

Original Research Article

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Fabrication and Performance Evaluation of Improved Solar Drier for Preservation of Fish

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ABSTRACT

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A study was carried out to compare the change in various quality parameters of Bombay duck (*Harpadon nehereus*) fish under conventional sun drying and improvised solar drying method using concentrating solar (CS) technology during storage at room temperature under aerobic packaging conditions in Sunderban area of West Bengal. The results of the current study revealed that there were no significant differences in the various quality parameters of dried fish samples in both the drying methods. However a significant ($p < 0.05$) decreasing trend in protein content, hardness and fracturability was observed with the advancing storage period. A significant ($p < 0.05$) increase in the mean moisture content, springiness value, water activity, thiobarbituric acid reacting substances value and yeast and mould count was observed during the storage period in both the drying methods. An absence in total plate counts of dried fish samples in both methods was observed throughout the storage period.

Introduction

Fish is an important source of protein in the daily diet and the dried fish also plays the same role in India. Drying is the traditional method of preserving fish since the modernization of society. Drying of fish basically is carried out by traditional sun drying method. In sun drying method, drying procedure is not so hygienic and thus fishes are vulnerable to infestation of insect and larva during the drying process. To avoid and prevent this infestation and for safe storage purposes, farmers used to apply various insecticides including DDT in fish. This fishes are highly contaminated which helps to

increase broad spectrum of environmental and health risks. A whole fresh fish contains up to 80% of water and due to this reason it is a highly perishable material. When moisture content is decreased, contaminating agents cannot survive and as a result autolytic activity is greatly reduced. Tropical species of fishes generally withstand up to temperatures ranges of 45 to 50 °C before proteins are denatured or cooking starts. In major area of the world, awareness is growing about the fact that renewable energy has an important role to extend technology to the farmer in many developing countries to increase their productivity (Waewsak *et al.*, 2006). Solar drying can be considered as an elaboration of

normal sun drying method (Bala, 1997 and 1998). Doe *et al.*, (1977) developed a polythene tent solar dryer for drying of fish. Sachithanathan *et al.*, (1985) conducted four experimental trials in Yemen comparing the performance of solar drying and sun drying of fish. Solar drying was found to be a realistic proposition. Mukherjee *et al.*, (1990) designed and tested a greenhouse type solar dryer and reported that it was possible to dry fresh fish of mixed variety and size to the desired moisture.

Bombay duck, (*Harpadon nehereus*), fish of the family Synodontidae, is found in estuaries of the Indo-Pacific, where it is widely used as a food fish and, when dried, as a condiment. This study was carried out to determine the effect of indigenous and improvised solar drying method on various quality parameters of Bombay duck fish.

Materials and Methods

Collection of fresh fish

The study was carried out in Sunderban belt at Kakdwip block of South 24 Parganas district of West Bengal during the month of April - May of 2017. Fresh Bombay duck (*Harpadon nehereus*) fish was collected from the local market.

Pre-drying treatment of fish

The fish was initially treated with dry salt (salt to fish ratio of 1:4) and stacked for about 16 hours before drying. Then fish was washed and spread on in a thin layer over the dryers in both the method.

Conventional sun drying method

This study focused on processing of fish by indigenous sun drying method where on metal wire mesh was used as potentially renewable

energy source. For each experimental runs the dryer was loaded to the full capacity of 5 kg fish. The drying was started usually at 9.0 am and continued upto 4.0 pm each day and continued under subsequent days for a period of total exposure of 48 hours or more till the desirable drying is palpable.

Experiment with improvised solar dryers

Different concentrating technologies have been developed or are currently under development for various commercial and industrial applications. For industrial processes where temperature above 120°C is required concentrating solar collectors such as parabolic or dish collectors are used. Keeping these facts in mind, a solar dryer was constructed in an attempt to find possible alternatives of traditional methods of fish drying process.

The solar dryer was fabricated with the locally available cheap materials namely bamboo, aluminium sheet, cardboard, polythene pipes, wires and net wires using indigenous technology (Fig. 1).

Drying operations were performed at 50-60°C temperature and relative humidity 60-70% 24 hours. An idea about improvised solar drying method using concentrating solar (CS) technology is given in figure 1.

Storage study of dried fish samples

The dried fishes in both the drying methods were packaged in Low Density Polyethylene (LDPE) bags (150 gauges) under aerobic conditions and stored at room temperature (24-30°C) for 180 days.

The dried fish samples obtained in both the drying methods were analyzed for various quality parameters at 30 days interval till 180 days under aerobic packaging conditions.

Proximate composition

The moisture and crude protein of the dried fish samples were estimated as per the standard method of AOAC (2003).

Physico-chemical quality

The water activities of the fish samples were measured by a water activity meter (Aqua Lab, Dew Point Water Activity Meter).

Thiobarbituric acid reacting substances (TBARS) value of fish was determined by the method described by Witte *et al.*, (1970) with some modifications.

Microbiological quality

Total plate count (TPC) and yeast and mould count of the dried fish samples were enumerated during the storage study as per the methods described by American Public Health Association (APHA, 2001).

Texture analysis

The hardness, fracturability and springiness of the dried fish samples were evaluated using a food texture analyzer (TA HD plus texture analyzer).

The samples were placed on the uniform platform of texture analyzer.

An aluminium cylindrical probe (32 mm) which was compressed to 50% of its original height was used twice in two cycles.

Statistical analysis

The experiments were conducted in triplicates and the obtained results for various quality parameters were analyzed by the statistical method as described by Snedecor and Cochran (1994) using ANOVA and SAS software.

Results and Discussion

Changes in proximate composition

The changes in proximate composition of dried fish samples by different drying methods during storage at room temperature under aerobic packaging conditions are given in table 1.

There was a significant ($p < 0.05$) increasing trend in moisture content under aerobic packaging conditions from 0 to 180 days in the fish samples in both drying methods, but no significant differences were observed in moisture content of fish samples in improvised solar drying and conventional sun drying methods.

Similar results were obtained by Akhter *et al.*, (2009). These findings may be supported by findings of Ajiboye *et al.*, (2011) who reported that during storage of dry meat moisture content increased significantly.

There was a decreasing trend in protein content of fish samples with increase in storage period under aerobic packaging condition. No effect of different drying systems on protein content could be observed on the fish samples.

This might be due to the fact that moisture influences protein percentage and the results are in agreement with findings of Okerman (1985) who reported that as moisture content of meat increased, protein and dry matter content decreased reciprocally. Another reason might be due to breakdown of protein during storage of the products due to breakdown of protein during storage due to enzymatic action of microbes. This study may be supported by the findings of Akhter *et al.*, (2009) who also observed decrease in protein content of meat during sun drying and oven drying.

Fig.1 Concentrating solar (CS) technology used in fabrication of improvised solar dryer

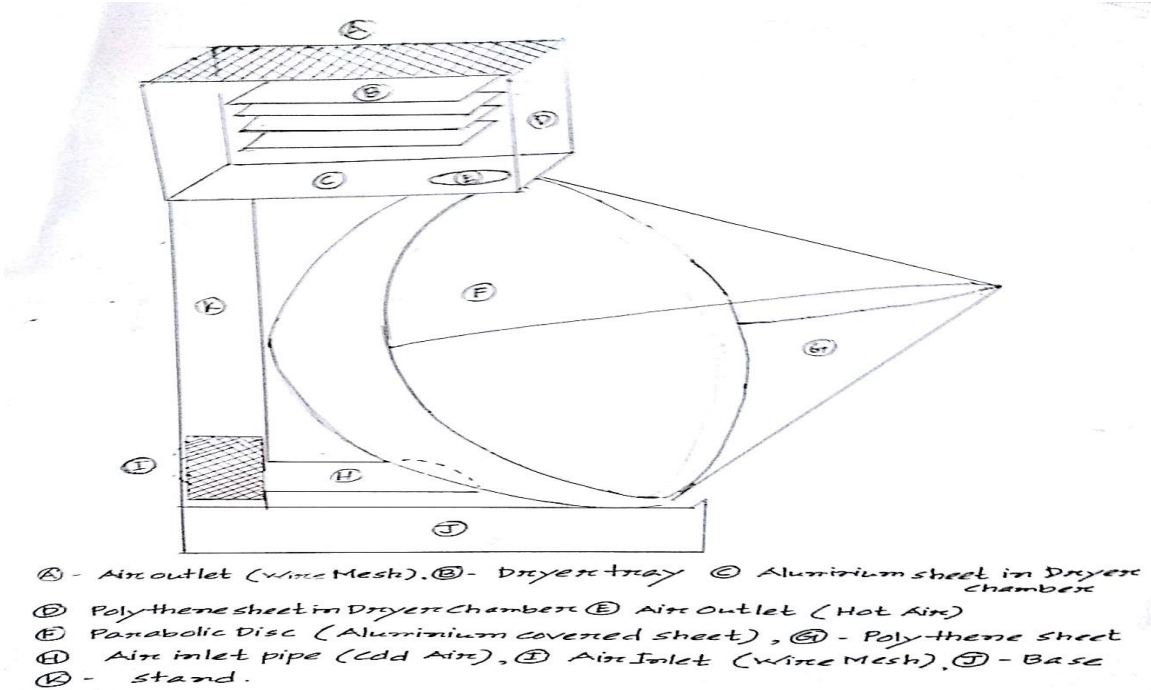


Table.1 Proximate composition of dried fish samples in different drying methods during storage at room temperature under aerobic packaging conditions (Mean±SE)

Moisture (%)		
Storage period (days)	drying method	
	solar dried	mechanically dried
0	11.04±0.10 ^A	11.02±0.10 ^A
30	11.47±0.10 ^A	11.42±0.12 ^{AB}
60	11.79±0.09 ^{BC}	11.76±0.18 ^{BC}
90	12.15±0.16 ^{CD}	12.08±0.22 ^C
120	12.48±0.17 ^{DE}	12.38±0.23 ^{CD}
150	12.85±0.23 ^{EF}	12.74±0.26 ^D
180	13.15±0.25 ^F	13.01±0.26 ^D
Crude protein (%)		
storage period (days)	drying method	
	solar dried	mechanically dried
0	55.81±0.20 ^A	55.04±0.34 ^A
30	54.60±0.68 ^B	54.49±0.36 ^{AB}
60	54.59±0.16 ^B	53.98±0.42 ^{ABC}
90	54.04±0.24 ^{BC}	53.40±0.54 ^{BCD}
120	53.60±0.25 ^{BCD}	52.94±0.56 ^{BCD}
150	53.04±0.34 ^{CD}	52.52±0.58 ^{CD}
180	52.53±0.44 ^D	51.99±0.61 ^D

Mean having different superscript in the column (capital letter) differ significantly (p<0.05).

SE= Standard error, n=5

Table.2 Texture analysis of dried fish samples in different drying methods during storage at room temperature under aerobic packaging conditions (Mean±SE)

Hardness (g)		
Storage Period (Days)	Drying Method	
	Traditional Sun Drying	Improvised Solar Drying
0	8707.57±23.07 ^A	8626.55±28.16 ^A
30	8455.42±29.28 ^{AB}	8416.98±39.48 ^B
60	8251.26±62.04 ^{BC}	8230.94±43.10 ^C
90	8028.53±85.26 ^{CD}	8071.32±60.33 ^D
120	7868.66±96.39 ^{DE}	7822.98±60.61 ^E
150	7646.62±115.06 ^{EF}	7622.09±56.51 ^E
180	7462.42±130.93 ^F	7392.91±89.29 ^F
Fracturability(g)		
Storage Period (Days)	Drying Method	
	Traditional Sun Drying	Improvised Solar Drying
0	8.183±0.013 ^A	9.876±0.024 ^A
30	8.074±0.031 ^A	9.749±0.020 ^{AB}
60	8.002±0.030 ^{AB}	9.591±0.022 ^{BC}
90	7.881±0.046 ^{BC}	9.465±0.044 ^{CD}
120	7.718±0.084 ^{CD}	9.315±0.078 ^{DE}
150	7.574±0.114 ^{DE}	9.194±0.105 ^{EF}
180	7.458±0.154 ^E	9.041±0.133 ^F
Springiness (g)		
Storage Period (Days)	Drying Method	
	Traditional Sun Drying	Improvised Solar Drying
0	0.152±0.003 ^A	0.156±0.004 ^A
30	0.168±0.003 ^{AB}	0.168±0.005 ^{AB}
60	0.182±0.005 ^{BC}	0.184±0.005 ^{BC}
90	0.197±0.005 ^{CD}	0.199±0.008 ^{CD}
120	0.214±0.009 ^{DE}	0.216±0.008 ^D
150	0.236±0.007 ^{EF}	0.237±0.008 ^E
180	0.248±0.007 ^F	0.254±0.006 ^E

Mean having different superscript in the column (capital letter) differ significantly (p<0.05).

SE= Standard error, n=5

Table.3 Physico-chemical qualities of dried fish samples in different drying methods during storage at room temperature under aerobic packaging conditions (Mean±SE)

Water activity (a_w)		
Storage Period (Days)	Drying Method	
	Traditional Sun Drying	Improvised Solar Drying
0	0.6139±0.0016 ^A	0.6080±0.0020 ^A
15	0.6262±0.0019 ^B	0.6218±0.0027 ^B
30	0.6388±0.0027 ^C	0.6322±0.0029 ^C
45	0.6500±0.0031 ^D	0.6411±0.0035 ^D
60	0.6623±0.0040 ^E	0.6511±0.0037 ^E
75	0.6713±0.0037 ^F	0.6654±0.0049 ^F
90	0.6837±0.0038 ^G	0.6783±0.0066 ^G
105	0.6939±0.0059 ^H	0.6887±0.0050 ^H
120	0.7066±0.0072 ^I	0.7028±0.0054 ^I
135	0.7226±0.0071 ^J	0.7249±0.0046 ^J
150	0.7334±0.0084 ^K	0.7377±0.0050 ^K
165	0.7437±0.0070 ^L	0.7523±0.0052 ^L
180	0.7545±0.0070 ^M	0.7609±0.0039 ^M

TBARAS Value (mg malonaldehyde/kg)		
Storage Period (Days)	Drying Method	
	Traditional Sun Drying	Improvised Solar Drying
0	0.15±0.01 ^A	0.17±0.01 ^A
15	0.18±0.01 ^B	0.19±0.01 ^B
30	0.24±0.01 ^C	0.24±0.01 ^C
45	0.28±0.01 ^D	0.29±0.01 ^D
60	0.34±0.01 ^E	0.35±0.01 ^E
75	0.40±0.01 ^F	0.40±0.01 ^F
90	0.45±0.02 ^G	0.45±0.01 ^G
105	0.50±0.01 ^H	0.50±0.01 ^H
120	0.55±0.01 ^I	0.55±0.01 ^I
135	0.61±0.01 ^J	0.60±0.01 ^J
150	0.66±0.01 ^K	0.64±0.01 ^K
165	0.71±0.01 ^L	0.68±0.01 ^L
180	0.76±0.01 ^M	0.72±0.01 ^M

Mean having different superscript in the column (capital letter) differ significantly (p<0.05).

SE= Standard error, n=5

Table.4 Yeast and mould count (cfu/g) of dried fish samples in different drying methods during storage at room temperature under aerobic packaging conditions (Mean±SE)

Storage Period (Days)	Drying Method	
	Traditional Sun Drying	Improvised Solar Drying
0	ND	ND
15	ND	ND
30	ND	ND
45	ND	ND
60	ND	ND
75	ND	ND
90	ND	ND
105	ND	ND
120	ND	ND
135	ND	ND
150	2.428±0.010	2.394±0.010
165	2.482±0.010	2.442±0.016
180	2.538±0.008	2.500±0.17

Mean having different superscript in the column (capital letter) differ significantly (p<0.05).
SE= Standard error, n=5

Changes in physico-chemical qualities

The changes in physico-chemical qualities of dried fish samples by different drying methods during storage at room temperature under aerobic packaging conditions are given in table 2. The water activity of dried fishes increased with increasing storage period, which might be due to increase in moisture content with advancing storage days. No significant (p<0.05) difference was observed in two different drying methods.

The mean TBARS Value of dried fish samples stored under aerobic packaging conditions had a significant (p<0.05) increase during the entire storage period. The trend was similar in both drying methods but no significant differences were observed in both methods. The increasing trend of TBARS values might be due to lipolysis occurred in the dried samples during increasing storage period. Similar results were obtained by Kim *et al.*, (2014) in beef jerky.

Changes in texture profiles

The changes texture profile parameters of dried fish samples by different drying methods during storage at room temperature under aerobic packaging conditions are given in table 3.

No significant differences could be observed due to different drying systems on hardness of the fish samples. But with advancing storage period, the hardness of the dried fish samples followed a significant (p<0.05) decreasing trend. Hardness is affected by moisture content (Yang *et al.*, 2012). Hardness of the products lowers down due to proteolysis (Ruiz-Ramirez *et al.*, 2006). The decrease in hardness of the fish samples with the increasing storage period might be due to moisture intake and decrease in protein content.

The drying methods did not influence the fracturability of the products significantly.

There was a significant ($p < 0.05$) decreasing trend in fracturability of fish samples with increase in storage period under aerobic packaging condition. These results can be correlated with the fact that moisture content determines the texture profile of dry products (Konieczny *et al.*, 2007). No effect of different drying systems on springiness could be observed on the fish samples. The significant ($p < 0.05$) increasing trend in springiness of fish in the advancing storage period might be due to increase in moisture content during subsequent storage. Hsu and Yu (1999) reported the springiness behavior varies significantly with influence of moisture in the product. These findings also have similarity with findings of Kim *et al.*, (2014) in beef jerky.

Changes in microbiological qualities

The changes in microbiological qualities of dried fish samples by different drying methods during storage at room temperature under aerobic packaging conditions are given in table 4.

The results on microbiological quality revealed that there is an absence of TPC during the whole course of storage period. The yeast and mould counts in the dried fish samples in both drying methods were absent up to 120 days and after 150 days there were few colonies of yeasts and moulds observed in the dried fish samples. The observed microbial colonies in later parts of storage period might be due to higher moisture content and water activity of dried fish samples during the advent of storage period. No effect of different drying systems on microbiological quality of dried fish samples could be observed on the fish samples. Similar results were found by Ryoba *et al.*, (2013) to support the present study where there was absence of TPC and yeast and mould count in dry meat up to six months.

A comparative study was carried out on the effect of conventional sun drying and improvised solar dryer on the various quality parameters of Bombay duck fish. From the above results it is evident that improvised solar dryer has no significant differences in quality of dried fish as compared to conventional sun drying method in term of proximate, physio-chemical, texture and microbial qualities. Besides, the improvised solar drying technique is more hygienic than the traditional one. Further study can explore the use of improvised solar dryer in various fish drying procedures with studies of other critical parameters concerning quality and shelf stabilities of different fish and fish products.

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