ISSN 2319 – 7757 EISSN 2319 –7765

discovery Cover the uncovered

Indian Journal of Engineering

Effect of brining on drying kinetics of Tilapia (Tilapia Zilli) fish fillets

Elijah George Ikrang☼, Joseph Udoudo Okoko, Nnam-Ntefon Udo Etuk

Department of Agricultural and Food Engineering, University of Uyo, PMB 1017, Uyo, Nigeria

☼**Corresponding author:** Department of Agricultural and Food Engineering, University of Uyo, PMB 1017, Uyo, Nigeria; E-mail: elijahikrang@yahoo.com; Phone: 234 802 569 3683

Publication History
Received: 23 November 2013
Accepted: 19 January 2014
Published: 5 February 2014

Citation
Elijah George Ikrang, Joseph Udoudo Okoko, Nnam-Ntefon Udo Etuk. Effect of brining on drying kinetics of Tilapia (Tilapia Zilli) fish fillets. *Indian Journal of Engineering*, 2014, 8(18), 6-10

ABSTRACT

The influence of pre-treatment (salting) on Tilapia fish filets were studied in a direct passive solar dryer. A factorial experiment laid out in a completely randomised design (CRD) with two factors being fish and salt at three levels replicated ten times was chosen for the work Results showed that the fish fillets dried in the falling rate period and also salt concentration had significant effect ($p< 0.01$) on drying kinetics. It was also found that the moisture ratio increased as the salt concentration, whereas the drying rate decreased appropriately. Moreover, the equilibrium moisture content of the dried product increased with increase salt concentration .From the result it is evident that fish and the interaction between fish and salt did not have any significant effect on the drying characteristics of the fish fillets.

Keywords: pre treatment, equilibrium moisture, drying rate, dehydration, adsorption

discovery Cover the uncovered

Indian Journal of Engineering

1. INTRODUCTION

Solar energy being one of the substitute energies belongs to the renewable energy sources. It is abundantly available in the tropical region of the world .Solar thermal technology is rapidly gaining acceptance as an energy saving measure in agriculture. It is often preferred to other alternative sources of energy such as geothermal, wind, ocean thermal, tidal wave and shale because it is abundant, inexhaustible and non-polluting (Akinola, 1999, Akinola and Fapetu, 2006, Akinola et al., 2006). To heat up the air, simple devices are employed by utilizing solar energy as found in many applications requiring low to moderate temperature below 80^{0}C such as space heating and crop drying (Kurtbas and Turgut, 2006).

© 2014 Discovery Publication. All Rights Reserved

Drying processes are defined as moisture removal as a result of simultaneous heat and mass transfer (Ertekin and Yaldiz, 2004). From the dehydration point of view of food materials, two types of water are found in food items the chemically bound water i.e. water held by molecular adsorption and the physically held water implying, water held by capillary adsorption. The chemically held water is strongly bound to the protoplasm of the food materials and requires enormous amount of energy before part of it can be detached during drying. The physically held water is loosely bound unto the molecules of the food material and can be easily detached by a slight application of physical force or energy as in drying. Molecular adsorption is accompanied by heat generation whose value is 840-1680kJ/kg water (Sitkei, 1986). The major target in drying therefore is to remove mostly the physically held water to enhance longer shelf life of the product. It brings about reduced volume to enhance transportation and storage. The dehydration process is a complex heat and mass transfer phenomenon that depends on internal and external variables. The internal variables are material property dependent. Examples include chemical composition, physical structure, size and shape of products. External variables include temperature, relative humidity, and velocity of drying air.

Sodium chloride has traditionally been used in curing and preservation of meat and fish due to its capacity to improve the water holding capacity of proteins. Kaiye (2004) stated that brining (dissolved sodium chloride, NaCl in water) reduces the microbial count on dried fish. Oliviera et al., (2006) and Grawier et al., (2006) pointed out that concentration of salt used in osmotic dehydration in excess of 5% are beyond the permissible levels for human consumption. Kituu et al. (2009), in their work on the influence of brining on the drying of tilapia fish in a solar tunnel dryer reported that if the tilapia fish is brined, the moisture content reduces linearly with increased brine concentration, and that there exists a high correlation existing between them. It was also pointed out that brining reduced the drying rate of tilapia fish when dried in a glass covered solar tunnel dryer. The drying rate constant and the effective diffusivity varied between 0.0813 and 0.1217 per hour and between 5.72 and 8.56 x 10-11 m^2s^{-1} respectively for brine concentrations ranging between 0 and 15% and that they also decreased with increased brine concentration.

Salting of fish has long worldwide traditions as means to preserve and increase the shelf life. Moreover, it is a preliminary operation in some smoking, drying and marinating processes. Ismail and Watton (1992) reported that brining has been most empirically developed and has remained unchanged for many years. The preservative nature of salt has remained unchallenged for centuries by decreasing water activity, making water less available for microbial activities and enhancement of functional properties leading to an increase of shelf life (Aubourg and Ugliano, 2002). It has also been reported that salt inhibits the growth of micro-organisms by drawing water out of tissue through osmosis (Horner, 1997). Salt concentration and length of time of exposure depends on the expected final product (Bellagha et al., 2007).

Gumus et al. (2008) in their work on quality changes of salted red mullet (fish) reported that red mullet soaked in 20% salt concentration prior to preservation could retard the microbial growth, delay the chemical changes and extend the shelf life of the product during refrigeration storage. The common method of preserving are freezing, salting, smoking and frying .The other alternative to enhance food security and diversity is drying.

1.1. Objectives of the Study

The objective of this study was therefore to determine

1. The influence of brining on the equilibrium moisture content, drying rate constant and the moisture ratio
2. The interaction between the factors chosen for the drying of Tilapia fish (Tilapia zilli) when dried in a direct passive solar dryer.

2. MATERIALS AND METHOD

The work was carried out as a factorial experiment with two factors at three levels arranged in a completely randomized design (CRD) with ten replicates. The treatments were descaled fish fillets with no salt (NO), descaled fish fillet with 10 % salt (N10), descaled fish fillets with 20% salt (N20). Others are fish fillet with scale and no salt (SO), fish fillets with scale and 10% salt (S10) and fish fillets with scale and 20% salt (S20). Some samples were also dried in the open sun to serve as the control for each experimental set up. The control experiment samples were CNO, CN10, CN2Oand CSO, CS10, CS20 for descaled and fish fillets with scale respectively. The duration of drying in the entire work varied between 1500 minutes (25hrs) of 3 days to 2,040 minutes (34hrs) of 4 days per replicate. The fish samples were obtained from Domita Farms Nig. Ltd., Uyo, Akwa Ibom State for the study. A total weight of 15 kg drawn from refrigerated storage were cleaned, eviscerated, heads removed, washed and filleted longitudinally to expose the backbone in preparation for solar drying.

The salt solutions were prepared by dissolving the desired amount in 100ml of distilled water. Samples were soaked for about one hour after which they were removed and excess water was allowed to drain off. The essence of soaking in salt solution is to help prevent spoilage by bacteria and to enhance quick drying. Sample of about 1.5kg

© 2014 Discovery Publication. All Rights Reserved

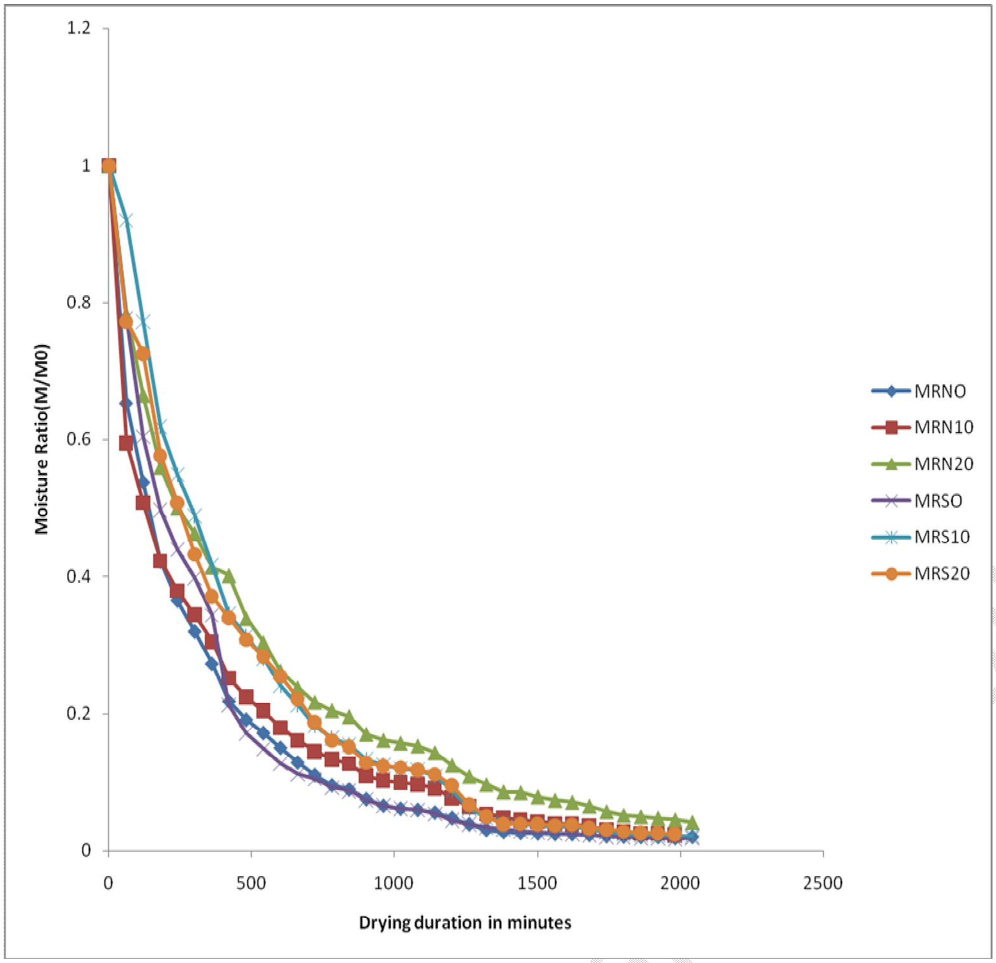

Figure 1

Graph of Moisture Ratio against drying duration of replicate one

were drawn from refrigerated storage divided into three sub samples for soaking for the drying test. For thin layer solar drying test the samples were shaped approximately into a rectangular slab of thickness ranging from 5 to 6 mm, length 5 mm and width 3 mm. Moisture content was determined for each set of treatment combination prior to the commencement of solar drying.

The measurement of temperature inside the solar dryer was carried out with a digital pocket thermometer (Checktemp model HI98501 by Hanna instruments). USA. Temperature was measured at three positions inside the solar dryer in addition to inlet and exit temperatures .The atmospheric temperature was also similarly measured. The relative humidity was estimated through the measurement of both wet and dry bulb temperatures within and outside the dryer through the use of hygrometer. The solar insolation on a horizontal surface for Nsukka and wind speed data for the period of drying were obtained from Centre for Basic Space Research, University of Nigeria Nsukka. The relative humidity, temperature and wind speed data were also obtained from the same source for comparison. Weight was measured through the use of digital weighing balance (Ohaus instrument model: Scout Pro SPU 402). The experiment were all set up with appropriate positioning of the dryer in North–South direction along side with other instruments to measure the relative humidity, temperature, moisture content ,wind speed and solar intensity for accurate recording. The drying experiment was carried out from 8.00am to 4.00pm everyday .At the end of each day a black polythene wrapper was then used to wrap around the entire dryer with the fish product remaining inside for safe storage in favour of the next day's operation. This is to help prevent moisture migration into the semi dried product.

2.1. Moisture Content Determination

Water content was determined using this method. About 5 g of sample was weighed accurately (± 1 mg) in a pre-weighed clean and dry metal dish with a lid. The sample was then heated in an oven at 102^{O}C – 105^{O}C for 4 hours. The lid was then placed on top of dish with the lid cooled in a desiccators and then weighed. The water content of the sample corresponded to the weight loss observed and results were given as percentage of the weight of dried material (wb or db).

$$M_{db} = \frac{initial\ weight - dried\ weght}{dried\ weight}\ x\ \frac{100}{1} \qquad 1$$

3. RESULTS AND DISCUSSION

In the course of this work some physical characteristics of the fish were evaluated experimentally. The fish length ranged between 13 and 19cm and weight 50 and 100g. The proximate composition of the fish fillets were: moisture content 71.77-74.77 %(wb), crude protein 13.0—16.25%, crude lipids 15.5-27.83%, ash 14.74-16.16% .On drying

© 2014 Discovery Publication. All Rights Reserved

Table 1

Final analysis of variance for equilibrium moisture content for dried fish fillets

Source of variation	df	SS	MS	Fcal	F tab	
					5%	1%
Treatment combination	5	288.2971				
Factor A (Salt)	2	237.2004	118.6	5.8781**	3.11	4.51
Factor B (Fish)	1	0.0728	0.0728	0.036 ns	3.91	7.01
Interaction (AXB)	2	51.0245	25.512	1.264 ns	3.11	4.51
Error	54	1089.531	20.1765			
Total	59	1377.829				

ns = Non significant effect

** significant effect(p <0.01)

Table 2

A Two way table of Factors A and B means

Salt	0%	10%	20%	Total
Fish with no scale	9.971667	10.90683	13.95611	34.83461
Fish with scale	8.539259	10.75567	14.78867	34.08359
Total	18.51093	21.6625	28.74478	68.9182

completion, the final moisture content varied between 12.5-16.0%(wb). The drying kinetics of the various treatment combinations of the first replicate can best be explained through plotted graph of Figure 1. At 120 minutes (2 hours) drying time the observed moisture ratio in the first replicate treatments listed as NO, N10, N20, S0, S10, and S20 had the following values 0.5376, 0.5752, 0.6647, 0.6040, 0.7715 and 0.7252 respectively. Also at 600 minutes (10 hours) of drying, the values for the treatments changed slightly to 0.1503, 0.1789, 0.2616, 0.1268, 0.2408 and 0.2546 respectively. Considering NO treatment at 1200 minutes (20 hours) drying time, it was found that the moisture ratio was 0.04735, N10 had a value of 0.07611 and N20 had a value of 0.12437. The treatment of fish with scale also had a similar result. SO had a moisture ratio of 0.0443, S10 had a moisture ratio of 0.0868 whereas S20 had moisture ratio of 0.09553.

Moisture ratio at 1800 minutes (30 hours) of drying had the following values of 0.0206, 0.026, 0.0511, 0.0192, 0.0236 and 0.0280 for N0, N20, S0, S10, and S20 respectively. From this result, it is evident that as the salt concentration increased the moisture content decreased linearly with increased moisture ratio and hence decreasing drying rate. The decrease in moisture content is consistent with the fact that salt is a hygroscopic substance thus increase in its concentration increases the amount of salt particles for absorbing water molecules from the fish sample (Gravier et al. 2006). In addition more salt particles will be available to enter any void space in the fish sample to achieve dehydration (Kituu et al. 2007).

In the control experiment, the results obtained showed low drying rate with increasing salt concentration in open sun drying. It is similar to solar drying and it agrees with the work of these authors Medina- Vivanco, (2006) and Sankat and Mujaffa, (2004). It is evident from this result that the drying rate of the control experiment is lower than the drying rate obtained in the solar dryer. This could be explained in terms of higher temperature reached in the solar dryer with reduced relative humidity thereby enhancing moisture transport and hence dehydration of the fish fillets (Zoomorodian and Dadaszadeh, 2009; Rafiee et al. 2009; Hii and Cloke, 2009). The salt treatment also affected the drying rate in the control samples dried in the open sun as well as those dried in the solar dryer. This confirms the fact that when the salt concentration increases the drying rate decreases as appropriate.

From the ANOVA Table 1, it is observed that factor B (fish) and the interaction of factors A and B (salt and fish) have no significant effect on the drying characteristics of the fish filets. On the other hand factor A (salt) is highly significant (p<0.01) on the drying characteristics of tilapia fish filets. From Table 2, it is evident that as the salt pre – treatment concentration increases, the equilibrium moisture content also increases in both fish samples. The pre-treatment salt concentration is limited by customer's acceptance of the final product since concentration higher than 10% is often discriminated upon by consumers as they will have to soak it for desalting before cooking for consumption. Moreover the higher the concentration of salt in the treatment of the tilapia fish fillets the lower the drying rate with accompanied high moisture ratio and the drying curve takes place in the falling rate period

4. CONCLUSION

The pre-treatment (salt) concentration significantly influenced the drying characteristics of tilapia fish filets. Some of the drying parameters influenced by pre-treatment concentration are drying rate, moisture ratio, and equilibrium moisture content. It has been shown that as the salt concentration increased, the moisture content decreased linearly with increased moisture ratio and hence decreasing drying rate. From the result it evident that fish and the interaction between fish and salt did not have any significant effect on the drying characteristics of fish fillets. Also in the control experiment, the results obtained showed low drying rate with increasing salt concentration in open sun drying.

© 2014 Discovery Publication. All Rights Reserved

REFERENCES

1. Akinola AO. Development and Performance Evaluation of a Mixed- Mode Solar Food Dryer.M.Eng. Thesis, Federal University of Technology, Akure, Nigeria, 1999
2. Akinola AO, Fapetu OP. Exergetic Analysis of a Mixed-Mode Solar Dryer. *J. Eng. Appl. Sci*. 2006, 1, 205-210
3. Akinola AO, Akinyemi AA, Bolaji BO. Evaluation of Traditional and Solar Fish Drying Systems towards Enhancing Fish Storage and Preservation in Nigeria (Abeokuta Local Government as case study). *J. of Fisheries Int. Pakistan,* 2006, 1(2-4), 44-49
4. Aubourg SP, Ugliano M. Effect of Brine Pretreatment on Lipid Stability of Frozen Horse Mackerel (*Trachurus trachurus*) *European Food Research and Tech.* 2002, 215, 91-95
5. Ayensu A. Dehydration of Food Crops Using a Solar Dryer with Convective Heat Flow. *Inter. J. of Solar Energy,* 1997, 59(4-6), 121-126
6. Bellagha S, Sahli A, Farhat A, Nkechaou, Glenza A. Studies on Salting and Drying of Sardine (Sardinella aurita). Experimental Kinetics and Modelling. *J. of Food Engineering*. 2007, 78, 947-952
7. Ertekin C, Yaldiz O. Drying of eggplant and selection of a suitable thin layer drying model. *J. Food Engr*. 2004, 63, 349-359
8. Graivier N, Pinotti A, Califona A, Zaritzky N. Diffusion of Sodium Chloride in Fork Tissue. *J.of Food Engrg*. 2006, 77(4), 910-918
9. Gumus Bahar, Ramazan Ikiz, Mustafa Unlusayin, Hayri Gulyavuz. Quality Changes of Salted Red Mullet (Mullus barbatus L; 1758) During Vacuum Packaged Stored at $+4^{O}C$. *EU Journal of Fisheries and Aquatic Sciences*, 2008, 25(2), 101-104
10. Horner WFA. Salting In: Fish Processing Tech. Preservation of Fish by Curing (edited by GM Hall) Chapman and Hall Pub., UK, 1997, 32-72
11. Ismail N, Wootton M. Fish Salting and Drying: A Review. *Asean Food J.*, 1992, 7, 175 183
12. Kaiye. Effect of Improved Processing Techniques on the Quality and Storage Stability of Tilapia From L. Victoria In Kenya, MSc Thesis, Jomo Kenyatta Univ. of Agric. and Tech. Juja, Kenya 2004
13. Kituu GM, Shitanda D, Kanali CL, Mailutha JT, Njoroge CK; Wainaina JK. P. M. O. On dote Influence of Brinning on the Drying Parameters of Tilapia (Oreochromis Niloticus) in a Glass-Covered Solar Tunnel Dryer. *Agric. Engrg. Inter: The CIGR Ejournal*. 2009, EE1349, Vol XI
14. Kurtbas I, Turgut E. Experimental investigation of solar air heater with free and fixed fins: efficiency and energy loss. *Int. J. Sci. Technol,* 2006, 1, 75-82
15. Oliviera IM, Fernandez FAN, Rodriguez S, Sousa PHM, Maia GA, Figueirend RW. Modelling and Optimization of Osmotic Dehydration of Bannana Followed by Air Drying. *J. of Food Engrg.* 2006, 29, 400-443
16. Sitkei, Gyorgy. Mechanics of Agricultural Materials, Elsevier Sc. Publishers, The Netherlands, 1986

Indian Journal of Engineering

© 2014 Discovery Publication. All Rights Reserved