Journal of Researches in Agricultural Sciences Vol. 8

Journal of Researches in Agricultural Sciences

JRAS

Ekiti State University, Ado-Ekiti. Nigeria

Vol. 8(2), September 2020 pp 45-51

Drying Behaviour of Plantain Chips using Three Methods of Drying.

A. S. Oyerinde,

Dept. of Agric. Engineering, Federal University of Technology Akure, Nigeria.

Email: sooyerinde@futa.edu.ng

Abstract

Various studies have confirmed that in view of the time required for drying agricultural products to safe and suitable moisture content for storage, consumption and transportation, the forced convection solar dryer is time saving, effective, and user-friendly. With these benefits, drying is expected to enormously increase the quantities of agricultural produce ready for sale, storage and consumption, raise farmers' incomes and consequently improve their standards of living. The recent efforts to improve "sun-drying" have led to the development of "solar drying" methods which can preserve foods for long periods of time after harvesting and prevent spoilage or deterioration as much as possible. Thus, a comparative analysis of the performance of the solar dryer and sun-drying method is an important contribution to the storage aspects of agricultural mechanization. The solar dryer is able to raise the ambient air temperature to the high level needed to increase the drying rate of an agricultural produce. The moisture content of plantain of about 70% wet basis indicated by the drying rate was removed by an oven dryer at constant temperature of 105° C within 340 minutes and by the assisted solar dryer in 1440 minutes. During the forced convection mode, the air-assisted solar dryer temperature was higher than the sun-drying by a maximum of 6.3%. The variation in temperature affected other drying parameters like moisture content, relative humidity, drying rate, and equilibrium moisture content.

Keywords: Drying, plantain chips, dryers, temperature, relative humidity, thickness, moisture content, drying rate, time.

Cite as: Oyerinde ,A.S. (2020 Drying Behaviour of Plantain Chips using Three Methods of Drying. *Journal of Researches in Agricultural Sciences.* Vol. 8(2):45-51

Introduction

Drying was probably the first ever food preserving method used by man, even before cooking (Alamu *et al.*, 2010). It is a heat and mass transfer process resulting in the removal of water moisture, by evaporation from a solid, semi-solid or liquid to end in a solid state. The drying technique is probably the oldest and the most important method of food preservation practiced by humans. It could also be defined as using the appropriate methods and techniques under suitable conditions to bring a particular agricultural product to what is technically termed safe storage moisture content. It involves the removal of moisture from agricultural produce so as to provide a product that can be safely stored for longer period of time. During drying, excessive moisture removal can be achieved by dehydration when the moisture content is reduced below 6%. With cultural and industrial development, artificial mechanical drying came into practice, but this process is highly energy intensive and expensive which ultimately increases product cost.

Drying is an essential process in the preservation of agricultural products and during which many changes take place: structural and physico-chemical modifications affect the final product quality, and the quality aspects involved in dry conversion in relation to the quality of fresh products and applied drying techniques. Drying reduces the possibilities of the contamination by insects and microorganisms so that product is preserved. Various drying methods are employed to dry different agricultural products. Each method has its own advantages and limitations such that choosing the right drying method is important in the process of drying agricultural products. There must be studies to compare traditional drying and other drying methods for the reduction of the drying time and significant improvement of the product quality in terms of color texture and taste. Recently, efforts to improve "sun-drying" have led to "solar drying" to remove the physically-held water to obtain dried products whose increasing popularity is due to longer shelf-life, product diversity and substantial volume reduction, and improvements in product quality and process applications (Akinola *et al.*, 2006)

Plantain *(Musa paradisiaca)* is an important staple food in Central and West Africa, which along with bananas provide 60 million people with 25% of their calories. Over 2.11 million metric tons of plantains are produced in Nigeria annually (FAO, 2006). The chemical composition of plantain varies with the variety, maturity, degree of ripeness and where it is grown (soil type). The water content in the green plantain finger is about 61% and increases on ripening to about 68%. The increase in water is presumably due to the breakdown of carbohydrates during respiration. The green plantain contains 21-26% starch which is mainly amylose and amylopectin and this is replaced by sucrose, fructose, and glucose during the ripening stage due to the hydrolysis of the starch (Marriott *et al.*, 1981). Thus, the ripe banana is very perishable and subject to fast deterioration after harvesting. Air-drying alone or together with solar or sun drying is largely used for preserving it. Besides the preservation, drying adds value to banana. Banana chip is one such value-added products with a crispy and unique taste consumed as a snack food and an ingredient in breakfast cereals. It can be consumed as produced or further processed by coating with sweeteners, frying in oil, etc. (Herrmann, 1997).

The solar dryer can be regarded as one of the solutions to the world's food and energy crises. With drying, most agricultural produce are preserved and this can be achieved more efficiently through the use of solar dryers. The aim of this work is to determine the effect of drying methods on plantain chips.

Methodology

A bunch of unblemished mature green plantain was purchased from the market in Ilara-Mokin, Ondo state. The fingers were removed and washed in clean water to remove dirt and surface micro-organisms, and peeled directly in water containing a solution of anti-browning agent (1 teaspoon full of sodium metabisulphite in a bowl of water). A small plantain slicer is used to slice the peeled plantain to 4-, 6- and 8-mm thick slices. A digital Vernier caliper was used to measure the accuracy of the thickness of the sliced plantain. The plantain slices were drained, put inside different plastic trays according to the thickness and weighed. The weight of the plastic tray was obtained before putting the plantain in the tray. The air temperature and the relative humidity were also monitored.

The sliced plantain was arranged on the drying net inside the solar dryer, and drying commences. At the end of drying, the colour of the end product changes as shown in Plate 1. After 60 minutes, the 4-, 6- and 8-mm plantain slices under sun drying, air assisted solar drying and oven drying were re-weighed to obtain moisture loss. The drying rate at each time was calculated as shown in equation 1 and 2.

$$\frac{w_0 - w_f}{t} \qquad 1$$

The moisture content at the initial stage as well as at each point of measurement was also calculated using the expression:

$$MC_{wb} = \frac{w_o - w_f}{w_0} \times 100 \qquad 2$$

Where

w_0 = the initial weight of plantain (g)
w_f = the final weight of plantain (g)

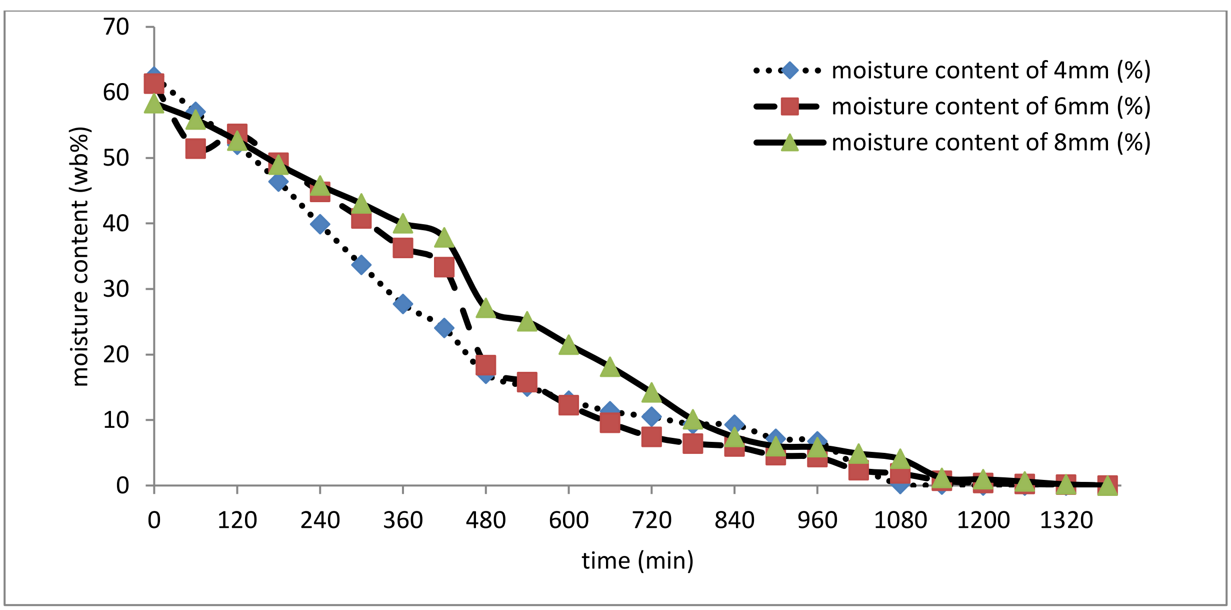
t = time of drying (s)
MC_{wb} = moisture content wet basis (%)

Plate 1: Plantain chips dried with Oven (A), Solar (B) and Sun drying (C).

Results and Discussion

Moisture Content

The moisture contents a and the drying curves against time for 4-, 6- and 8-mm plantain slices using solar drying, sun drying and oven drying are shown in Fig. 1 to 3. In all the three dryers (solar, sun and oven), the 8 mm chips had the highest moisture contents probably because of the thickness of the slices. It took about 15 h 30 min (990 min) for the 4 mm chips to reach 5% mc, the 6 mm chips took 14 h 40 min (880 min) and the 8 mm chips took about 17 h (1010 min) for direct sun drying whereas the assisted solar dryer took 11 h 30 min (690 min), 18 h (1080 min) and 19 h (1140 min) for the 4-, 6- and 8-mm chips to reach 5% mc, respectively



.

Fig. 1: Moisture content with drying time for chips in solar dryer

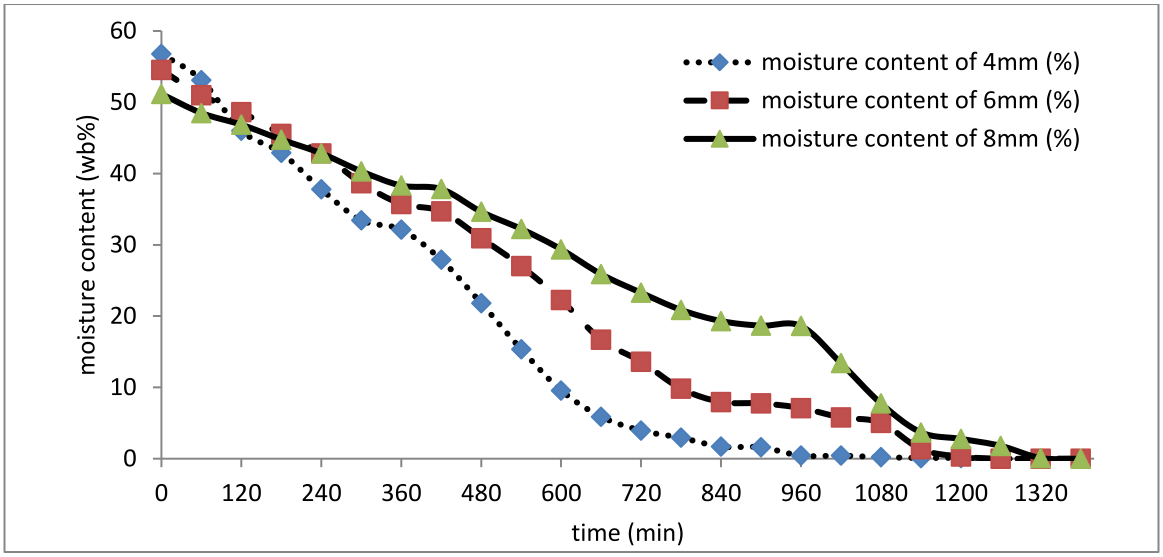


Fig. 2: Moisture content with time for chips during sun drying

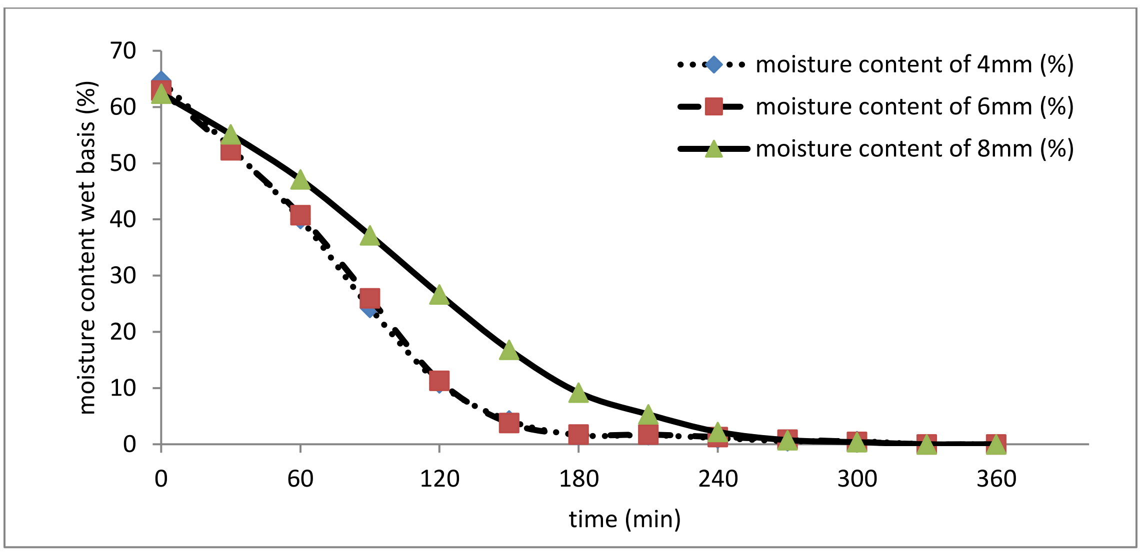


Fig. 3: Moisture content with time of drying for chips during oven drying

During oven drying, the temperature was high and it took a lesser time to remove the moisture from the chips being 2 h for 4- and 6-mm slices and 3 h 30 min for the 8 mm thick slices. In all, the thicker the chips, the longer time it took to remove the moisture and hence the longer the drying time.

Drying Rate and Time

The drying rate curves are shown for oven drying, solar drying and sun drying in Fig. 4-6. The entire drying processes were characterized by falling drying rates and did not show any visible constant drying rate. The critical moisture content was 59% and this was attained shortly at the beginning of the drying process such that no constant rate was observed for all the chip sizes. A similar result was obtained by Nguyen and Price (2007). Most of the drying happened in the falling rate period which is the second phase of drying. An increase in temperature at a time makes the drying rate curve to go up which is more significant in 8 mm slices because of the higher moisture present (Fig. 4 and 5). Togrul and Pehlivan (2004) had observed that there was no constant rate during the sun-drying of grape and plum with all the drying taking place by moisture diffusion in the falling rate.

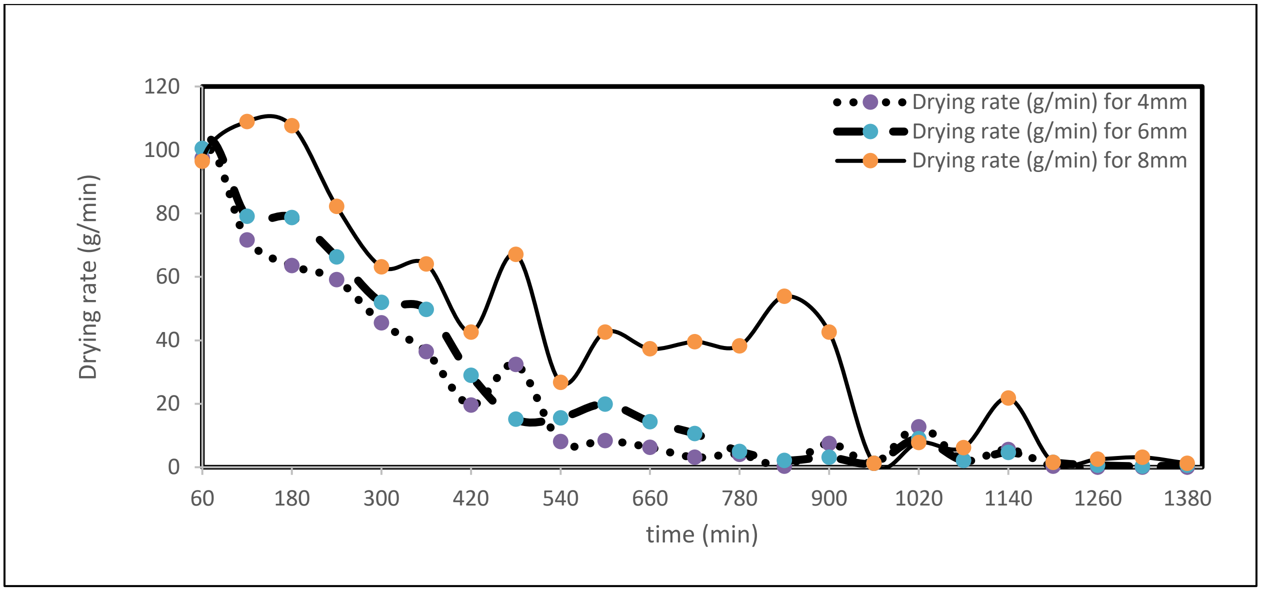


Fig. 4: Drying rate of plantain slices with time in the solar dryer

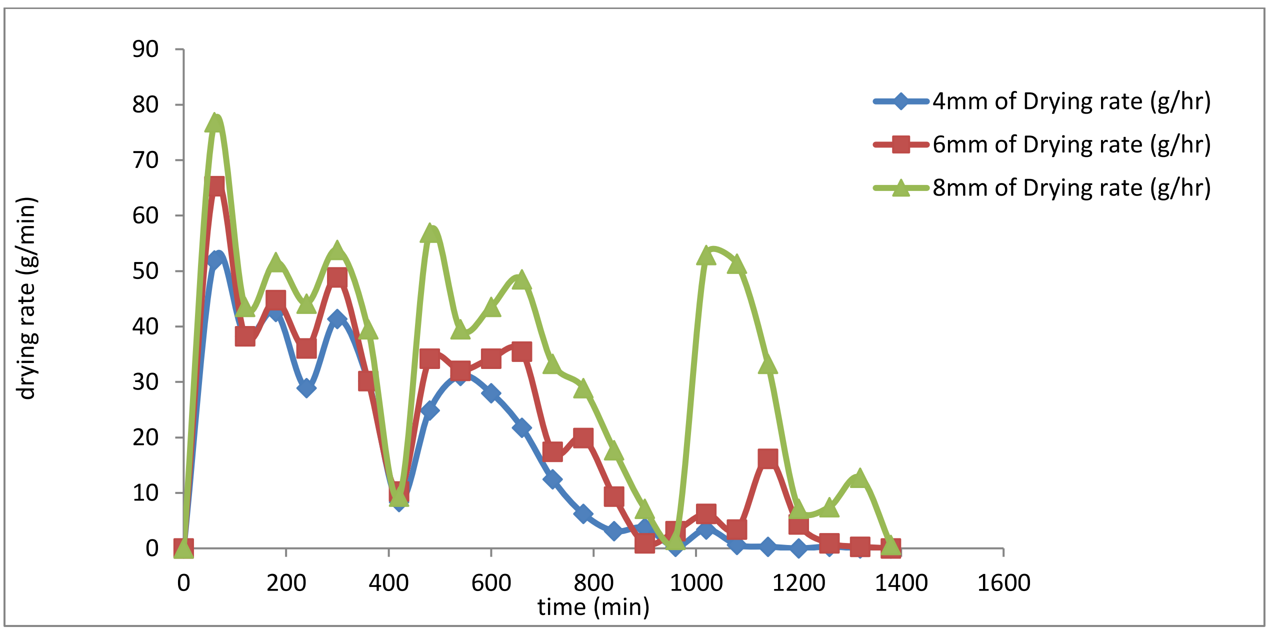


Fig. 5: Drying rate of plantain slices with time for sun drying

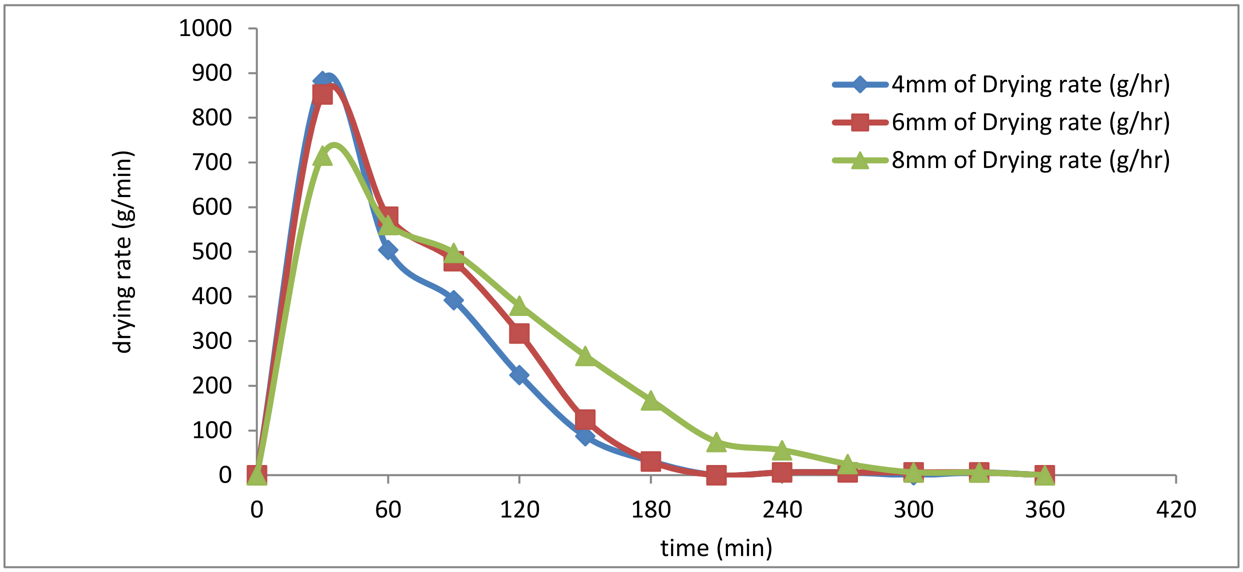


Fig. 6: Drying rate of plantain slices with time for oven drying

Table 1: The relationship between the Oven drying, Air-assisted solar dryer and sun drying

Parameters	Air-assisted solar drying	Sun drying	Oven drying
Average temp (°C)	33.85	31.72	105
Initial moisture content, % wb	62.40	66.78	64.65
Critical moisture content, %wb	59	59	59
E.M.C (%)	5	5	5
Colour of dried product	Creamy	Light brown	Brown
Time of drying (h)	14	18	4-6

The temperatures of the sun-drying and solar dryer were similar thus, the nearness in their final drying time. Since the temperature of the oven is higher at 105°C, the drying time significantly reduced from 188 h to 4 h. Also, the product colour changes with drying modes from creamy to dark brown when oxidation and browning process occurs. Demirel and Turhan (2003) reported that any temperature above 60°C can cause browning except when the sample is blanched before drying, a situation that helps preserved the dried samples. It has been clearly shown from the results of the experiments that during drying at different temperatures and size configurations, moisture is removed from the chips according to their size ranges, the smaller the better. It was also shown that the plantain chips dried mainly at the falling rate period with little or no constant rate noticed as reported by Satimehin *et al.* (2010). It is noteworthy that the solar dryer will perform more efficiently if after loading, the drying chamber door is permanently closed for days without unloading the agricultural materials at intervals to weigh them.

Conclusion

From the test carried out, the following conclusions are made:

1. The solar dryer can raise the ambient air temperature to a considerable high value for increased the drying rate of agricultural crop.
2. The drying rate revealed the moisture content of plantain of about 70% wet basis.
3. The oven dryer at constant temperature of 105°C removed moisture within 340 minutes and it took the assisted solar dryer 1440 minutes to remove the same moisture.
4. During forced convection mode, the air assisted solar dryer temperature was higher than the sun drying by a maximum of 6.3%.

5. The hourly variation of the temperatures inside the solar dryer cabinet was higher than the ambient temperature during the most hours of the day.
6. The variation in temperature affected the drying parameters: moisture content, relative humidity, drying rate and equilibrium moisture content.

The dried product in the air assisted solar dryer is neat and free from dirt while the conventional air-drying is brown because of the exposure to ambient air. This system can be successfully implemented for industrial production because it minimized the problem of exposure to rain and pests (insects, human beings and animals).

References

Akinola, O.A., Akinyemi, A.A., and Bolaji, B.O. (2006). Evaluation of traditional and solar fish drying systems towards enhancing fish storage and preservation in Nigeria. *Journal of Fishery International, Pakistan* 1(3-4): 44-49.

Alamu, O.J., Nwaokocha, C.N. and Adunola, O. (2010). Design and construction of a domestic passive solar food dryer. *Leonardo Journal of Sciences.* Vol 7. :71-82.

Demirel, D. and Turhan, M. (2003). Air drying behaviour of Dwarf Cavedish and Gros Michel banana slices. *Journal of Food Engineering* 59: 1-11.

FAO, (2016). *The State of Food and Agriculture: Food Aid for Food Security?* Food and Agriculture Organization of the United Nations, Rome. 183 pp.

Herrmann, G. (1997). Adding value to bananas. *Food Chain* 21, ITDG, 20 pp.

Marriott J., M. Robinson and S.K. Karikari (1981). Starch and sugar transformations during ripening of plantains and bananas. *Journal of Science Food and Agriculture.* 32: 1021-1026.

Nguyen, M.H. and Price, W.E. (2007). Air drying of banana: Influence of experimental parameters, slab thickness, banana maturity and harvest season. *Journal of Food Engineering* 79: 200-207.

Satimehin, A.A., Alakali, J.S. and Alabi, O.T. (2010). Thin layer drying characteristics of plantain chips. *Journal of Tropical Agriculture, Food Environment and Extension* 9(1):31-37.

Togrul, I.T. and Pehlivan, D. (2004). Modelling of thin layer drying kinetics of some fruits under open sun drying process. *Journal of Food Engineering* 65: 413-425