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The effects of brine concentrations on the drying characteristics and microbial quality of dried fillets of African Catfish *(Clarias gariepenus)*

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***Abstract*—** *This study evaluates the drying characteristics of brined fillets of African catfish (Clarias gariepenus) at four brine concentrations (0, 10, 15 and 20%) and four drying temperatures (40, 50 60 and 70º C). Fresh catfish samples were obtained from a farm at Ikorodu, Lagos. They were cleaned, gutted and cut into fillets of approximately 5×4×3 cm sizes and soaked in the different concentrations of salt (NaCl) solutions for about 6 hours. Thereafter, the fillets were placed on trays and dried in a cabinet dryer till no appreciable changes in weight of the samples were observed. The drying data obtained were analyzed and employed to construct the drying curves, obtain the drying rate constants, the diffusion coefficients and activation energy. Drying rate increased with drying temperatures, with the fillets experiencing greater moisture loss at the initial stage of drying. Fillets dried at temperatures higher than 60 ºC acquired the aroma of cooked fish. Both the drying rate constants and diffusion coefficients increased with increasing temperature. Microbial analysis revealed that the higher the salt concentration, the lower the microbial load on each of the dried samples at the different drying temperatures. The microbial load -population of total viable count recorded in this study varied from 4.50 × 10^5 cfu/g (70ºC, 20% salt concentration) to 3.08 × 10^7 cfu /g (40ºC, 0% salt concentration). Thus, drying temperature and salt concentration has profound effects on the drying rates as well as the microbial load of the dried catfish.*

***Keywords*— catfish, drying, salt, drying rate, diffusion coefficient.**

I. INTRODUCTION

In Nigeria, the African catfish (*Clarias gariepenus*) is the one of the main fish species commonly stocked in ponds and one of the few that has demonstrated commercial viability (Olagunju *et al.*, 2007, Banjo *et al.*, 2009; Alawode and Ajagbe 2020, Ogah *et al.*, 2022). As noted by Onoche *et al.*, (2020), and Kaleem and Sabi (2021), a major production constraint is the high post-harvest losses recorded by farmers particularly during gluts. Appropriate preservation methods that significantly reduce the loss, including those occurring during distribution and marketing are therefore essential. Moisture control primarily by drying provides opportunity to prevent losses, which occur during harvesting, handling and storage.

Natural sun drying has been used for preserving fish catches, however, the limitations include lack of control of the drying process, weather uncertainties, high labour costs, insect infestation, and mixing with dust and other foreign materials. As a result, drying in which the drying heat is artificially provided is finding increasing applications for fish products. Salting and drying achieve a lowering of the water activity (a_w) of the fish flesh and hence an extension of the shelf life. Many researchers have studied conventional fish salting and drying methods (e.g Sen and Lahiry (2004) and Sen and Sripathy (2007)). Sobukola and Olatunde (2011) studied the effect of salting techniques on salt on uptake and drying kinetics of African catfish (*Clarias gariepinus*). Sankat and Mujaffar (2006) presented a report on the drying behaviour of salted fillets of catfish (*Arius sp*). The optimal drying conditions for the tropical African catfish species do not appear to be well established yet, particularly, the kinetics of water removal from salted fish fillets. The objectives of this study were therefore to study the drying behaviour of catfish fillets dried in a cabinet oven at different temperatures ranging from 40ºC to 70ºC and to determine the microbial load of the fillets after drying.

II. THEORETICAL CONSIDERATIONS

Moisture ratio during drying experiment is usually calculated using the equation (Vallero *et al*.,2023).

$$MR = \frac{M_t - M_e}{M_o - M_e} \quad . \quad \ldots\ldots\ldots\ldots\ (1)$$

With the drying rate calculated using equation (2)

$$Drying\_Rate = \frac{M_t +_{dt} - M_t}{D_t} \quad \ldots\ldots\ (2)$$

The effective moisture diffusivity is calculated by using the simplified Fick's second law of diffusion:

$$\frac{\partial M}{\partial t} = D_{eff} \nabla^2 M \quad \ldots\ldots\ldots\ldots\ (3)$$

The solution of Fick's second law in slab geometry, with the assumption that moisture migration was caused by diffusion, negligible shrinkage, constant diffusion coefficient and temperature was given as (Vallero, 2023):

$$MR = \frac{M_t - M_e}{M_o - M_e} = \frac{8}{\pi^2} \sum_{i=1}^{n} \frac{1}{(2n-1)^2} \exp\left(\frac{-(2n-1)^2 \pi^2 D_{eff} t}{4H^2} \right) \quad \ldots\ldots\ (4)$$

Where D_{eff} is the effective moisture diffusivity (m^2s^{-1}), H is the half thickness of the slab (m) and n is a positive integer. Since only the first term of the equation can be used for long drying time (Lopez *et al.*, 2000) the equation becomes:

$$MR = \frac{8}{\pi^2} \exp\left(\frac{-\pi^2 D_{eff} t}{4H^2} \right) \quad \ldots\ldots\ (5)$$

III. MATERIAL AND METHODS

3.1 Samples preparation

Catfish *(Clarias gariepinus)* samples were obtained from the Lagos State Polytechnic fish farm at Ikorodu. Upon capture the fish were cleaned, gutted and then spitted into half and filleted. They were immediately cut into 5cm by 4cm by 3cm fillets using filleting knife. Brine solution made from food-grade sodium chloride dissolved in distilled was used. The fillets were soaked in various salt concentration range (0, 5, 10, 15 and 20%) in separate bowls for a period of 6 hours to allow adequate salt absorption and to stop normal bacteria spoilage.

The brined fillets were spread in single layer on pre-weighed shallow wire trays. Seven samples per salt concentration level were placed in different trays for each temperature setting of the Gallenkamp 300 plus cabinet oven. At regular intervals, the samples were taken out quickly from the oven, cooled in desiccators, weighed and return to the dryer. Drying was continued until moisture content reduces to safe storage moisture content. The procedure was repeated at a temperature of 50ºC, 60ºC and 70ºC respectively. From these, the average value moisture loss as a function of time was determined and use to construct the drying curves.

A 2.5g representative sample was obtained aseptically from the muscle (the thickest part of the muscle) of the cat fish steak and crushed using a lab pestle and mortal. Serial dilutions (10^{-1}–10^{3}) of the homogenized samples were made using 25mls distilled water. Briefly, serial dilutions of the homogenized samples (10ml) in duplicate were passed through a 0.45 mm grid membrane filter, which was subsequently placed onto an absorbent pad soaked with appropriate broth in a Petri-dish, and incubated at 35ºC for 24–48hrs.

IV. RESULTS AND DISCUSSION

4.1 Air drying curves

The drying data obtained were used in constructing the drying curves for salted catfish fillets dried at 40, 50 60 and 70º C. The drying rate curves for the air drying of salted catfish fillets are shown in Figures 2 (a-d). The figures revealed that drying rates were higher during the first two hours of drying, when the moisture content was greater. An increase in rate constant with increasing drying air temperature has been shown for the drying of many biological materials (Krokida *et al.,* 2004; Mujaffar and Sankat, 2005). Drying at a higher temperature resulted into a greater movement of fat from the within the muscle to the surface of the fillets. Drying at 70ºC also resulted in hard and crusty fillets. At 20% salt concentration a thick layer of salt on the surface developed which impeded further drying. Salted fillets dried at 40ºc appeared moist and later developed off- odours.

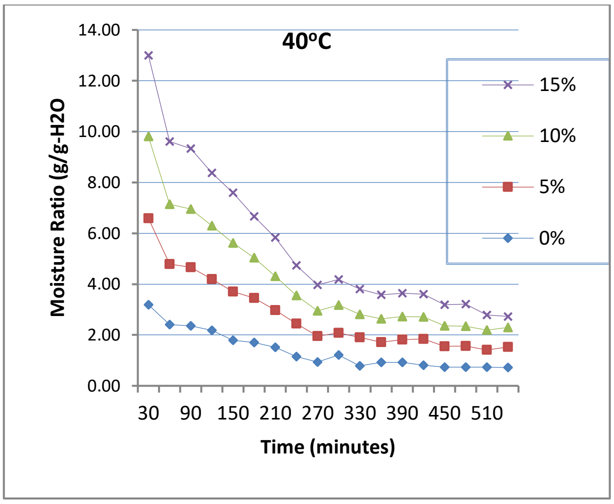

Fig 1a. Drying curves for fish at 40⁰C and varying salt concentration

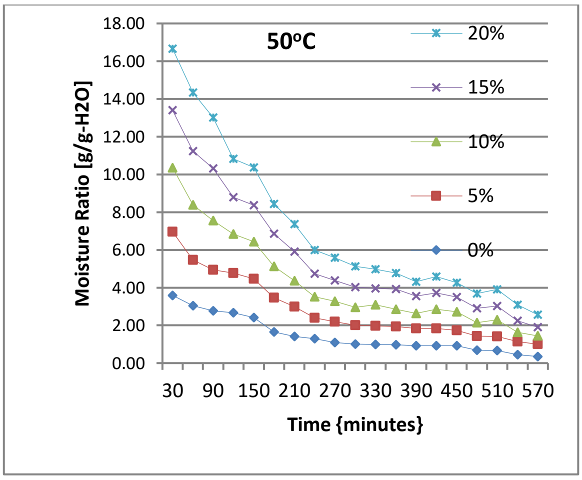

Fig 1b. Drying curves for fish at 50⁰C and varying salt concentration

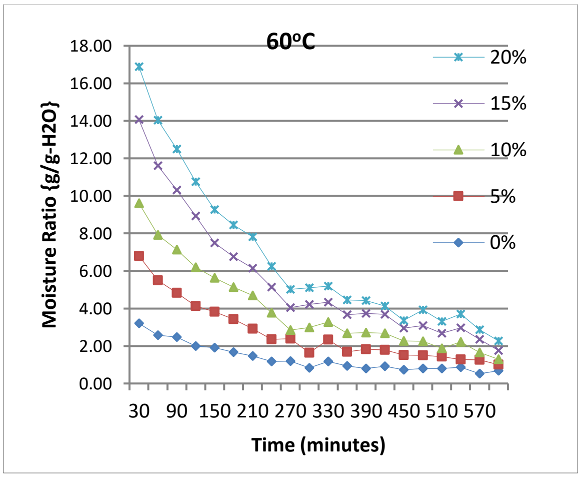

Fig 1c. Drying curves for fish at 60⁰C and varying salt concentration

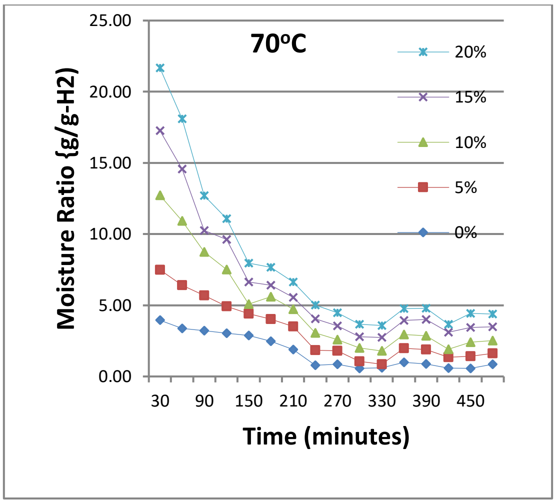

Fig 1d Drying curves for fish at 70⁰C and varying salt concentration

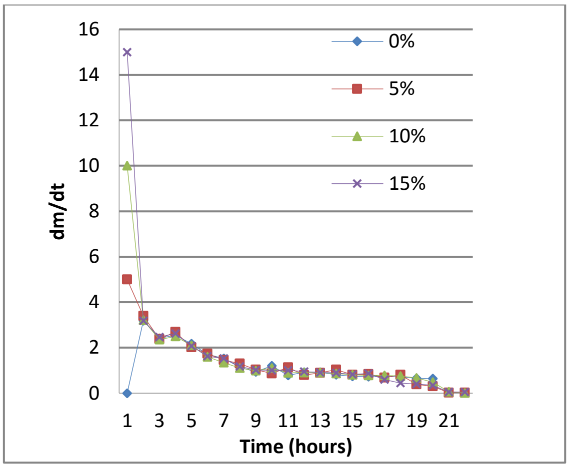

Fig 2a. Drying rate curves for fish at 40⁰C and varying salt concentration Time (hours)

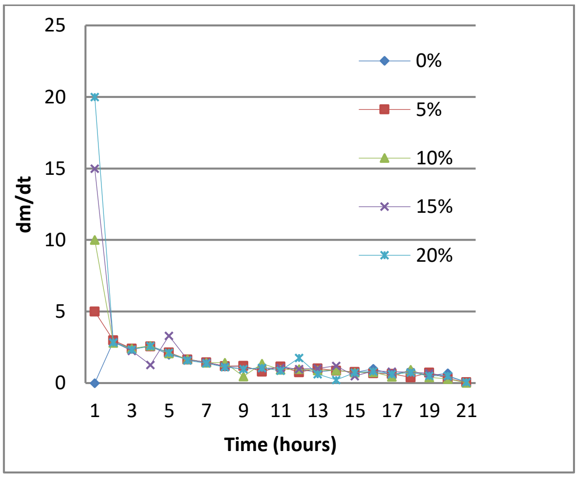

Fig 2b. Drying rate curves for fish at 50⁰C and varying salt concentration

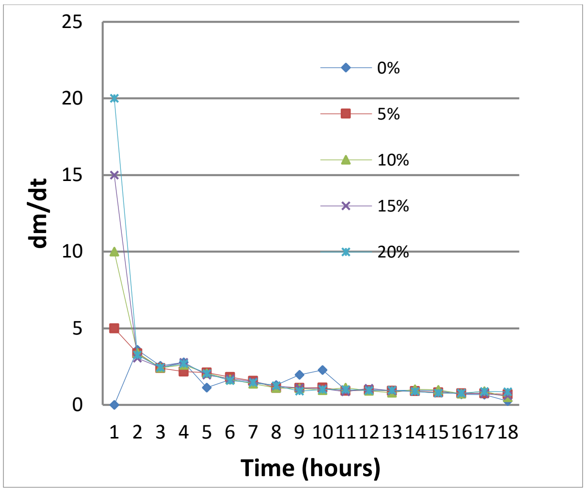

Fig 2c. Drying rate curves for fish at 60⁰C and varying salt concentration

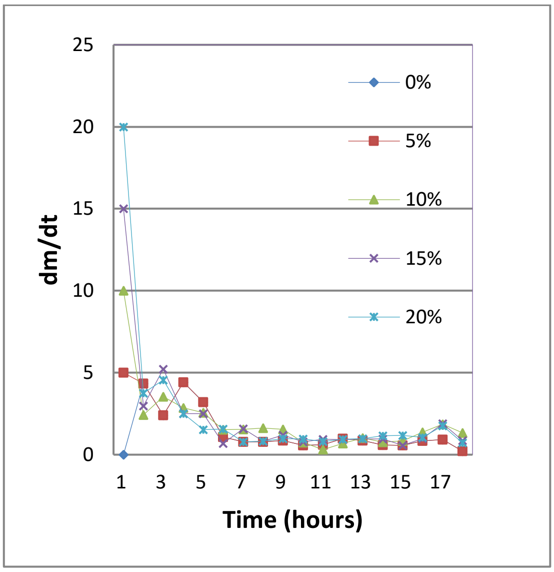

Fig2d. Drying rate curves for fish at 70⁰C and varying salt concentration

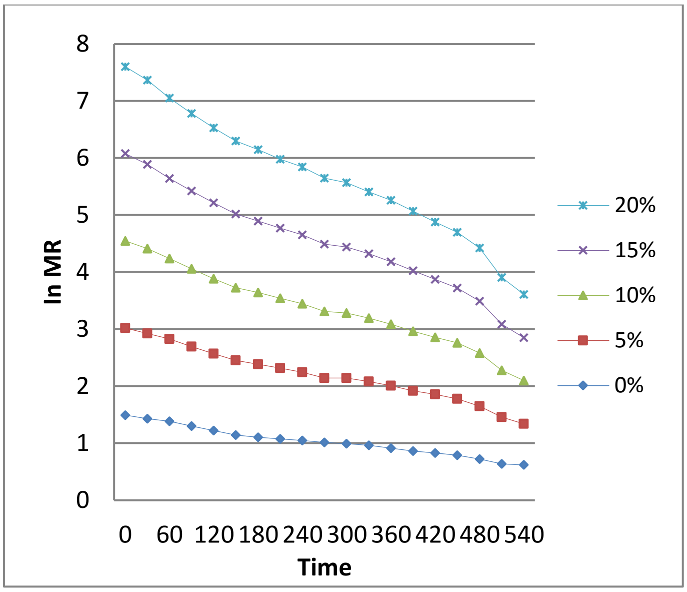

Fig.3: Plot of Ln MR against time for salted catfish dried at 60⁰c

4.2 Drying constants, diffusion coefficient and activation energy

It is generally accepted that moisture is removed from salted fish during the falling rate period during which the rate is governed by the transfer of water by diffusion. (Jason, 1998; Wheaton and Lawson 2000; Ismail and Wooton 2002). The drying constant (k) is obtained from the slope of the plot of In MR versus time and is shown in Table 1. Figure 3 presents a plot of In MR against time for 60°C.

The drying rate constants for salted fillets were used to calculate diffusion (D) using the following equation:

$$A=\pi^2 D/L^2$$

where A is the diffusion area. The temperature dependence of the D-values for salted fillets and the activation energies were estimated from a plot of In D versus I/T using an Arrhenius type equation:

$$\text{In}D = \frac{-E_a}{RT}$$

The values obtained are presented in Table 1 above.

Table 1: Values of drying constants, Diffusion coefficient and activation energy at different salt concentrations and drying temperatures

Drying Temp	Salt concentration	K-value $\{\frac{Y_1 - Y_2}{X_1 - X_2}\}$	Diffusion coefficient $\{D = \frac{4KL^2}{\pi^2}\}$	Activation energy calculated from $In\ D = \frac{-Ea}{RT}$
40ºC	0%	0.0013	0.013	12384.3
	5%	0.0012	0.012	12612.6
	10%	0.0012	0.012	12612.6
	15%	0.0011	0.011	12860.7
	20%	0.0010	0.010	13132.5
50ºC	0%	0.0013	0.013	11660
	5%	0.0013	0.013	11660
	10%	0.0012	0.012	11877.2
	15%	0.0011	0.011	12110.8
	20%	0.0010	0.010	12366.8
60ºC	0%	0.0015	0.015	10926.9
	5%	0.0014	0.014	11106.5
	10%	0.0013	0.013	11299.1
	15%	0.0012	0.012	11509.4
	20%	0.0012	0.012	11509.4
70ºC	0%	0.0016	0.016	11412
	5%	0.0015	0.015	12131.8
	10%	0.0014	0.014	11798.4
	15%	0.0014	0.014	11798.4
	20%	0.0013	0.013	12002.1

4.3 Microbial quality: total viable count

The total viable count (TVC) is one of the indicators for the quality of dried fish. The population of TVC recorded in this study varied from 4.50 × 10^5 cfu/g (70ºC, 20% salt concentration) to 3.08 × 10^7 cfu /g (40ºC, 0% salt concentration). The unsalted sample, dried at low temperature was confirmed spoilt. As stated by Broekeart *et al.*, 2011, loads of 10 7 -10 8 CFU/g make spoilage organoleptically detectable. The effects of temperature and salt concentration on the microbial load of the dried catfish was thus evident.

V. CONCLUSION

The drying characteristics of brined African catfish fillets were determined in this study. From the experimental result, under the same condition (temperature and salt variation), further increases the temperature to 70^0c resulted in case hardening of the fillets. It was also observed that as the salt concentration is increased at each drying temperature the microbial load decreases, but greatly with increasing temperature. Hence, salt serves as an inhibitor to the growth of micro-organisms and can be use in the preservation of fish. The results provide relevant information procedure for catfish processor, drying handling, modeling and designing of an over for drying fish.

NOMENCLATURE

∂M	change in moisture content
∂t	change in time
χ^2	Reduced chi-square
D	diffusion coefficients cm^2s^{-1}

D_{eff} effective moisture diffusivity (m^2s^{-1})

D_o Arrhenius equation constant (m^2s^{-1})

Ea activation energy $Jmol^{-1}$

H half thickness of sample

k drying rate constant (h-1)

M R moisture ratio

MC moisture content any time (kg water/kg dry matter)

M_e equilibrium moisture content (kg water/kg dry matter)

Mo initial moisture content g H2O/g DM

M_o initial moisture content (kg water/kg dry matter)

N number of observations

R gas constant 8.314 JK-1mol-1

R^2 coefficient of determination

RMSE root mean square error

t drying time (min or h)

T process temperature K

W_r reduced weight of samples after drying

W_s initial weight of samples before drying

Z number of constants in the model

REFERENCES

[1] Alawode O O and Ajagbe S O (2020). Profitability of small scale catfish production in South West Nigeria : the challenges. Scientific Papers Series. Management, Economic Engineering in Agriculture and Rural Development. 16(3), 78-87, 2020. *and Bioproduct Processing, 89, 170-177.*

[2] Banjo Oluwole Sikiru, Nosiru Marcus Omobolanle, B.J.O. Ayorinde and Odusina Olaniyi Adegoke 2009: Improving Clarias Productivity towards Achieving Food Security in Ijebu-Ode, Ogun State, Nigeria: A Socioeconomic Analysis. *Advances in Biological Research 3 (1-2): 24-28, 2009.*

[3] Broekeart K Heyndrickx M, Herman L, Devlighere F, Vleamynk G (2011). Seafood quality analysis : molecular identification of dominant microbiota after ice storage on several general growth media . Food Microbiology18 : 1162-1169.

[4] Ismail, M.N. and M. Wooton (2002), Fish salting and drying: a review, *ASEAN Food Journal, Vol 7(4), pp.175-183.*

[5] Jason, A.C. (1998), General theory of drying of fish. *Proceedings of the Conference International Association of Fish Meal Manufacturers on Drying, Handling and Storage of Fish Meal*, Athens, October 1980. News Summit, International Association of Fish Meal Manufacturers paper No. 49

[6] Kaleem O , Singou A B (2022) : Overview of aquaculture systems in Egypt and Nigeria, prospects potentials and constraints. Aquaculture and Fisheries 6(5):535-547

[7] Krokida M. K. , Foundoukidis E, Maroulis Z. B (2004) : Drying constant: Literature data compilation for foodstuffs Journal of Food Engineering 61(3):321-330 February 2004 DOI: 10.1016/S0260-8774(03)00136-5

[8] Lopez, A., Iguaz, A., Esnoz, A. and Virseda, P. 2000. Thin layer drying behaviour of vegetable wastes from wholesale market. *Drying Technology*, 18, 995–1006.

[9] Mujaffar, S. and Sankat, C.K. 2005. The air drying behaviour of shark fillets. Canadian Biosystems Engineering/Le génie des biosystèmes au Canada 47: 3.11-3.21

[10] Ogah S I, Miteu GD, Oyewole E O, Adebayo JO, and Benneth EO (2022) The role of technology in Nigerian Catfish Production: A review. Agricultural Reviews 43(3) 304 -311, 2022

[11] Olagunju F I, Adesiyan I O, and Ezekiel A A (2007): Economic viability of catfish production in Oyo State Nigeria. *J Hum Ecol* 2(12): 121-124; Kamlar Raj Publ.

[12] Onoche U, Ahmed T A, Ebenechi O (2020). Assessment of Constraints to Catfish farming in Kogi State Nigeria. Asian Research Journal of Agriculture 12(3): 36-46.

[13] Sankat C K and Mujaffar S (2006): Modelling the drying behavior of salted catfish fillets. *15th International Drying Symposium,* Budapest Hungary

[14] Sen, D. P. and N. L. Lahiry (2004). Studies on the production of better quality salt cured and sun dried mackerel. *Food Technology Campaign*, **18** (10):17

[15] Sen, D. P. and N. V. Sripathy (2007). Improved method of salt curing and sun drying mackerel. *Indian Sea Foods* **5** (1):12.

[16] Sobukola, O.P. and Olatunde, S.O. (2011). Effect of salting techniques on salt uptake and drying kinetics of African catfish (*Clarias gariepinus*). *Food*

[17] Vallero D. A (2023). Air pollution calculations: quantifying pollutant formation, transport, transformation, fate and risks. *ScienceDirect Topics*. 163-190. www.sciencedirect.com Retrieved March 6, 2024