Research in
AGRICULTURE, LIVESTOCK and FISHERIES
ISSN : P-2409-0603, E-2409-9325
An Open Access and Peer-Reviewed International Journal

Article Code: 0271/2020/RALF **Res. Agric. Livest. Fish.**
Article Type: Research Article **Vol. 7, No. 1, April 2020: 121-128.**

EFFECTS OF DRYING TECHNIQUES ON THE QUALITY OF MOLA (*Amblypharyngodon mola*) DRIED BY SOLAR TENT DRYER AND OPEN SUN RACK DRYER

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ARTICLE INFO

Received
08 March, 2020

Revised
30 March, 2020

Accepted
09 April, 2020

Online
30 April, 2020

Key words:
Dry fish
Amblypharyngodon mola
Biochemical quality
Dryer

A B S T R A C T

Quality change of Mola (*Amblypharyngodon mola*) from open sun rack and solar tent dryer was evaluated at 1st, 2nd and 3rd days of drying. Sensory analysis showed that, solar tent dryer dry fish were excellent in overall quality of dry fish from open sun rack dryer. Moisture content of Mola from solar tent dryer was significantly ($p>0.05$) lower than the moisture content of dry fish from open sun rack dryer. Protein, lipid, ash and TVB-N content was significantly ($p>0.05$) higher in solar tent dried fish than dried fish from open sun rack. However, microbial load was higher on dry fish obtained from open sun rack dryer compared with the dry fish from low coat solar tent dryer. Moreover, the quality of the dried fish products from solar tent dryer was excellent in quality compared to the dried fish from open sun rack dryer.

To cite this article: Lithi UJ, S Surovi, M Faridullah and KC Roy, 2020. Effects of the drying technique on the quality of Mola (*Amblypharyngodon mola*) dried by solar tent dryer and open sun rack dryer. Res. Agric. Livest. Fish. 7(1): 121-128.

INTRODUCTION

Fish represents a valuable source of protein in the diet of the many individuals including human and play an important role in food security of Bangladesh (Burger and Gochfeld, 2009; Ahmed and Garnett, 2011). It additionally provides a good supply of prime quality protein and contains several vitamins and minerals. Fish is highly perishable and quality loss occur very quickly when catch (Ashie et al., 1996). Therefore, processing of fish has been practiced for a long time in Bangladesh; the simplest methods of processing are drying, salting, smoking and semi-fermentation (Alam, 2012). An efficient and cheap method for food preservation is drying. Dry fish is one of the popular food items in Bangladesh because of its characteristics flavor (Lithi et al., 2019). Around one fifth portion of total artisanal catch are sun dried and mostly consumed in the domestic market annually in Bangladesh (DoF, 2010). People of greater Sylhet, Mymensingh, Chittagong and Cox's Bazar districts relish it more while people all over the country consume dried fish.

The physical and organoleptic qualities of most of the traditional sun dried products available in the market are not satisfactory for human consumption (Reza et al., 2005). In Traditional drying process, fishes are normally sun dried over open ground, beach sand, wooden platforms or even on palm leaves (Nath et al., 2013). Therefore, traditionally dried fish become unhygienic because of contamination by fly, bird or vermin's and fungal growth as it carry out in a open area in direct sunlight sometime in the absence of moving air (Oparaku et al., 2013). Another major problems related with traditional drying of fish are the blow fly and insect larvae infestation during drying and storage, contaminants and spoilage (Nowsad, 2005). To prevent insect infestation use of insecticides like DDT, Nogos, Rubral etc. were reported during market survey in Cox's Bazer, which have very negative impact on human health (BFRI, 1998). However, considerable amount of losses have been estimated for dried fish due to spoilage and insect attack (Doe et al., 1977; Ahmed et al., 1978). A large quantity of dried fish are spoiled every year because of insufficient drying, preservation and storage facilities in Bangladesh (Neuschler, 1998)

To minimize the post-harvest losses and to produce high quality dried fish products, low-cost solar tunnel dryer could be used as a suitable alternative to the traditional sun drying process (Sengar et al., 2009). The drying process can be accelerated by concentrating solar radiations to increased temperatures rapidly and relative humidity can be decreased during drying time by using solar dryers (Ojutiku et al., 2009). As solar tent dryer can dry fish in a covered area therefore, effectively reduced the chance of insect infestation, spoilage, and produced top quality dry products with longer shelf-life (Shitanda and Wanjala, 2006). Mola (*Amblypharyngodon mola)* is selected for this study because of its high nutritional profile like protein, mineral, and vitamin (Larsen et al., 2000). With the view of aforementioned facts, the aim of the present research work was to evaluate and compare the sensory, chemical and microbial quality of dried Mola obtained from open sun rack dryer and solar tent dryer.

MATERIALS AND METHODS

Study area and study period

Experiment was conducted in the Fisheries Technology Laboratories of the Department of Fisheries Technology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, during the period of January 2018 to December 2018.

Making of solar tent dryer and open sun drying rack

A wooden frame was constructed with1m wide by 0.8 m long and 1.2 m height to construct the solar tent dryer (Figure 1). A transparent plastic polythene sheet stretched over the wooden frame, a stick wrapped at the bottom of polythene sheet to roll up or down to allow air into the tent. The humid air can leave the tent through air outlet at the top of the tent which was covered by net. Black polyethylene sheet was placed underneath of the solar tent dryer to absorbed extra heat and accelerate drying process. Locally available wood material was used for the preparation of open sun rack dryer (Figure 2) with 0.5m wide by 0.4m long by 0.4m height and chicken wire mesh was used to prepare top of the rack. One drying rack was placed within the solar tent dryer and another drying rack was placed on the open atmosphere.

Figure 1. Solar tent dryer without polythene sheet and with polythene sheet

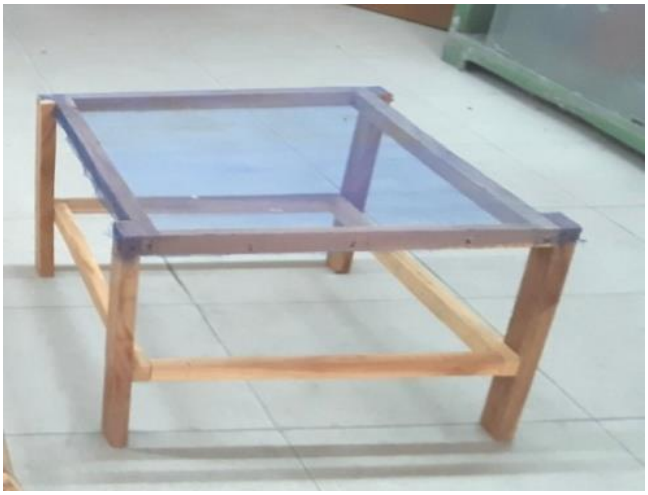

Figure 2. Open sun rack dryer

Sample collection, preparation and drying

Fresh Mola (*Amblypharyngodon mola*) were collected from Bahadurbazar fish market of Dinajpur sadar. The collected fish samples were washed, gutted and scaled properly with fresh water to remove all dirt, slime, and unnecessary particles from body surface. The gutted and washed Mola were divided into two parts, one part for solar tent dryer and another part for open sun drying rack. The solar tent dryer placed on black polyethylene sheet to absorbed more heat and then, covered with transparent polythene sheet. Front side was rolled up by a stick wrapped at the bottom to allow air into the tent and to regulate the temperature a bit. The air entering was heated in the tent and absorbs moisture when it flows pass the fish on the rack. The humid air leaves the tent through air outlets in the top of the tent covered by a net. The open sun drying rack also covered with mosquito net after putting the fish on the rack. The drying time was about 8h to 9h per day and drying was carried out up to 3rd days.

Experimental design to evaluate the quality of dried Mola

The study was designed to visualize the drying performance of Mola on solar tent dryer and in open sun drying rack to produce quality dried fish. The chemical and microbiological quality assessment of dried Mola and were performed at 1st day, 2nd and 3rd days of drying period.

Sensory analysis

Sensory quality of dry Mola obtained from solar tent dryer and open sundry rack was determined by a trained panel of seven-person of students, teachers and staffs of the Department of Fisheries Technology. Panelists recognize every attribute and scored for color, taste, texture, and overall acceptability through hedonic scale as 1-2 “excellent”, 3-5 “good”, 5-7 “average”, 8-10 “Bad” (Lithi et al., 2013).

Biochemical analysis

Proximate composition (moisture, protein, lipid and ash) and Total Volatile Base Nitrogen (TVB-N) of fresh and dry Mola were tested according to the methods described by Association of Official Analytical Chemists (AOAC, 2005).

Microbiological analysis

Standard plate count (SPC) was determined by using consecutive decimal dilution technique in the spread plate method. Approximately 10g of dry fish samples were put in a blender containing 200 ml of peptone water (0.2% peptone) and the homogenate was properly mixed with peptone water. Aliquots of 0.1 ml of the serial dilutions were pipette out and transferred aseptically to the agar plates by. The samples were spread by L-shaped glass rods throughout the surface of the media until the samples were dried out. The plates were then put in an incubator at 30°C for 24-48 hours and then plates were counted. Plates containing 30-300 colonies were used to calculate bacterial load in CFU/g (colony forming unit).

Statistical Analysis

The statistical analyses were performed using statistical program SPSS 11.5 (SPSS Inc, Chicago, IL, USA) for Windows. All data were statistically compared by one way variance analysis (ANOVA) and means were compared by using T- test.

RESULTS AND DISCUSSION

Sensory quality assessment of dry Mola from solar tent dryer and open sun rack dryer

The organoleptic character such as color, odor, texture and overall quality of dry Mola (*Amblypharyngodon mola)* obtained from the open sun rack dryer and solar tent dryer were evaluated using hedonic scale and results were presented in Table 1. Color of dry Mola of solar tent dryer was silvery bright at 1st, 2nd and 3rd day of drying where in open sun rack dryer color were silvery to yellowish in color at 3rd days of drying. In case of odor, dry fish from open sun rack dryer and solar tent dryer both had moderate dry fish odor 4.32±0.07 and 3.21±0.03 respectively at 1st day of drying. However, in final day dry fish from both solar tent dryer and open sun rack dryer had characteristic dry fish order 1.68±0.17 and 0.91±0.08 respectively. Texture of dry fish from both dryer had more or less similar with lack of firmness and elasticity nevertheless the dry fish from solar tent dryer at 3rd days of drying were excellent as they were firm and elastic (1.16±0.05) whereas, dry fish from open sun drying rack had lack of firmness and elasticity but they were found good condition (2.63± 0.16). Furthermore, overall quality of dry fish prepared from solar tent dryer was excellent compared with the overall quality of dry fish from open sun rack dryer. Reza et al., (2006) conducted an observation of the organoleptic quality of solar tunnel dryer products and found that quality of solar tent dryer product was superior to the traditional dry fish products. Rahman et al., (2012) also observed that quality of the products from BFRI Fish Dryer was attractive compared to traditional sun dried fish products.

Assessment of biochemical composition (%) of sun dried Mola from open sun rack and solar tent dryer

Proximate composition and TVB-N content of Mola was analyzed in fresh condition and 1st, 2nd and 3rd drying day at open sun rack and solar tent dryer presented in table 2. Moisture content of fresh Mola was 80.71±0.76, where moisture content of Mola from open sun rack dryer day were 78.18 ± 0.48, 9.52 ± 0.23**,** 8.30 ±0.05 on 1st, 2nd and 3rd days. On the other hand, from initial to final day of drying in solar tent dryer moisture content of Mola were 77.63 ±0.24, 7.81 ±0.15 and 7.51 ± 0.09. At starting period moisture content was higher in both drying conditions but moisture content decreased dramatically as drying day increased. At

1st day difference between moisture content of both dryer were not significant (p>0.05), whereas at 2nd and 3rd days of drying moisture content was significantly (p<0.05) lower in solar tent dryer dry fish compared with the dry fish from open sun rack dryer. Ojutiku et al., (2009) found the similar result when White Nile (*Hyperopisus bebe)* was dried on solar tent dryer. Moisture content of dried Bombay duck was 15% from 89.8% in 9 h of drying in STD (solar tunnel dryer) as compared to 20 h of open sun drying (Bala and Janjai, 2005). Furthermore, during sun drying moisture content of fresh *Tilapia nilotica, Arius parkiiand, and Silurus glanis* were reduced in to 14.06, 13.92 and 11.50%, respectively (Ali et al., 2011).

Table 1. Sensory quality of dry fish from solar tent dryer and open sun rack dryer

Parameter	1st day of drying		2nd day drying		3rd day drying	
	Open	Solar	Open	Solar	Open	Solar
Color	3.73±0.05	1.33±0.11	4.27±0.33	1.43±0.12	4.43±0.22	1.58±0.15
Odor	4.32±0.07	3.21±0.03	2.71±0.14	1.29±0.06	1.68±0.17	0.91±0.08
Texture	3.37±0.06	3.14±0.08	3.23±0.21	2.14±0.03	2.63±0.16	1.16±0.05
Overall quality	Good	Good	Good	Excellent	Good	Excellent

Score: 1-2="excellent", 3-5= "good", 6-8= "average", 9-10="Bad"

Table 2. Change of biochemical composition of fresh and dry Mola fish in open sun rack dryer and solar tent dryer

Proximate composition (%)	Fresh fish	1st day drying		2nd day drying		3rd day drying	
		Open	Solar	Open	Solar	Open	Solar
Moisture)	80.71±0.76	78.18±0.48^a	77.63±0.24^a	9.52±0.23^a	7.81±0.15^b	8.36±0.05^a	7.51± 0.09^b
Protein	17.47±0.45	15.97±0.12^b	17.56 ±0.45^a	54.30±0.37^b	59.78±1.20^a	60.83±0.57^b	62.15±0.27^a
Lipid	1.26±0.20	1.34 ±0.10^b	2.23±0.30^a	3.70±0.08^a	2.78±0.11^b	4.24±0.14^a	3.06±0.18^b
Ash	3.23±0.11	3.93± 0.05^b	4.73± 0.15^a	7.67±0.09^b	9.23±0.10^a	9.60 ±0.09^b	10.16±0.02^a
TVB-N	0.02±0.16	0.24± 0.04^a	0.26± 0.03^a	0.63± 0.01^a	0.48±0.00^b	0.78±0.013^a	0.58±0.00^b

Data are expressed as means± standard deviation, means of same rows are significantly different at p<0.05. Protein content of fresh Mola was 17.47±0.45, at the 1st, 2nd and 3rd day of drying protein content of Mola from open sun rack dryer 15.97 ± 0.12 ,54.30 ±0.37, 60.83 ± 0.57. On the other hand, protein content of Mola in solar tent dryer was 17.56 ±0.45, 59.78 ± 1.20, and 62.15±0.27 respectively on consecutive drying days. Protein content increased with increased drying periods. In solar tent dryer dry fish protein content was significantly higher (p<0.05) on the open sun rack dryer dry fish throughout the drying period. Quality of solar tent dried Anchovy was examined and result was quite similar with the present study (Abraha et al., 2017). Furthermore, due to reduction in moisture content protein content was increased (Ninawe and Rathnakumar, 2008). Ahmed et al., (1979) also reported higher amount of protein content in solar tunnel dried fish products compared with traditional sun dried fish products.

Lipid content of fresh Mola was 1.26±0.20, where on 1st, 2nd and 3rd days lipid content of dry fish from open sun rack dryer was 1.34±0.10, 3.70±0.08 and 4.24±0.14, respectively. On the other hand, at same drying days lipid content of dry fish in solar tent dryer was 3.06±0.10, 2.23±0.30 and 2.78±0.11, respectively. Lipid content increased with increased drying periods. In open sun rack dryer dry fish lipid content was significantly higher (p<0.05) on 2nd and 3rd days compared with the solar tent dryer dry fish. Mustapha et al., (2014) found that lipid content of African catfish species (*Clarias gariepinus*) and nile tilapia (*Oreochromis niloticus*) was 8.19 and 6.89, respectively when dried on low cost solar dryer. Karthikeyan et al., (2007) reported that lipid content of sun-dried *Mystus gulio* and *Puntius sophore* were 14.4 ± 0.28 and 18.4± 0.22, respectively.

Ash content of fresh Mola was 3.23± 0.11; on the other hand ash content of Mola on 1st to 3rd day from open sun rack dryer was dryer 9.60±0.09, 3.93±0.05, 7.67 ± 0.09. Furthermore, on similar days of drying ash content of Mola in solar tent dryer were 4.73± 0.15, 9.23 ±0.10, 10.16 ± 0.02 respectively. Ash content also rose with subsequent drying periods and ash content on the solar tent dryer dry fish was significantly higher than the ash content of open sun rack dryer dry fish throughout the drying period. Ojutiku et al., (2009) find that ash content of White Nile (*Hyperopisus bebe)* on traditional drying ash content was 1.14% and on solar tent dryer ash content was 0.96%. According to the study of (Haque et al., 2013) showed that ash content of solar dried fish products ranged from 8.29 to 9.45%, on the other hand ash content was from 16.95 to 21.41% for traditional sun dried products.

TVBN content of fresh Mola was 0.021±0.16 and 0.24± 0.04, 0.63± 0.01 and 0.78±0.013 was on open sun rack dried fish at 1st to 3rd days of drying. On the other hand, on the consecutive day of drying TVB-N content on solar tent dried fish was 0.26±0.03, 0.48±0.00 and 0.58±0.00 respectively. TVB-N content of open sun rack dried fish was significantly higher than solar tent dried fish on 2nd and 3rd days of drying. The total volatile basic nitrogen (TVBN) mainly contributed by ammonia in the muscle produced by determination of muscle protein (Chaijan et al., 2006). In the present study the content of nitrogenous substance as TVB-N in fresh and dried Punti and Mola was found below the levels suggested by different researchers for different fish and fish products (Abraha et al., 2017).

Microbiological quality assessment Log (CFU/g) of sun dried Mola from open sun rack and solar tent dryer

Microbial load of fresh and dried Mola as presented in Table 3. In fresh Mola bacterial load was 5.79 Log CFU/g and open sun rack dried Mola had microbial load 4.74, 4.50 and 3.42 Log CFU/g on 1st, 2nd and 3rd day. On the other hand, 3.57, 3.49 and 3.32 Log CFU/g microorganisms was found on solar tent dried fish on 1st to 3rd day of successive drying. Mola microbial load was higher on dry fish obtained from sun rack dryer compared with the dry fish from low coat solar tent dryer. Solar tent dryer can concentrate solar radiation with the result that elevated temperature, which increase drying rate, in turn, lower relative humidity makes unfavorable to the activities of microbes. Rillo et al., (1998) find that studied the microbial quality of commercially available dried mackerel of Philippines and reported presence of microbes in sufficient quantity. According to ICMSF (1986) acceptable limit of bacterial load in dry fish as < 5 log cfug-1, findings of the present study was justified the earlier findings. Nurullah et al., (2006) reported that the bacterial load in solar dried Puti was $4.6\times l0^5$/g and Dhela was of 4.0×10^3/g.

Table 3. Microbiological changes Log CFU/g of Mola on open sun rack and solar tent dryer

Dryer	1st day drying		2nd day drying		3rd day drying	
	CFU/g	Log CFU/g	CFU/g	Log CFU/g	CFU/g	Log CFU/g
Open sun rack	5.54×10^4	4.74	3.17×10^4	4.50	2.65×10^4	3.42
Solar tent	3.75×10^3	3.57	3.15×10^3	3.49	2.13×10^3	3.32

CONCLUSION

Drying is a method of food preservation that works by removing water from the food which inhibits the growth of microorganisms. Present study was conducted to determine the effects of the drying techniques on the quality of dry fish prepared from open sun rack dryer and solar tent dryer. Sensory, biochemical and microbiological quality of both fish was analyzed in fresh condition and 1st, 2nd and 3rd days of drying on both dryer. From the sensory analysis, biochemical analysis and microbial analysis Mola obtained from solar tent dryer was superior in quality compared to open sun rack dryer dried product.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest about this manuscript.

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