Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol 2, No.4, 2012

Effects of Pre-Treatments and Drying Temperatures on Drying Rate and Quality of African Catfish (*Clarias gariepinus)*

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Abstract
Effects of pre-treatments and drying temperatures on the drying rate and the quality of African Catfish *Clarias gariepinus* was examined by drying samples of catfish under four different temperatures (40 ^{0}C, 45 ^{0}C, 50 ^{0}C and 55 ^{0}C) and four different pre-treatment methods (Salting, Sugaring, Blanching, and Control) using an experimental dryer. Drying of the fish samples for all the pre-treatments at 40 ^{0}C to 55 ^{0}C occurred in the falling rate period only showing that the predominant mechanism of mass transfer in drying process of catfish is that of internal mass transfer. The drying rate increases with increase in temperature for all the pre-treatment methods and decreases with time. The statistical analysis using a factorial design shows that drying rate was significant at (F; 0.05) but there is no significant difference in the pre-treatment methods as well as the interaction between drying temperature and the pre-treatment. The quality parameters (Protein, crude fat and Ash) measured decreases with increase in the drying temperature for all the samples with the blanched samples having the highest value of % protein of 55.94 at 45 ^{0}C. The sugared samples have the least value of 43.82% at 55 ^{0}C. The control has the highest amount of Ash 5.36% at 40 ^{0}C and 4.04% for blanched samples at 55 ^{0}C. Generally the values are higher for blanched samples and low for the sugar treated samples.
Keywords: Temperature, pre-treatment, falling rate, drying rate, quality.

1. Introduction

Fish is one of the major animal protein foods available in the tropics. This has made fishery an important aspect of study. According to Olatunde (1989) in Nigeria fish constitutes 40% of animal protein intake; unlike any other animal protein source with one problem of religious taboo or health hazard, fish is eaten across the country. Fish protein also provides vital protein constituents which enable the body to carry out certain functions such as growth. Unfortunately, however, fish is one of the most perishable of all stable commodities, and in the tropical climate of most developing countries it will become unfit for human consumption within about one day of capture, unless it is subjected to some form of processing (Ames et al, 1999). According to Abba (2007), Nigeria has the resource capacity (12 million ha inland water and aquaculture) to produce 2.4 million MT of fish every year, with an estimated demand at 1.4 million MT which currently exceeds supply.

As soon as fish dies spoilage begins to set in. This spoilage is accompanied by various physical and chemical changes in the gills, eyes, slime and skin tissues. Microbial activities accounts for major spoilage in fish (Eyo, 2001). Thus there’s the need for processing techniques ranging from sun drying, drying in solar dryers and with mechanical dryers, smoking, salting, freezing and irradiation.

Fish drying is an age long practice across the world. It is one of the methods of processing fish. Drying is the removal of water from fish. Normally the term 'drying' implies the removal of water by evaporation but water can be removed by other methods: for example, the action of salt and the application of pressure will remove water from fish. Since water is essential for the activity of all living organisms its removal will slow down, or stop, microbiological or autolytic activity and can thus be used as a method of preservation. (Clucas, 1982)

In traditional method of preserving fish, the action of the sun and wind is used to effect evaporative drying. In recent times, smoking kilns and artificial dryers are used to obtain product of high quality. According to Sablani et al (2002), solar drying produced better quality dried fish compared to that of sun drying due to reduction in insect infestation and other contaminants.

Traditionally, fish is not filleted before smoking, but large fish (e.g. catfish) is normally cut into portions. The choice of whether fish will be hot-smoked or smoked-dry depends on the type of fish to be smoked and how long the product is going to be stored. Results from previous studies have shown that the hot smoked process takes about 1 -3 hours and yields a product with about 35 - 45 % moisture content, but with a limited shelf-life of 1 - 3 days at ambient temperatures. The smoke-dry process takes about 10 - 18 hours, and sometimes 3 – 4 days and yields fish of 10 - 15% moisture content, sometimes even below 10% with a shelf-life of 3 - 9 months when stored properly (Jallow 1995).

In a study conducted by Davies and Davies (2009), it was reported that six different types of traditional fish processing techniques were in use in the Niger-delta part of Nigeria. These techniques were characterized with inefficient utilization of fuel wood, poor quality of fish due to lack of control over the temperature of the fire and smoke density, labour intensive and low capacity. Three improved technologies were equally observed in Bayelsa. They are; drum oven, mud oven, and chorkor kiln. The chorkor kiln proved to be a successful technology with high efficiency in fuel uses, easy to operate and maintained, high batch capacity and produces evenly smoked fish which fetches high market value.

Ichsani and Wulandari (2002) developed a Solar Dryer combined with kerosene stoves to dry Fish. The solar dryer hybrid system can be used in all seasons and gives alternative for selecting the source energy. This dryer system provides better product quality than the open sun drying.

Bellagha et al, (2002) in their experiment to determine the drying kinetics and characteristic drying curve of lightly salted sardines (*sadinella aurita*), reported that higher air temperature produced a higher drying rate and reduced drying period. This was due to the increase of the air heat rate to the product and to the acceleration of water migration inside the fish. Similarly, drying rate increased with increase air velocity but lessened at higher air flow velocities, due to hardening of fish surface caused by protein modification as a result of the combined effect of heat and salt. Mwithiga and Mwangi (2005) in analysing fish fillet drying rates under three solar energy drying systems reported that rapid increase in ambient temperature have a significant effect on the drying rates of the fillet fish.

According to the report of a study conducted by Olokor et al, (2009), fish weight loss in solar dryers differs in the ecological zones of Nigeria with the North-East recording highest value while the value of weight loss was least in South-South; this was attributed to the influence of relative humidity on drying. Drying method is however dependent on the nature of fish to be dried, size, quantity and consumer requirement in taste, quality and economic considerations.

Athough some other reported researches on fish drying vis-a-vis the drying rate and other connecting factors have also been documented,(Mujaffar and Sankat, 2005, Jain and Pathare, 2006, and Kituu et a l, 2009; Chuckwu and Shaba, 2009; HassabAlla *et al.*, 2009), effects of pre-treatment methods have not been investigated under varying drying temperatures.

Therefore the objective of this study is to investigate the effects of pre-treatments on the drying rate and quality of African Catfish under varying drying temperatures.

2. Materials and methods

The experimental dryer used for the drying test consists of heating chamber having an electrical heating coil of 1.8 kW, connected directly to a centrifugal fan of 0.5 Hp, and drying chamber. The heating coil is connected to the temperature regulator which controls the drying temperature. The drying cabinet measures 50 cm long, 50 cm wide and 80 cm high (with external dimension of 56 cm x 56 cm x 86 cm) consisting of three set of trays separated by 15 cm . The drying chamber is double walled insulated with fibre glass of 3 cm thick.

2.1. *Sample Preparation*

Catfish weighing approximately 280 g with an average length of 30 cm were purchased from a village (Aleara) one of the adopted village of Nigerian Stored Products Research Institute (NSPRI), Ilorin and conveyed to the laboratory in water. The fish were gutted and washed before cutting them to the required sizes of four pieces for effective drying and grouping. Thereafter each size group was divided into four subgroups randomly but at the same time ensuring that each of the parts are represented in each pre-treatment before applying the treatments.

2.1.1 Application of Treatments

Blanching: Fish samples were dipped in 1 litre of boiling water (100 ^{0}C) for about 5 minutes. The fish were then removed and arranged on trays for about 30 minutes to remove all surface water from the fish before arranging them on the drying trays in the dryer.

Salting: Fish samples were dipped into salt solution (15 g of salt to 1 litre of water; 1.4 Brix at 20 ^{0}C) for about 15 minutes. They were removed and arranged on a tray and left for about 30 minutes to allow the surface water to be removed.

Sugaring: Fish samples were dipped into sugar solution (15 g of sugar to 1 litre of water; 1.2 Brix at 20 ^{0}C) for about 15 minutes.

Control: The selected fish samples (without any form of pre-treatment) for control were just arranged on the trays for about 30 minutes to allow removal of surface water before drying.

2.2 *Drying Procedure*

The dryer was pre-heated to the desired temperature of 40^0C by the means of temperature regulator while the samples were being prepared to ensure stability of the condition of the drying chamber when the fish will be introduced.

After arranging the trays in the dryer, the fan was switched on and was set to a velocity of 0.5 m/s using the fan regulator with the speed measured with a digital anemometer. The initial condition of the environment and the drying chamber was recorded immediately after loading.

The samples were weighed at an interval of 3 hours with a top loading balance (Snowrex counting scale SRC 5001 Capacity 5000 x 1 g, Saint Engineering ltd, Saint House, London) with an accuracy of 1g and measuring up to 5000 g, and the weights recorded.

This was done until an average moisture content of 12.6% (wb) was reached. The procedure was repeated for the samples at 45^0C, 50^0C and 55^0C respectively.

The drying rate was calculated using equation 1

$$R = \left(\frac{dM}{dt}\right) = \left(\frac{m_i - m_f}{t}\right) \quad 1$$

where;

R is the drying rate in g/hr.

dM and dt is change in mass and change in time in g and hr. respectively

t is the total time

m_i and m_f is the initial and final mass of fish samples respectively in g.

However, in order to monitor the trend in the drying rate as the drying progresses the relationship below was used to calculate the drying rate at interval.

$$\frac{W_t - W_{(t+\Delta t)}}{\Delta t} \quad 2$$

where; $W_{(t)}$ is the weight of fish at time t

$W_{(t+\Delta t)}$ is the weight of fish at time t+Δt

Δt is the time interval for sampling.

The variations in weight recorded.

The quality parameters of the dried fish samples were obtained using the objective methods in accordance with the AOAC (2005) standards.

2.3 *Statistical Analysis*

The data obtained were analysed using Analysis of Variance (ANOVA), where significant differences ($p<0.05$) were detected the Duncan New Multiple Range Test (DNMRT) was used to examine the differences in the mean values.

3. Results and discussion

3.1 *Effects of Pre-treatment and temperature on drying rate*

Table 1 shows the drying rates obtained. The analysis shows that the effect of the pre-treatment methods used was not significant ($p<0.05$). The result also revealed that the effect of interaction between the pre-treatment methods and the drying temperatures was not significant. However, the effect of drying temperature on the drying rate was significant ($p<0.05$). This shows that temperature is the major factor that affects the drying rate of agricultural products. The result of Duncan's New Multiple Range Test (DMRT) shows that there is no significant difference between the mean drying rates at 40 ^{0}C and 45 ^{0}C. However, the mean drying rates obtained at 45 ^{0}C, 50 ^{0}C and 55 ^{0}C are significantly different (Table 2).

3.1.1 Effects of Pre-treatment on the drying rate

The drying rate increases generally for all the pre-treatment as the temperature increases. At 40 ^{0}C the sugar treated samples have the least drying rate of 0.8 g/hr the values increases with Salt, Blanched and control (in ascending order). This shows that the pre-treatment used does not affect the drying rate significantly. In all, the drying rate for control was the highest recorded except at 50 ^{0}C when the salted samples have the highest value of 1.64 g/hr. For the blanched samples a marginal increase of 0.01 g/hr was recorded as the temperature is increased from 40 ^{0}C to 45 ^{0}C. The sugared and salted samples shows higher increase in value of drying rate at 50 ^{0}C and 55 ^{0}C than those of blanched and control. This is an indication that salting and sugaring enhances water movement from the fish head under the drying condition investigated.

The blanched samples have the highest drying rate for all the temperatures increasing from 1.0 g/hr at 40 ^{0}C to 2.58 g/hr at 55 ^{0}C. This is due to the effect of heat treatment of the blanched samples which introduced porosity in the fish muscle as a result of cooking thereby enhancing the release of water from the fish muscles. Jason (1980) found that cooking of fish increased 2.7 times the diffusivity of water in the falling rate period, compared with an uncooked sample. The drying rate for salt treated samples was also greater than the values for that of sugar. This is an indication of the effect of osmosis action of salt in the fish samples leading to free movement of water from the fish. However, it was observed that the drying rate of salted samples was less than that of the control sample at 55 ^{0}C which is an indication that at high temperatures salt tends to have a reverse effect on drying rate as pointed out in earlier studies by Kilic, 2009; and Oladele and Adediji, 2008. The fact that sugared samples shows the least value shows that sugar treatment is not a preferred method of pre-treatment in fish drying; it affects the taste of the dried samples. However, values obtained are a reflection that the drying rate of fish is not only affected by nature of fish and moisture content but also by the treatment methods.

Generally, the drying rate increases with increase in temperature for all the pre-treatment methods for all the fish parts. However, it should be noted that the blanched samples only show marginal increase in the value of drying rate as the temperature increases from 40 ^{0}C to 45 ^{0}C. This further stressed the fact that while salting is a good pre-treatment at low temperature blanching shows better effect at high temperatures.

3.1.2 Effects of pre-treatment on drying curve patterns

The effects of the pre-treatments used on the drying curve patterns are presented in figures 1 to 4.Figure 1 shows that there are two distinct stages of falling rate for the fish samples dried at 40 ^{0}C, however there is a shift in this stages depending on the treatment. The salt treated samples and the control shows clearly that two stages of falling rate period can be observed for the fish samples dried at 40 ^{0}C. The first falling rate period of the salted samples was longer than others terminating after 30 hours of drying thus having a short second falling rate period, whereas the sugared samples and control have a short first falling rate period occurring in 12 hours respectively and 18 hours for the blanched samples. This is an indication that salt treatment is a good pre-treatment method for drying at a temperature as low as 40 ^{0}C due to its effect on elongating the first falling rate period.

Figure 2 shows that the first falling rate period for the blanched samples occurred until 30 hours of drying. The sugared, salted and control samples shows identical drying pattern with the first falling rate period terminating at 18 hours. All the pre-treatment methods including control show that for fish samples dried at 50 ^{0}C the first falling rate period ends after 21 hours of drying (Fig. 3). From Figure 4 the first falling rate period is longer than the second falling rate period for all the samples dried at 55 ^{0}C. This shows that with high temperatures the drying time is reduced. However, the length of the first falling rate is longest for the blanched samples.

In general the drying rate patterns showed that pre-treatments do not only affect the drying rate but also have effects on the drying pattern. The pre-treatments affects the shift observed in the falling rate period for the fish samples dried at 40 ^{0}C to 55 ^{0}C. This is important in the determination of the drying constant. The drying pattern obtained for different fish parts for different pre-treatments at different temperatures are necessary to study the drying behaviour of the parts which is one of the reasons that makes a whole fish to be susceptible to spoilage due to uneven drying of the parts.

3.1. 3 *Effects of Drying Temperatures on drying rate*

The plot of the air drying curves (Fig. 5) reveals that fish like some other agricultural materials does not exhibit the constant rate drying period. The drying curves obtained show that drying of fish at 40 ^{0}C to 55 ^{0}C occurred only in the falling rate period. This further confirms previous works done by Mujaffar (2005).

In general, drying rate increases with increase in drying temperature but decreases with time which shows that temperature is a major factor affecting the drying rate of a product. The drying rate of the fish samples at 55 ^{0}C was initially high (for all the samples)and declined drastically which implies that internal water movement was controlling the drying rate from the beginning of the drying process at this temperatures (Yusheng and Poulsen, 1988). Consequently increase in temperature resulted in reduction in drying time. This is in conformity with previous study carried out on drying of agricultural commodities. (Mujaffar and Sankat, 2005, and Kilic, 2009).

3.2 *Effects of pre-treatment and drying temperature on quality parameters*

The values of the percentage composition of the quality parameters determined (Protein, Crude fat, and Ash) are presented in Table 3. The quality parameters measured generally decreases as the drying temperature increases irrespective of the pre-treatment method used. This is in conformity with the discovery of Kilic, (2009) which noted that the increase of drying temperature decreases the fish quality because it accelerates the biochemical and microbiological decomposition of fish, especially salted fish. Generally, the values of protein, crude fat, and ash decreases as the temperature increases as expected, but the variation is affected by the type of pre-treatment used. The sugared samples show the highest reduction with increase in temperature for the three quality parameters except for ash content.

3.2.1 Effects of drying temperature and pre-treatment on protein content

Just as Osibona (2009), noted in his report, African catfish *C. gariepinus* belong to high-protein, low-oil category. The Blanched samples have highest value of protein having a value of 55.94% and 48.58% at 40 ^{0}C and 55 ^{0}C respectively. The sugared samples have the least values of protein with a value of 49.59% and 43.26% at 40 ^{0}C and 55 ^{0}C respectively. This further stress the fact that sugaring is not a good pre-treatment method in fish drying because as it has been earlier on seen; it does not enhance the drying rate but also lead to reduction in protein content. Blanching enhances the drying rate as well as the protein quality of the dried fish samples.

3.2. 2 Effects of drying temperature and pre-treatment on crude fat content

The crude fat content of the pre-treated dried fish samples decreases as the drying temperature increases for all the pre-treatment method used. The fat content was highest for the control sample with a value of 28.8% followed by 25.43% for sugared sample while the salted and blanched samples have a value of 21.99% and 21.86 respectively. However it should be noted that the loss of lipid (crude fat) is high for all the samples due to lipid oxidation at high temperatures resulting into loss of lipid. By raising the drying temperature from 40 ^{0}C to 55 ^{0}C lipid value reduce by 34.3% for the control and 30.8% for sugared. The blanched sample has the list reduction of 21. 4% while the value for salted sample reduced by 29.4%. This is an indication that blanching is a preferred pre-treatment where lipid content of dried fish is the most important quality to be preserved. Chukwu and Shaba (2009) also pointed out that high losses of lipid content resulted from high drying temperatures.

3. 2. 3 Effects of drying temperature and pre-treatment on Ash content

The ash content also decreases as the drying temperature increases in all the samples. As expected the blanched sample has the least value of 4.63% at 40 ^{0}C and 4.04% at 55 ^{0}C respectively, while the sugared sample has a value of 5.48% at 40 ^{0}C and 4.14% 55 ^{0}C respectively. Increasing the temperature from 40 ^{0}C to 55 ^{0}C resulted in a reduction of 24.4% for sugared and control sample respectively, and 22.3% for the salted samples. The Ash content of the blanched samples however, reduced by 12.7%.

4. Conclusion

This study establish the fact that increase in the drying temperature without any corresponding change in the velocity of the drying air irrespective of the type of pre-treatment method has a significant effect on the drying rate. The pre-treatment methods used namely Salt, sugar and blanching does not have a significant effect on the drying rate of African catfish *C. gariepinus*. The results obtained have also reinforced that drying of African Catfish *C. gariepinus* like any other species of fish for all the pre-treatment methods used at the temperatures 40 to 55 ^{0}C occurred in the falling rate period only. This is very important for the design and construction of dryers. It also serves as fundamental information in modelling the drying characteristics as well as the determination of drying constants of the fish in studying the drying kinetics of the fish.

The study results show that different nutritional components of fish undergo different changes as the drying temperatures increases. Although the quality parameters decreases with increase in drying temperature the percentage reduction in value is affected by the type of the pre-treatment method used with blanching showing the least reduction in value.

References

Abba, A. (2007). "The potentials of Aquaculture sector in Nigeria". Seminar paper presented at workshop on Fish Farming Organized by Federal Department of Fisheries (FDF) and Fisheries Society of Nigeria (FISON) in Ilorin.

Ames, G., Clucas, I., and Paul, S. S. (1999). Post-harvest losses of fish in the Tropics. Natural Resources Institute. Overseas Development Administration. pp 11.

AOAC (2005). Official Methods of Analysis (18th Edn.) Association of Official Analytical Chemists International, Maryland, USA.

Bellagha. S, Amami. E, Farhat. H, and Kechaou. N. (2002). Drying Kinetics and Characteristics Drying Curve of Lightly Salted Sardine (*Sardinella aurita*). Proceedings of the 13th *International Drying Symposium* (IDS).Vol. C., pp 1583-1590.

Chukwu, O. and Shaba, I. M. (2009). Effects of Drying Methods on Proximate Compositions of Catfish (*Clarias gariepinus*). *World Journal of Agricultural Sciences 5 (1): 114-116.*

Clucas, I. J. (Compiller) (1982). Fish handling, preservation and processing in the tropics: Part 2. Report of the Tropical Development and Research Institute. Overseas Development Administration. Pp 3-4.

Davies, R. M. and Davies, O. A. (2009). Traditional and Improved Fish Processing Technologies in Bayelsa State, Nigeria. *European Journal of Scientific Research. Vol.26 No.4, pp.539-548.*

Eyo, A.A. (2001). Fish Processing Technology in the Tropics. Published by National Institute for Freshwater Fisheries Research (NFFRI), New Busa, Nigeria.

HassabAlla. A. Z., Mohamed, G. F., Ibrahim, H. M., and AbdElMageed, M. A. (2009). Frozen Cooked Catfish Burger: Effect of Different Cooking Methods and Storage on its Quality. *Global Veterinaria 3(3): 216-226.*

Ichsani, D and Dyah, W. A. (2002). Design and Experimental Testing of A Solar Dryer Combined with Kerosene Stoves to Dry Fish. *American Society of Agricultural and Biological Engineers*. (ASABE), pp 1-3.

Jain. D. and Pathare, P. B. (2006). Study the drying kinetics of open sun drying of fish. *Journal of Food Engineering*. *78 (2007) 1315-1319.*

Jallow, A.M. (1995). Contribution of improved chokor oven to artisanal fish smoking in The Gambia: *In Workshop on Seeking Improvements in Fish Technology in West Africa.* IDAF Technical Report. No: 66.

Jason, A. C. (1980). General theory of drying of fish. *In Proceedings of the International Association of Fish Meal Manufacturers on Drying, Handling and Storage of Fish Meal, Athens, October 1980*. News Summit, International Association of Fish Meal Manufactures. No. 49.

Kituu, G. M., Shitanda, D., Kanal, C. L., Mailutha, J. T., Njoroge, C. K., Wainaiana, J. K., Odote. P. M.O. (2009). "Influence of Brining on the Drying Parameters of Tilapia (*Oreochromis Niloticus*) in a Glass-Covered Solar Tunnel Dryer". Agricultural Engineering International: *the CIGR Ejournal. Manuscript number. EE 1349, Vol. XI. August, 2009.*

Kilic A. (2009). Low temperature and highvelocity (LTHV) application in drying: Characteristics and effects on fish quality. *Journal of Food Engineering*. 91(2009)173 -182.
Mujaffar S. and Sankat K. C. (2005). The mathematical modelling of the osmotic dehydration of shark fillets at different brine temperatures. *Int. J. Food Sci. Tech., 40: 1-12.*
Mwithiga .G and Mwangi. S.G. (2005). Analysis of Fish Fillet Drying Rates under three solar Energy drying systems. Proceedings of the 15th *International Drying Symposium.*
Oladele, A.K. and Adedeji, J.O. (2008). Osmotic Dehydration of Catfish (*Hemisynodontis membranaceus*): Effect of Temperature and Time. *Pakistan Journal of Nutrition 7 (1): 57-61.*
Olatunde, A.A. (1989). Approaches to the study of fisheries biology in Nigerian Inland waters. Proceedings of national conference of two decades of research on Lake Kainji. Ayeni and Olatunde (Eds) pp. 1538-1541.
Olokor, J. O., Ugoala, C., and Ibitoye, A. (2009). Study of weight loss in solar dryer across different ecological zones of Nigeria. *Nature Proceedings. Vol. 1038.*
Osibona, A. O., Kusemiju, K. and Akande, G. R. (2006). Proximate composition and fatty acids profile of the African Catfish *Clarias gariepinus. Journal of life and Physical Science. Faculty of Science and Technology, Babcock University. acta SATECH 3(1). www.actasatech.com.*

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Table 1: Average drying rate of African Catfish (*C. gariepinus*)

Treatment	Temperature (^{0}C)	Parts			
		Head	Trunk	Middle	Tail
Sugar	55	1.88	2.00	1.82	0.97
	50	1.58	1.17	1.08	0.92
	45	1.02	1.19	0.87	0.52
	40	0.80	0.83	0.81	0.56
Salt	55	1.82	2.27	1.61	1.15
	50	1.64	1.53	1.17	0.67
	45	1.09	1.13	1.02	0.63
	40	0.83	0.96	0.63	0.52
Blanched	55	1.97	2.58	1.73	1.00
	50	1.31	1.53	1.22	0.89
	45	0.94	1.04	0.87	0.46
	40	0.93	1.00	0.85	0.52
Control	55	2.06	2.40	1.82	0.94
	50	1.33	1.25	1.08	0.81
	45	1.09	1.15	1.00	0.61
	40	1.00	0.89	0.80	0.50

Table 2: Duncan's New Multiple Range Test

Temperature (^{0}C)	Mean drying rate (g/hr)
40	0.78^a
45	0.92^a
50	1.20^b
55	1.75^c

Values with different letters are significantly different

Table 3: Variation in % Composition of the quality of the fish samples*

Treatment	Temperature (^{0}C)	Quality Parameter			
		MC (%)	Protein (%)	Lipid (%)	Ash (%)
Sugar	40	12.9	49.59	25.43	5.48
	45	12.8	47.48	21.88	5.06
	50	12.4	43.82	17.46	4.37
	55	12.2	43.26	17.60	4.14
Salt	40	12.9	50.54	21.99	5.33
	45	12.7	48.84	19.86	4.81
	50	12.6	48.54	18.08	4.72
	55	12.2	45.08	15.52	4.14
Blanched	40	12.6	55.94	21.86	4.63
	45	12.3	52.92	20.52	4.28
	50	12.3	53.20	18.04	4.08
	55	12.2	48.58	17.19	4.04
Control	40	12.9	52.69	28.80	5.36
	45	12.6	49.00	24.21	4.75
	50	12.3	48.84	20.75	4.33
	55	12.2	48.16	18.92	4.05

* Values presented are average of three samples.

Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol 2, No.4, 2012

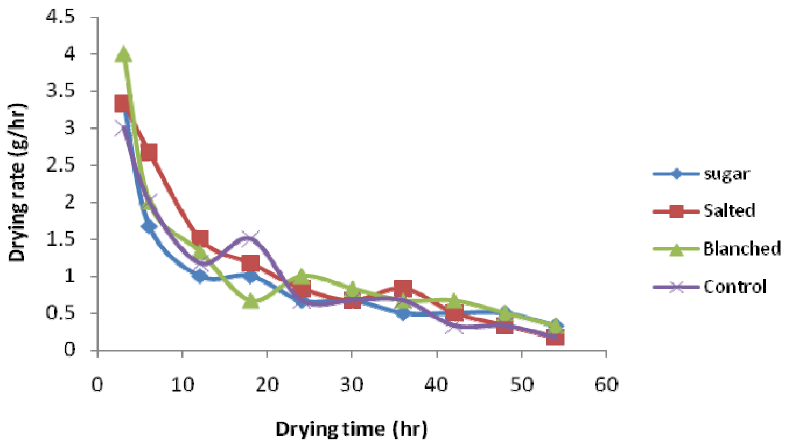

Figure 1: Effect of drying time on drying rate for different pre-treatments (at 40 ^{0} C)

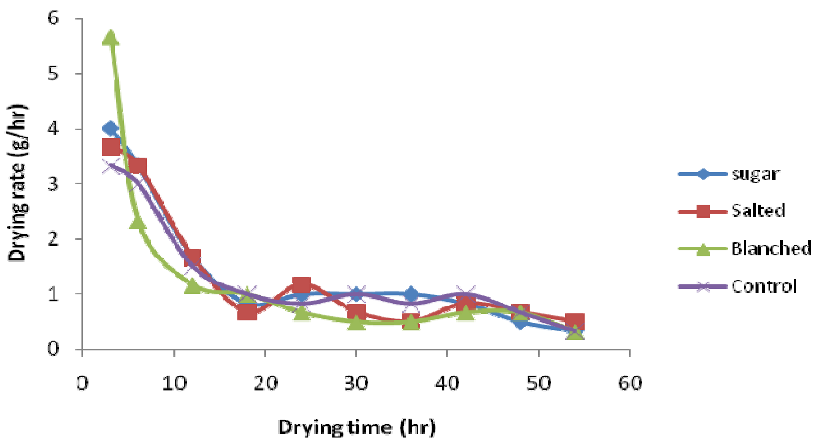

Figure 2: Effect of drying time on drying rate for different pre-treatments (at 45 ^{0} C)

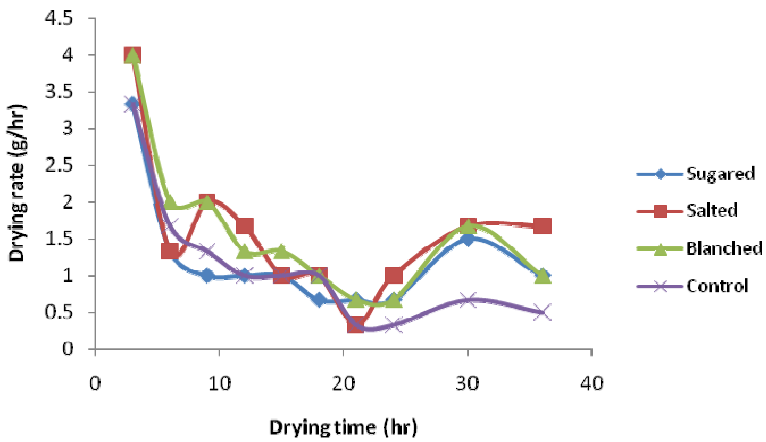

Figure 3: Effect of drying time on drying rate for different pre-treatments (at 50 ^{0} C)

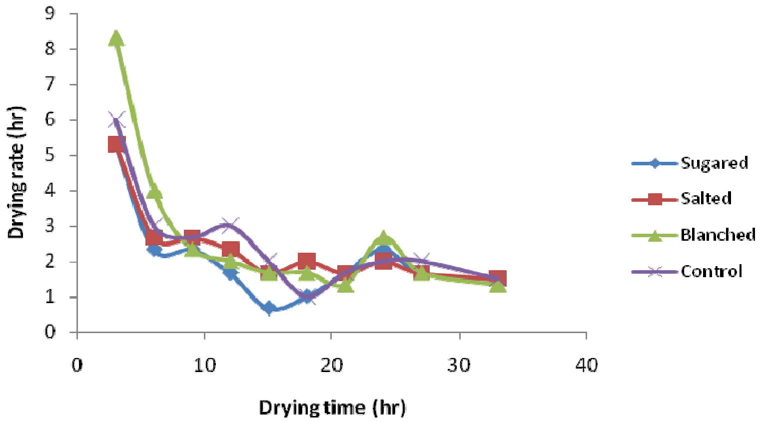

Figure 4: Effect of drying time on drying rate for different pre-treatments (at 55 ^{0} C)

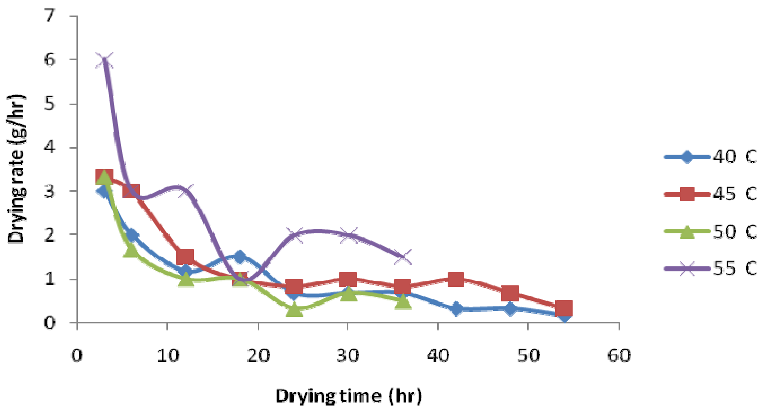

Figure 5: Effect of drying time on drying rate at different drying temperatures