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Studies on drying rates of brined and spiced *Clarias gariepinus* (Catfish) using solar dryer

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The objective of this study was to determine the effect of brining and spicing with ginger or garlic on the drying rate of cat fish in a passive solar dryer. Samples of cat fish were solar dried under three different conditions: brine only, spiced with garlic and spiced with ginger. Their respective weight losses were used to determine the reduction in moisture contents. Graphs of drying rate versus time were plotted in each case and used to obtain the drying rate constant, k for the three drying conditions. This procedure is useful when a given level of moisture content must be linked to time of drying under similar conditions. The results obtained showed that cat fish dried using brine solution only is the best since its drying rate constant has the highest value of 0.375 units per day followed by ginger (0.273 units per day) and then garlic (0.254 units per day) is the least. The results also show that spicing with ginger and garlic reduce the drying rate of cat fish when dried in a passive solar dryer.

Key words: Comparative, drying, solar, rate, brine, ginger, garlic, fish.

INTRODUCTION

The importance of fish in Nigeria lies in its contribution to food and financial security. Fish provides a good source of readily digested high quality animal protein together with a high concentration of vitamins A and D, a significant source of phosphorous and iron, as well as high concentrations of calcium in the bones, (Choo and Williams, 2003). In addition, the annual fish harvest fluctuates seasonally, with periods of high and low supply. During the periods of high supply, a lot of fish is spoilt and wasted, while acute shortage and increased costs of fish are experienced in periods of low harvest. According to Orengoh and Kisumo (2007), 50% of total annual fish harvest goes to waste due to poor treatment, management and storage. Fish spoilage is due to three main factors: Activity of micro–organisms (bacteria, moulds and yeast), chemical deterioration due to enzymatic activity (break- down of oils and fats that is, rancidity), attack by insects (blowfly and beetle infestations) and vermin (UNIFEM, 1988; Ogunja et al., 1992). In order to reduce the wastage and spoilage of fish during periods of oversupply, and to enhance long storage, it is necessary to adopt appropriate as well as affordable processing and preservation techniques for fish especially in the artisanal fishermen‘s environment. Now that fish resources are frequently over-exploited there is increasing emphasis on up-grading post-harvest technologies (UNIFEM, 1988).

Dry salting, open-air sun drying, deep frying and smoking constitute the most common methods of fish processing and preservation for rural fishermen. The last two methods contribute to environmental degradation, since they use biomass, while smoking introduces cancer causing substances in fish flesh (Delgado et al., 2005). Drying of fish by sun or solar-dryers would offer alternative methods to smoking and deep frying dryers. Drying reduces or completely eliminates physiological,

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microbial and enzymatic degradation of biological materials such as fish (Shitanda and Wanjala, 2006). The disadvantages of open-air sun-drying of fish include destruction by birds, animals and man, contamination by excreta from birds and animals, soiling, fungal growth and mycotoxins, loss of nutrients, intensive labour and a large area requirement, while drying in solar dryers shields fish from agents of contamination and destruction and accelerates rate of drying. Several works have been reported on the development and evaluation of solar dryers to mitigate the limitations of open-air sun drying (Ojike et al., 2009; Ekechukwu and Norton, 1999; Muthuveerappan et al., 1985; Sadykov and Khairoddinov, 1982; Shaw, 1981). Solar drying combines the advantages of traditional open-air drying and industrial methods. This according to Whitefield (2000) requires low investment costs but yields high product quality. The use of solar drying systems by farmers is still unpopular in Nigeria.

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. While brining reduces the micro-organisms count on dry fish. Studies by Oliviera et al. (2006) and Graivier et al. (2006) indicated that high concentrations of salt used in osmotic dehydration are beyond the permissible levels for human consumption. Therefore, limiting the amount of salt used in brining, and subsequently dehydrating fish with a solar dryer would probably achieve a more stable and suitable dried fish product than carrying out separate osmotic dehydration or solar drying. Most a times brined fish are spiced with substances like ginger and garlic to add among other things flavour to the stored fish. The objective of this study is therefore to evaluate the effect of brine, ginger, and garlic solutions on the drying rate constant of cat fish when dried in a solar dryer. The contribution of this study will then be to discourage the use of smoking as a drying process for fish while replacing it with solar dryers which are more environmentally friendly in-addition to the effect of brining the dried fish.

MATERIALS AND METHODS

Description of the solar dryer system

A model of passive solar dryers developed at the National Centre for Energy Research and Development, University of Nigeria, Nsukka was used for this study. The solar dryer used was of natural convection type as shown in Figure 1a and b.

The brining process of fish

Cat fish was procured from a fishpond in University of Nigeria, Nsukka, then eviscerated, de-scaled and thoroughly washed, its heads removed, split open longitudinally and cut into small pieces of approximately 4 cm by 3 cm by 1 cm. Three pieces of fish were used to evaluate the initial moisture content of the fish by using MB 35 Halogen moisture meter. The remaining pieces, divided into three sets of samples, and were soaked in 50° brine solution for 12 h. Then a set was spiced with 2 g of grounded ginger and another spiced with 2 g of grounded garlic. Then a set was pickled in ginger solution and another in garlic solution. After brining and pickling, three pieces of fish from each treatment were used to determine the moisture content before solar drying. When all the three sets were placed in the solar dryer, the weight loss which was assumed to be only moisture loss was monitored periodically by weighing the samples until the weight was constant. The quantity of water removed during drying was determined by periodic weighing of the samples using the electronic balance, at one hour intervals for ten hours each day until the weight was constant. It was used to determine moisture content periodically. The ambient and chamber temperatures and relative humidity throughout the duration of the process were measured using Vaisala humidity and temperature indicator and I-BK precision thermocouple. These temperature and relative humidity instruments were placed just above the midpoint of the tray in the dryer. The data collected was used to plot graphs of moisture content and moisture ratio against drying time.

RESULTS AND DISCUSSION

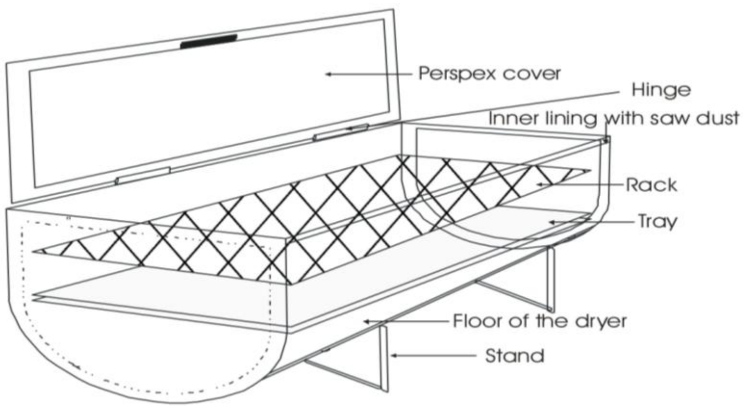
Figure 2 is the graphical representation of the hourly solar radiation and ambient temperatures of March, 17th to 21st 2010 which were the periods the study was done. In the graphs, Ta is the ambient temperature; the subscripts 1, 2, 3, 4, 5 represent 17th, 18th, 19th, 20th and 21st March, respectively; G is the solar radiation. The ambient temperature varies in sympathy with the solar radiation rising as the solar radiation reaches its peak. Then as the solar radiation decreases the ambient temperatures were still high till late evenings due to the cloudiness of the area which trapped the heat wave (Duffie and Beckman, 1991). It is observed that the hourly solar radiation is maximum between the hours of 12:00 and 14:00 when the sun is vertically overhead while lowest at early morning and late evening hours of the day, respectively.

The ambient and chamber temperatures throughout the duration of the process excluding night periods ranged between 26.6 to 31.7°C (ambient), and 30.3 to 48.5°C (solar dryer), with ambient temperature having the least values for all readings as shown in Figure 3a. The maximum relative humidity recorded were 88.5% (ambient), and 59.5% (solar dryer) with ambient relative humidity having the highest values for all readings as shown in Figure 3b.

At interval of one hour each sample was weighed and moisture content calculated from the weight loss. The average initial moisture content (wet basis) of the samples was 71.82% while the moisture content (wet basis) of the samples when they were dried were 43.63% (Garlic), 46.2% (Ginger) and 40.82% (Brine). The monthly average daily radiation for the month of November during which the study was done has been estimated to be 17.101 MJm-2day-1 for Nsukka (Agbo and Ezema, 2008).

Based on the Newton model of thin layer drying and

a



b

Figure 1. (a) Solar dryer (b). Cross-section of the dryer.

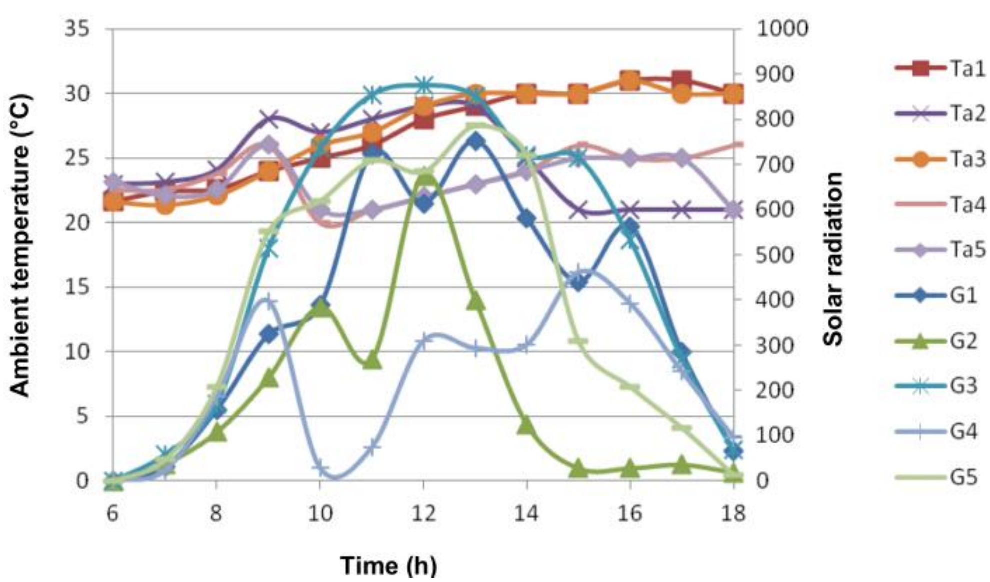


Figure 2. Graph of solar radiation and ambient temperature against time.

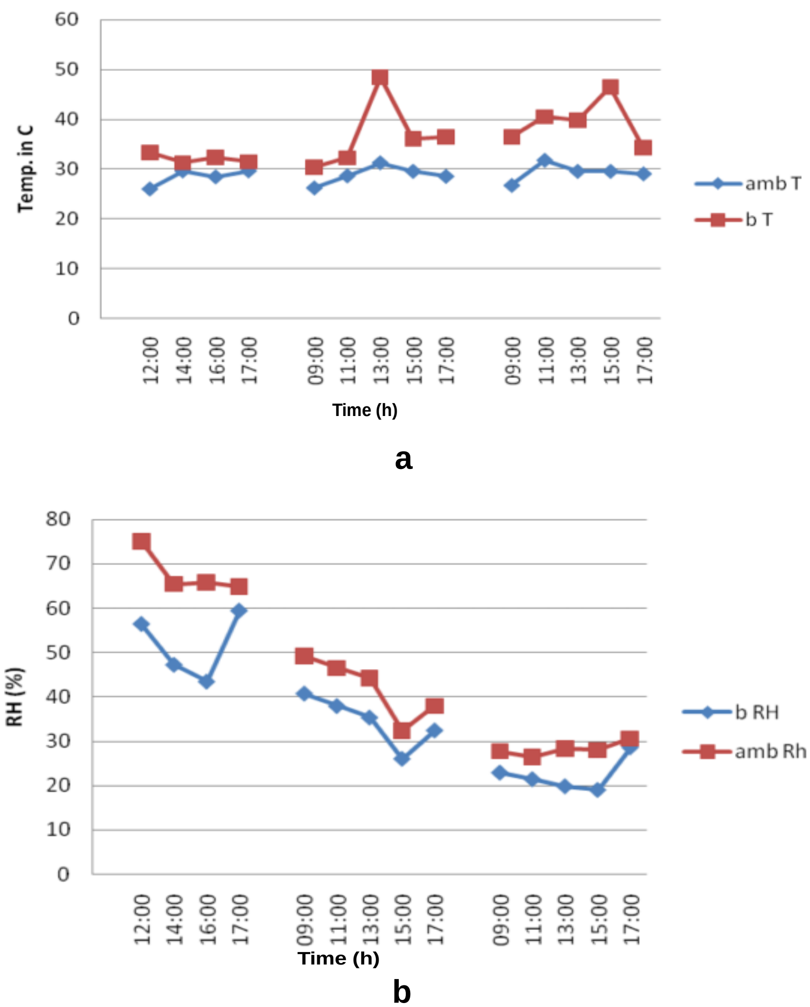


Figure 3. (a) Temperature (T) readings of the dryer and open-air system against time, (where b = dryer and amb = ambient). (b) Relative humidity (RH) of the dryer and open-air system against time.

observations by Kingsly et al. (2007) and Uluko et al. (2006) for material drying under varying relative humidity as in solar drying, the moisture ratio equation can be expressed as Equation 1, where MR is the moisture ratio (dimensionless), Mo is the initial moisture content (kg/kg, w.b), k is the drying rate constant (per day) and M = Moisture content dry basis (wb%) at the time t:

$$MR = \frac{M}{M_o} = e^{-kt} \quad (1)$$

$$Ln(\frac{M}{M_o}) = -kt \quad (2)$$

$$M = \frac{Initialweight - finalweight}{finalweight} \times 100 \quad (3)$$

Figure 4 relates the moisture content of catfish with drying time for different solutions (viz, brine, gingar, garlic). The figure shows that the drying process reduces with time. It is seen from the figure that within the first two days of drying that there was no significant difference among the moisture content for the solutions. However, from the third day the brined samples had the lowest moisture content for any given time.

Analysis of the graph Ln (M/M_o) against t (Appendix 1) indicates that the rate constant k (the slope of the graph) for the fish are 0.258 units per day (Garlic), 0.274 units per day (Ginger), 0.374 units per day (Brine). Using these values it is quite possible to link a given level of moisture content with a specified drying time. This could be achieved either graphically or analytically using Equation 2. It could be observed from the graph that only five days reading were used. This is because the fish for each drying method stopped losing significant moisture after the fifth day. Thus, only five days of drying were considered for achieving a linear slope. Furthermore,

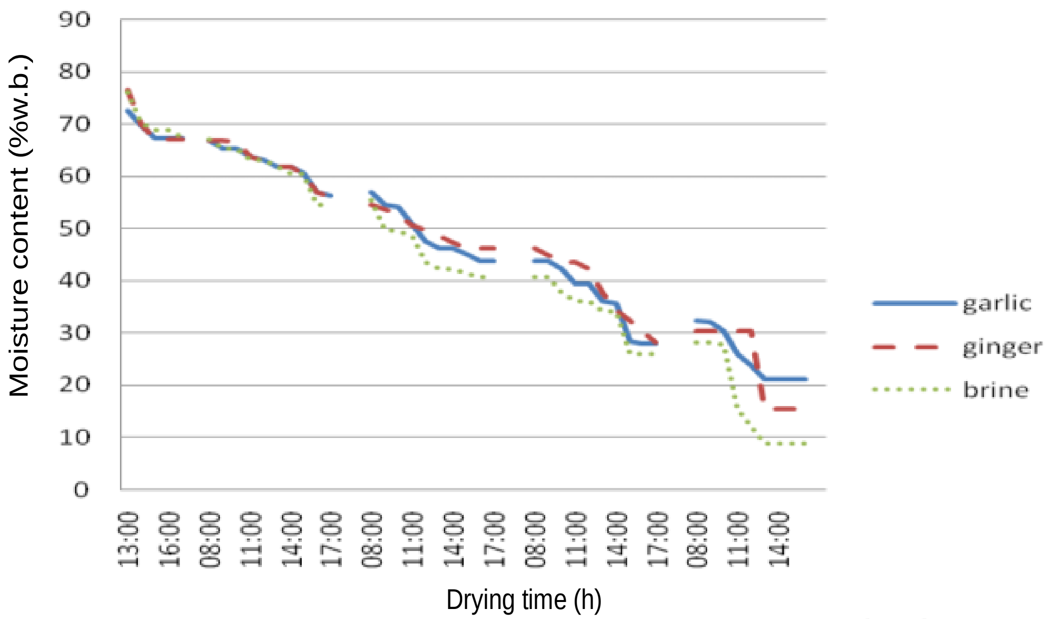


Figure 4. Moisture content (%w.b.) vs drying time (hours).

straight line graph was used because the equation used for the plotting of the graph is a linear one. The results of correlation of Ln (M/M_o) ratio and time (t) are as follows: 0.959 (Garlic), 0.927 (Ginger), 0.895 (Brine). Since the coefficient of determination (R^2) is high for all samples, there is a strong correlation between moisture ratio and time.

Conclusion

Samples of cat fish were dried in the selected solar dryer. Initial moisture contents were measured before and after treating the samples with preservation solutions (brine, ginger and garlic solutions) while loss in mass was monitored every hour of drying. As a result of this, the rate constants for the sample under different conditions were successfully determined graphically (Appendix 1). The results obtained showed that cat fish dried using brine solution is the best since its drying rate constant has the highest value of 0.374 units per day followed by ginger (0.274 units per day) and then garlic solution (0.258 units per day) is the least. Thus, pickling of cat fish with ginger and garlic after brining to add flavour to the fish actually reduces the drying rate of the fish. Equally, Chukwu and Shaba (2009) in comparing two drying methods (electric oven and smoking) for drying catfish concluded that electric oven is better in terms of shelf life; however, considering the fact that in most developing countries electric power supply is quite unstable and costly the use of solar dryer has proven to be a more acceptable option.

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APPENDIX 1. Graph Ln (M/M_o) against time for different solutions used in the study.