



Evaluation of Drying Characteristics of Selected Fishes in Dryers developed by ICAR-CIFT

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Abstract

ICAR-Central Institute of Fisheries Technology, Cochin, has developed different types of dryers for improving the quality of dried fishes *i.e.* Solar tray dryer with electrical back up (hybrid), Solar tunnel dryer, Electrical dryer and Solar cabinet dryer with electrical back up (hybrid). Drying characteristics studies on selected fishes, mackerel (*Rastrelliger kanagurta*) (80% moisture content (MC) on wet basis (wb) and glassy perchlet (*Ambassis spp.*) (77% MC on wb), was conducted using the solar tray dryer with electrical back up (hybrid) dryer. The temperature obtained inside the chamber during drying was 65°C. The solar tunnel dryer, electrical dryer and solar cabinet dryer with electrical back up (hybrid) was evaluated with fresh and salted sole fish (*Cynoglossus semifasciatus*) (77% MC). Solar tunnel dryer under normal atmospheric conditions attained 45°C temperature, Electrical dryer was operated at 65°C temperature and Solar cabinet dryer with electrical back up (hybrid) attained 70°C temperature. Among the CIFT dryers evaluated, electric dryer was found to yield lower moisture dry product. Also, fish dried under electrical dryer received highest overall acceptability in sensory evaluation study.

Keywords: Dryer, mackerel, solar energy, sensory evaluation

Introduction

Drying preserves fish from decay by removal of moisture from fish thereby arresting the growth of bacteria, action of enzymes and chemical oxidation

of the fat (Naidu et al., 2016). Open sun drying of fish is an age old practice, and has problems with regard to higher microbial load and lower product quality and requires longer time for complete drying (Okoroigwe et al., 2013). Traditional method of fish drying may add up impurities like dust, sand, insects and bird waste in the dried product (Pangavhane et al., 2002; Yusuf et al., 1989). This method of fish drying causes loss of material and deterioration of final product quality, resulting in reduced market price. Use of solar dryers helps not only to reduce losses and maintain the quality of the product but also helps in conserving the conventional energy sources (Sablani et al., 2003).

ICAR-Central Institute of Fisheries Technology (CIFT) has developed different types of solar dryers for improving the drying of fishes *viz.*, solar tray dryer with electrical back up (hybrid), solar tunnel dryer, electrical dryer and solar cabinet dryer with electrical back up (Anon, 2015; 2016). Fresh prawns (*Metapenaeus dobsoni*) were dried under CIFT solar tray dryer with electrical back up (hybrid) to evaluate dryer for its efficiency and performance (Nagori et al., 2015). Changes in protein content of milk fish (*Chanos chanos*) during drying at 60°C temperature was studied by Thippeswamy et al. (2001) using CIFT hybrid dryer.

An attempt was made to study the drying characteristics of selected fishes in four different dryers developed by ICAR-CIFT.

Materials and Methods

Fresh fishes used in the study were procured from the local fish market at Thevara, Kochi. Glassy perchlet (*Ambassis spp.*) and sole fish (*Cynoglossus semifasciatus*) were cleaned thoroughly before drying. Mackerel (*Rastrelliger kanagurta*) was prepared by removing guts, gills and fins, and split opened into a butterfly style by cutting along the backbone from head to tail, prior to salting and drying.

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All the drying experiments were conducted at ICAR-CIFT, Cochin, in the month of October' 2016, from 9:00AM to 07:00PM on the days of experimentation. Cleaned fish samples were divided into groups of 500 g and were loaded in trays of ICAR-CIFT dryers (Table 1 and Fig. 1). Three experimental runs were carried out and the dryers were operated simultaneously at each run. In all drying experiments, samples from three different trays were collected randomly and weighed to calculate percentage weight loss at 1h interval. The moisture content of fish sample was assessed using standard hot air oven method.

Average atmospheric conditions during the experiments were measured using renewable energy monitoring system developed by ICAR - CIFT, Kochi (Anon, 2012).

Water activity (aw) is defined as the ratio of partial vapor pressure in the food material to partial vapor pressure in the pure water at constant temperature. Water activity of dried fish was determined using water activity meter manufactured by Aqua Lab, USA.

The percentage moisture content (wb) was determined by using following formula, (AOAC, 1980)

$$MC = \frac{(W_1 - W_2)}{W_1} \times 100$$

Where,

W_1 = weight of sample before drying, gram

W_2 = weight of sample after drying, gram

The drying characteristics of different fishes were expressed by drying curves (Moisture content vs Time). Sensory attributes of dried fishes including



Fig. 1. Images of ICAR-CIFT Dryers

Table 1. Details of dryers developed by ICAR-CIFT

Sl. No.	Particulars	Solar tray dryer with electrical backup (hybrid)	Solar cabinet dryer with electrical backup (hybrid)	Solar tunnel dryer	Electrical dryer
1	Capacity (kg)	20	40	5	5
2	Solar collector/Heat absorbing area (m ²)	10	7	8	Not applicable
3	Tray material	Stainless Steel (SS) 304	SS 304	Nylon mesh & poly carbonate sheet	SS 304
4	Automatic temperature cut-off system	Yes	Yes	No	Not applicable
5	Heat energy back-up system	Electrical 2 coils of 1000W	Electrical 2 coils of 1500W	No backup	Not applicable
6	Number trays	10	36	4	5
7	Dimension of dryer (m)	1.85 × 0.85 × 1.3	3.1 × 2.45 × 1.3	2.21 × 2.10 × 0.60	1.25 × 1 × 0.71
8	Dimension of tray (m)	1.60 × 0.75	0.90 × 0.5	0.8 × 0.4	1 × 0.69

flavor, texture, odor, appearance and overall acceptability were evaluated (Amerine et al., 1965). The evaluation was conducted using a 9-point hedonic scale (1 - dislike extremely, 9 - like extremely) by panel of ten members of different age and sex, selected from scholars, staffs and scientists of ICAR-CIFT, Cochin. Statistical analysis was performed by Kruskal Wallis test (Pairwise comparison) using SAS, 9.3, Statistical software. In all cases P (0.05) was taken as the significance level.

Results and Discussion

Solar drying of fish mainly depends on prevailing atmospheric conditions during experiments. Hence, fluctuations in the atmospheric parameters such as temperature, relative humidity and solar radiation affect the drying process. To overcome the limitations, ICAR-CIFT dryers were provided with electrical heating coils and automatic temperature cut-off system to supply additional heat requirement to maintain optimum drying temperature. Therefore, atmospheric conditions particularly solar radiation (W/m^2) could influence only the heat supplied by solar collector, not the drying process in the CIFT dryers. To determine the energy consumption of the dryer (electrical coil) vis-à-vis prevailed atmospheric conditions during drying, the parameters were monitored on an hourly basis and reported (Table 2).

Solar tray dryer with electrical backup (hybrid), under no load condition reached $65^{\circ}C$ temperature within 8 minutes and retained the same heat up to 1 hour 20 minutes. Power consumption of the dryer was found to be lower (0.67 kWh) which means solar collector supplied more heat energy due to favorable atmospheric conditions ($766 W/m^2$ of solar radiation, 75.8 % RH and $30.3^{\circ}C$ temperature). From Figure 2, it is shown that the reduction of moisture content was high for the first two hours of drying, thereafter reduction level decreased gradually. This could be due to removal of surface moisture followed by the moisture migration process from the tissues of deeper layers to surface. The initial and final moisture content of mackerel and glassy perchlet were 80 and 14.5%, 77% and 14% respectively. Time consumed for complete drying of mackerel was 15 h and for glassy perchlet was 10 h. Water activity was observed to be 0.78 and 0.76 for dried mackerel and glassy perchlet respectively which were the indications of quality dried products. Sapkale et al. (2003) observed similar levels of water activity in the solar dried mackerel fish.

Table 2. Observations of atmospheric conditions during drying

Time	Solar Radiation (W/m^2)	Atmospheric temperature ($^{\circ}C$)	Relative Humidity (%)
9:00 AM	796	33.2	79.5
10:00 AM	815	34.4	76.3
11:00 AM	1072	34.2	75.5
12:00 PM	1257	33.1	74.3
1:00 PM	942	33.0	69.4
2:00 PM	918	32.3	70.2
3:00 PM	774	33.8	75.8
4:00 PM	652.7	32.7	76.2
5:00 PM	666	33.2	70.1
6:00 PM	445	33.2	77.4
7:00 PM	125	30.9	79.5

Sole fish was dried in solar cabinet dryer with 3 kW electrical backup system. Results showed that electrical coils supplied only 2 kWh of additional energy apart from solar energy to complete the drying process. This lower energy consumption (2 units of electricity) by backup system implies that major part of energy requirement was supplied by solar energy system alone due to favorable atmospheric conditions (Table 2). It was found that only 8 h of drying is required to bring down to the recommended moisture content of 18-20% for the dried sole fish (Fig. 3). It was also observed that salted fish took more time to dry than fresh because of the salt concentration in the cells which prevents

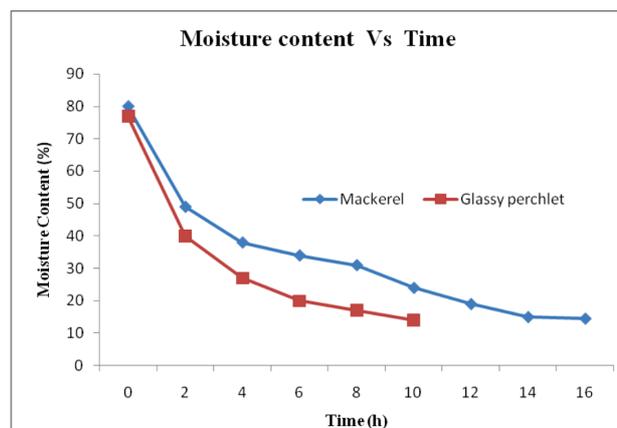


Fig. 2. Drying curve for Mackerel and Glassy perchlet fish in solar tray dryer

the movement of moisture from internal tissues. Joshi et al. (2014) noticed similar trends of drying of fishes in improved solar dryers. The quality of drying was confirmed with the water activity value of 0.70 for salted and 0.74 for fresh dried fish.

The electrical dryer was operated at 60°C temperature and 75% corresponding relative humidity. From Figure 4, it is seen that 10 h drying time was required for obtaining optimum moisture content in the salted sole fish where as unsalted fish require 8 h only. This may be explained by the fact that during salted fish drying, water movement to the surface of the fish is accompanied by salt migration. Further water evaporation on the surface results in crust formation which in turn makes the fish less permeable to water. Final products of salted and unsalted fishes showed uniform drying and equally distributed firmness which are the indications of quality dried product. Energy evaluation of dryer

revealed that the power consumption was as high as 1 kWh which confirms that heat was solely supplied electrical coils continuously which in turn provided controlled drying conditions.

The low cost solar tunnel dryer is fabricated using poly carbonate sheet and nylon wire mesh trays without electrical backup systems. It was observed that the temperature of solar tunnel dryer fluctuated between 29 and 65°C under no load conditions (Table 2). Sole fish was used in this dryer. It was observed that average temperature of drying was 45°C with 75% RH and took 3 days to dry to safe moisture level (<20 % MC). However, fungal growth was observed on the dried sample which could be due to prolonged drying time and cooling of sample during off sunshine hours. Bhor et al. (2010) observed similar results for dhoma fish drying under solar tunnel dryer.

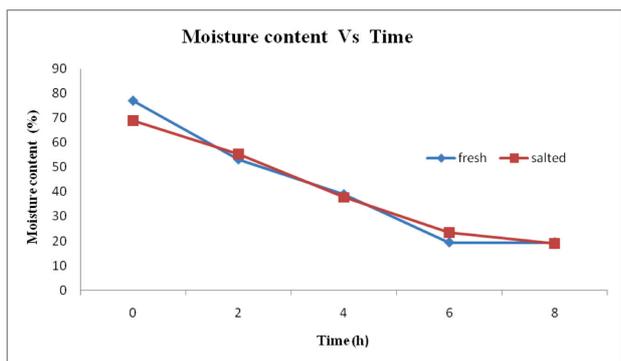


Fig. 3. Drying curve for fresh and salted sole fish in solar cabinet dryer

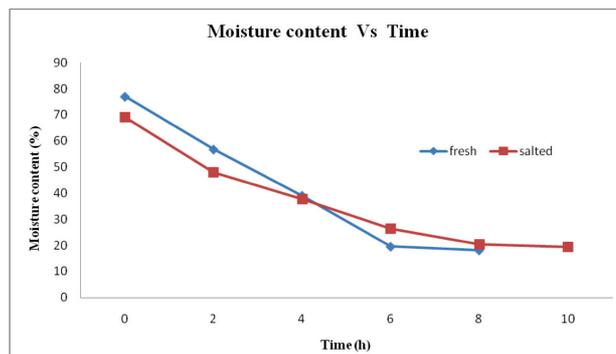


Fig. 4. Drying curve for fresh and salted sole fish dried in electric dryer

Table 3. Sensory evaluation of fish samples dried under ICAR-CIFT dryers

Parameters	Sensory scores of dried fish products			
	Solar tray dryer	Solar cabinet dryer	Solar tunnel dryer	Electrical dryer
Color	6.1±0.49 ^a	5.0±0.66 ^a	3.6±0.48 ^a	6.3±0.44 ^a
Appearance	5.2±0.48 ^a	5.9±0.19 ^a	4.0±0.71 ^a	7.8±0.15 ^b
Odour	5.4±0.74 ^a	5.0±0.87 ^a	3.5±0.37 ^a	6.0±0.74 ^a
Overall acceptability	6.0±0.25 ^a	7.3±0.15 ^a	3.1±0.65 ^a	8.9±0.76 ^b
Flavour	4.4±0.78 ^a	5.0±0.97 ^a	3.0±0.55 ^a	7.0±0.82 ^a
Texture	7.2±0.35 ^a	8.1±0.32 ^b	4.1±0.22 ^a	6.0±0.69 ^a

All values are given as mean ± standard deviation; Different letters (a-b) in the same row indicate significant differences within the sensory values (p<0.05).

Results showed that for all the sensory attributes examined, panelists preferred fish dried under electrical dryer with highest overall acceptability score (Table 3). This confirms that the highly acceptable dried fish products can be obtained only if the samples are dried under controlled conditions. This is in agreement with the results of sensory attributes of salted tilapia dried under thermostatically controlled kiln (Nketsia et al., 1995). It was observed that fishes dried under solar tunnel dryer received very low score in all the sensory attributes (Fig. 5). This may be due to visible fungal growth and discoloration that occurred during prolonged drying. The results show that there were insignificant differences in most of the sensory attributes of samples dried in solar tray dryer and solar cabinet dryer. However, significant differences were recorded in texture of fish products dried under solar cabinet dryer over other ICAR-CIFT dryers (Table 3).

From the studies it is concluded that drying time depends on the variety of fish used and drying conditions. It was also observed that the backup systems in the dryers are efficient in providing heat energy during off sunshine hours. Quality evaluation indicated that fish dried under electrical dryer is superior to other dryer due to its controlled drying conditions, and received highest overall acceptability in sensory attributes. The future scope of this study could be evaluation of storage stability of the dried fish products. The operating costs of different dryers could be compared along with assessment of various financial viability criteria. The study also indicated that the solar tunnel dryer requires additional heating source and air flow system to improve the quality of dry fish production.

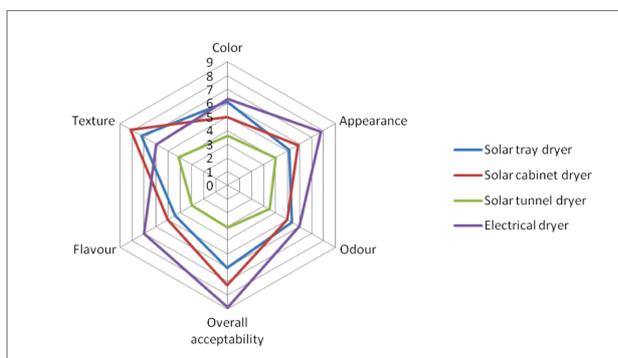


Fig. 5. Radar diagram for sensory evaluation of dried fishes under ICAR-CIFT dryers

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