Bombay duck and lowest value from Silver jew fish in products of both dryers. The average protein content was in the range of 57.32 to 67.38 % for the products obtained from dryer 1 and 58.51 to 68. 49 % of the products obtained from dryer 2. The highest protein value was obtained from Ribbon fish and lowest from Bombay duck in both dryers. Lipid content was 6.18 to 8.13 % in products obtained from dryer 1. Similar results were also obtained from the products obtained from dryer 2. The highest lipid content was obtained from Silver jew fish and lowest from Ribbon fish. Ash content was in the range of 12.25-14.28 % and 13.05 -14.88 % for the products obtained from dryer 1 and dryer 2, respectively. There is little much differences in ash content among the three samples. For better evaluation, the results were also shown in parentheses on dry weight basis for protein, lipid and ash contents. There is little or no such differences of the values among the products obtained from both dryers.

Table 3. Proximate composition of solar tunnel dried fish product

Dried fish	Amount							
	Dryer 1				Dryer 2			
	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)	Moisture (%)	Protein (%)	Lipid (%)	Ash (%)
Bombay duck	15.00	57.32 (67.04)	7.92 (9.41)	14.28 (16.70)	14.3	58.51 (68.27)	8.49 (9.91)	14.88 (17.36)
Silver Jew fish	12.30	64.41 (73.65)	8.13 (9.27)	13.20 (15.09)	11.80	65.00 (73.69)	8.62 (9.77)	13.92 (15.78)
Ribbon fish	13.00	67.38 (77.27)	6.18 (7.09)	12.25 (14.05)	12.1	68.49 (78.18)	6.08 (6.94)	13.05 (14.90)

Parenthesis indicate the amount ranges on dry matter basis

Ahmed *et al.* (1979) reported that fishes dried by a solar dryer contain an increased percentage of protein and fat over the traditional sun dried products. The quality of dried fish products is related to the final a_w values below 0.95. Frazier and Westhoff (1978) stated that, generally no microbe could grow in dried products with moisture content below 15%. The moisture content obtained from dried products from both dryers was within 15%.

Food quality

Food quality of the dried products was analyzed by determining some biochemical and bacteriological aspects where total volatile base nitrogen (TVB-N), peroxide value (PO) and aerobic plate counts are very important. The results of the Total volatile base nitrogen (TVB-N), Peroxide value (PO), Standard plate count (SPC of solar tunnel dried products are presented in Table 4.

The TVB-N values of the solar dried products produced from dryer 1 were in the range of 24.3 to 30.9 and incase of dryer 2 the value was in the range of 22.1 to 28.2 mg/100 g samples where highest values were obtained from Bombay duck and lowest value in Silver jew fish in both dryers. These TVB-N values are much lower than the recommended value for variety of salted and dried fish products which is not greater than 100-200 mg/100g as described by Connell (1995).

The peroxide values varied from 14.1 to 16.9 % in dryer 1 and 13.3 to 16.4 % in dryer 2. The highest peroxide value was obtained in Ribbon fish and lowest in Silver Jew fish. These values are within the acceptable limit of 10-20 set for oxidative rancidity of dried fish. The peroxide value of first model dryer is more or less higher than second model dryer.

It is well known that the sensory properties of dried products may deteriorate during storage due to oxidation of lipid. Fish oil as well as other edible oils spontaneously oxidizes in the presence of atmospheric oxygen, at or near the ordinary temperature. One of the most common factors influencing oxidation of lipid is degree of unsaturation. Temperature is another factor enhancing the rate of lipid oxidation. Rate of oxidation is increased with the increasing temperature. The rise of temperature activates the reacting molecules and at the same time oxidation (Tuschiya 1961). The increased peroxide values was reported for the dried products obtained from whole sale market and retail market samples stored for 6-7 months in abuse condition due to oxidation of lipid (Reza 2001).

The total aerobic plate count expressed as colony forming unit in one gram of sample (CFU/g) of the representative samples was determined by standard plate count (SPC) method on plate count agar media. Total bacterial load varied in the range of 6.6×10^4– 8.6×10^4 CFU/g in dryer 1 and 2.54×10^4 to 4.9×10^4 CFU/g in dryer 2. The highest value was obtained from Ribbon fish and lowest from Silver Jew fish.

There is a close relationship between the moisture content and bacterial load in food products. Fish is an ideal substrate for the growth and multiplication of microorganisms. Various factors are responsible for this. Suitable moisture content is one of them. The heat applied during drying cause considerable reduction of microorganisms of various types. Drying by heat usually destroys all yeasts and most of the bacteria, but spores of some bacteria and molds usually survive. Bacteria, yeast and mold do not grow with moisture content below 18%, 20% and 16% respectively. So, if the drying process and storage conditions are adequate, there will be no growth of microorganism in dried fish. But in practical, it is hardly possible to control moisture and growth of microbes during processing and storage of dried fish. Especially during improper storage and exposed condition in the retail market, dried products absorb a considerable amount of moisture. Even Coliform bacteria and other harmful bacteria may also be found in dried products. This, of course, can result in deterioration of food value and food quality. According to Sen *et al.* (1961), 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. Frazier and Westhoff (1978) reported that, generally no microbe (yeast, mold and bacteria) can grow in a product with moisture content below 15%.

Table 4. Total volatile base nitrogen (TVB-N), Peroxide value (PO), Standard plate count (SPC) of solar tunnel dried products

Dried fish	Amount					
	Dryer 1			Dryer 2		
	TVB-N (mg/100g)	PO (m.eq./kg of oil)	SPC (CFU/g)	TVB-N (mg/100g)	PO (m.eq./kg of oil)	SPC (CFU/g)
Bombay duck	30.9	15.2	7.45×10^4	28.2	14.4	3.51×10^4
Silver Jew fish	24.3	14.1	6.6×10^4	22.1	13.3	2.54×10^4
Ribbon fish	27.3	16.9	8.6×10^4	25.3	16.4	4.9×10^4

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