Cassava Sun Drying Performance on Various Surfaces and Drying Bed Depths

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Abstract

Processing of cassava (Manihot esculenta Crantz) to obtain flour is faced with a lot of technical constraints including inefficient drying. The traditional sun drying method is very inefficient as the product can take 2-3 days to dry. Mould growth and other problems such as contamination of the product are likely and therefore necessitate intervention. Among the interventions was sun drying on a platform raised 1 m above ground in comparison with drying in a direct box solar dryer; by using trays with various bottom surfaces. The experiments were done using kiroba cassava variety obtained from the University farm, which was peeled and sliced into thin chips (2-3 mm) then sun dried on wire mesh, black polythene, white polythene and woven mat for three days. The material was dried for 8 hours daily after which it was kept indoors overnight. The surface with highest sun drying performance was wire mesh while white polythene was the least. The 10 mm bed depth attained constant weight in just about six hours of drying while for 20 and 30 mm bed depth it was about 16 hours and 40 mm bed depth for about 24 hours. There was moisture adsorption which was at 10, 22 and 28 hours for the 10 mm bed depth, 10, 20, 26 and 28 hours for 20 and 30 mm bed depths, and 28 hours for the 40 mm bed depth. The time 0,10 and 20 hours marked the beginning of drying whereas 8, 18 and 28 hours marked the end of drying. The best performance was therefore obtained on wire mesh and 10 mm bed depth and recommended for sun drying of cassava. However; there is need to investigate on whether there is significant quality difference between cassava sun dried at different bed depths investigated in this study.

Key words: drying characteristics, weight loss, ambient air temperature, perforated surface, cassava drying, sun drying, fermentation

Introduction

Cassava (Manihot esculenta Crantz) is a relatively neglected tropical root crop rich in carbohydrates. It is a major staple in several countries of Sub-Saharan Africa, Latin America, and Asia. Of all the root crops, cassava is the most important in Africa (FAO STAT, 2000). Besides its direct use as food, cassava is also used as a livestock feed and as a raw material in the production of starch, tapioca and snack foods (Pardales, 2002). Its genetic potential is large and untapped, and adoption of improved technologies could make cheaper calories available per hectare (Grace, 1977).

A number of factors influence the demand of cassava as food. These include degree of urbanization, level of income, price of cassava compared to alternative foods, historical food habits, ability to store and process, and form in which it is processed. Other factors which constrain the demand and utilization of cassava are the toxicity, perishability and bulkiness of fresh roots. Most of these factors can be mitigated through use of appropriate processing technologies. Processing cassava into dry products is the easiest and cheapest method to reduce toxic substances, prolong its shelf life, and reduce its bulkiness. Traditional processing methods that include detoxification by solid-state fermentation and soaking followed by drying exist but in most cases they suffer from a number of problems such as lack of proper hygiene, inefficient drying, and poor

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storage facilities. Processing through size reduction and drying is also a traditional processing method but in some localities it has been blamed for causing toxicity based malfunctions to humans, attributed to inadequate processing. Improving the processing technologies will overcome the twin problems of perishability and toxicity, thus increasing availability and use of cassava in rural and urban areas (Sarma and Darunee, 2001).

Most of solid food materials require drying at some stage in their production and processing. Dried foods keep well because the moisture content is low such that spoilage micro' organisms cannot grow (Charlotte, 1994). Also, dried foods have the advantage of taking a very little space, not requiring refrigeration, and providing variety to the diet (USDA, 1977). There are a number of ways which can be used to dry cassava. These include use of artificial driers using different sources of energy such as fossil fuels, coal, fire wood, electricity, and solar radiation in the form of solar drying and direct sun drying. With the present high costs of the conventional fuels and expected increase over time, in addition to environmental degradation and technical and managerial skills required to operate these driers, the use of sun drying has been adopted as the most viable alternative.

Sun drying is the process of drying the food by direct exposure to the sun and by doing so the evaporation of water from the product occurs, assisted by movement of surrounding air (Charlotte, 1994). The method is cheap and relatively simple but uncontrollable due to variability on weather conditions. In order to be more successful and producing products of high quality this process demands a dry season of bright sunshine and a product temperature above 36°C. However, this temperature is not constant for all products, as it varies depending on the type of the product. Sun drying is relatively slow because the absorbed solar radiation does not cause rapid evaporation of moisture from the product compared to other techniques of drying (Charlotte, 1994). It also needs a lot of attention and considerable care in the sense that the product must be protected against pests and contamination. Also it must be sheltered or kept indoors during night time or when it rains. Wind and dust act as sources of contamination to the product while rain may spoil the product and high relative humidity affects the rate of drying by reducing the evaporation of moisture from the product (Kizza, 2006). Also, it should be noted that the thinner the drying bed depth of the materials being dried the higher the drying rate and vice versa (Kajuna, *et. al.,* 2001).

In order to reduce or eliminate the problems encountered in sun drying, such as lack of hygiene, inefficient energy utilization, localized heating and inferior product quality, solar drying has recently gained popularity over direct sun drying (Charlotte, 1994). However, this method is relatively expensive and is more practical when used to dry lesser bulky and higher value crops. Despite its problems, the technical simplicity and cheapness, direct sun drying is the dependable drying method widely practiced by the poor households. Being the dependable method at small and medium scale levels, sun drying requires low cost improvement, at least in increasing the drying rate and minimizing the risk of contamination. Therefore, the major aim of this study was to find out ways by which to improve the efficiency of sun drying of cassava chips. Specifically, it aimed at comparing sun drying performance of cassava chips on various surfaces and different drying bed depths and finally select and recommend the most efficient drying surface and drying bed depth for sun drying of cassava.

Materials and methods

This study was carried out at Sokoine University of Agriculture, in the Department of Agricultural Engineering and Land Planning. Its geographical location is roughly at 6.82°S; 37.660E (www.silobreaker.corn). Fresh cassava roots (Kiroba variety) were harvested from the University farm, washed, peeled, and sliced into thin chips (2-3mm) using a cassava chipping machine. The chips were dried in trays measuring 500mm x 500mm x 50mm lined with different bottom materials, which included wire mesh, black polythene, white polythene, and woven mat obtained locally. The sides of the trays were made of dry softwood timber. In comparison, solar drying in two cabinet solar driers was also conducted to bring about provision of covered environment. This involved use of a wire mesh bottom tray in the first cabinet solar dryer with perforated base and white polythene bottom tray in the second cabinet solar dryer with a solid base.

In order to determine the effect of the drying surfaces, four different empty trays were weighed, placed on a lm high slated platform made of wooden posts and reeds. On the trays, material loading of 1.5, 3.0, 4.5 and 6 kgs were dried. These material loadings approximately corresponded to bed depths of 10, 20, 30, and 40 mm respectively. Each loading was dried on its own day, and weight loss measurements were taken in three hour intervals by using a digital balance (Ohaus Corporation type). The same applied to the wire mesh tray and white polythene tray in the perforated solar dryer and solid base solar drier, respectively. Daily Mean Insolation in W/m2 was measured using solar radiation meter (Dystar Inc.) and daily mean ambient air temperature was measured using thermocouple (OAKTON, type K). The experiments were replicated three times. After every reading the drying material was turned to ensure uniform drying.

In order to determine the effect of depth the experiment was repeated using the wire mesh tray In order to determine the effect of depth the experiment was repeated using the wire mesh tray with chips spread at 10, 20, 30 and 40 mm bed depths in three parallel replicates. The wire mesh tray was adopted due to the observed drying efficiency over other tray types. Sun drying was performed, starting from 9.00 am in the morning to 5.00 pm in the evening, after which the trays and their contents were removed and kept indoors till the next morning. The sun drying experiments were continued for three days. The same response variable (i.e. weight loss) and weather elements (i.e. mean insolation and ambient air temperature) were measured. After every reading the drying material was also turned to ensure uniform drying.

The weight loss data with drying time were plotted as a means of assessing the relative performance of the experimented sun drying systems. The assessment was validated by Microsoft Excel Data Analysis statistical package (MS Office, 2007).

Results and discussion

The results of effect of drying surface on drying rate of cassava chips are shown in Figures 1 to 4. For the direct sun dried samples of cassava chips, the wire mesh tray showed the highest drying performance followed by the woven mat surface while the black and white polythene surfaces gave the lowest drying performance. This can be explained by the fact that in the case of the wire mesh drying surface ambient air was able to pass both across the top surface of the sample and upwards from below the tray through the material being dried, thus allowing fast removal of moisture from the sample. This phenomenon is also substantiated in Silayo (1995) in the case of sun drying of grains. For the case of the woven mat surface, drying air was also able to pass across the top of the sample and also through the sample from below the tray, but in this case at a reduced rate due to the fact that the pores on the woven mat are smaller compared to those of wire mesh, and hence the reduced drying performance. On the other hand, both black and white polythene surfaces did not allow any passage of ambient air through the bottom of the trays, thus leading to low drying performance. With respect to solar cabinet drying or in other words sun drying in a covered environment almost similar pattern was observed, with the white polythene tray giving the lowest drying performance while the wire mesh tray gave the highest performance.

As the sample bed depth on the drying trays was increased from 10 to 20, 30, and 40 mm bed depth the difference in drying performance between the treatments (wire mesh, woven mat, black polythene, and white polythene) became smaller. This was particularly so in drying trays with perforated drying surfaces (wire mesh and woven mat trays). This could be explained by the fact that, as the sample bed depth increased, the void space allowing now of air from the bottom through the sample were reduced hence the reduced performance.

The effect of sample bed depth for samples dried on wire mesh tray and subjected to same weather conditions is shown in Fig. 5. The 10 mm bed depth gave the highest drying performance, while the 40 mm depth gave the lowest drying performance. Analysis of variance showed that there was a significant difference in drying performance (a =

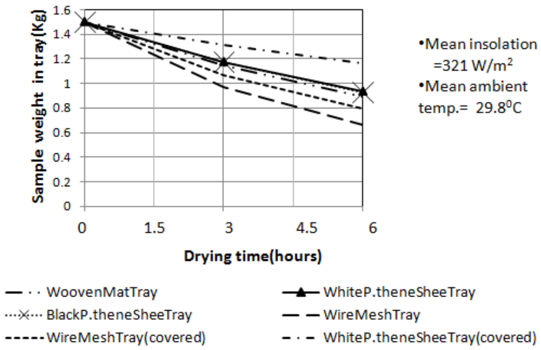

Figure 1: Sample weight in tray versus drying time for samples corresponding to 10mm bed depth

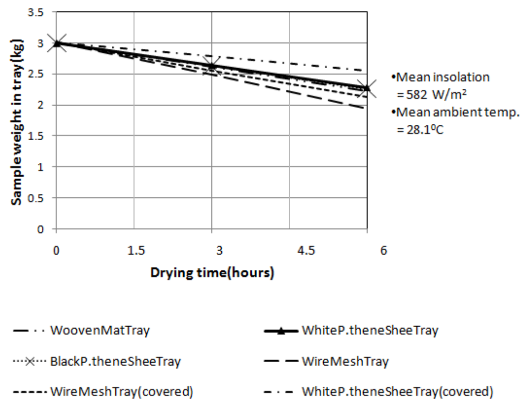

Figure 2: Sample weight in tray versus drying time for samples corresponding to 20mm bed depth

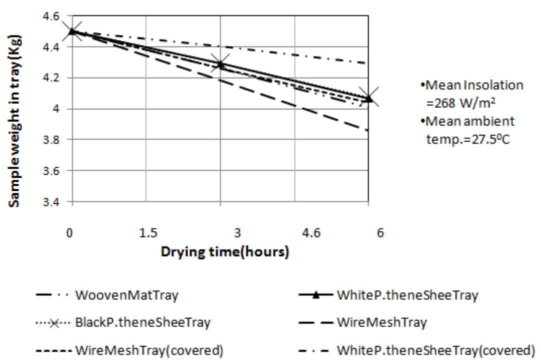

Figure 3: Sample weight in tray versus drying time for samples corresponding to 30mm bed depth

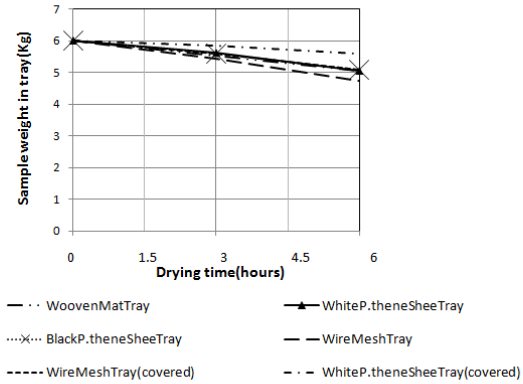

Figure 4: Sample weight in tray versus drying time for samples corresponding to 40mm bed depth

0.05) between trays at different drying depths.

Regarding drying characteristics curves of cassava chips in drying trays, the 10 mm bed depth tray attained constant weight after 6 hours of drying while the trays loaded with 20 mm and 30 mm bed depth attained constant weight after 18 hours of drying. The 40mm bed depth tray attained constant weight after 24 hours of drying. Adsorption behavior was noted in the drying characteristics curves. The 10mm bed depth tray exhibited moisture adsorption trend at 10, 22 and 28 hours of exposure to sun drying while both 20 and 30 mm bed depth trays showed moisture adsorption after 10, 20, 26 and 28 hours of sun drying. The 40 mm bed depth tray showed moisture adsorption at 28 hours. Note that at 0, 10, 20 hours and 8, 18, and 28 hours shown in drying characteristics curves marks the beginning and end of experiments respectively for all consecutive three days.

Conclusion and recommendations

Conclusion

The drying of cassava chips on uncovered wire mesh tray gave the highest drying performance compared to all other drying surfaces tested in this study. This was due to the fact that there was easy access of drying air to large part of the sample being dried, hence the increased drying efficiency. The black and white polythene surface trays showed more or less similar drying performance due to the fact that the

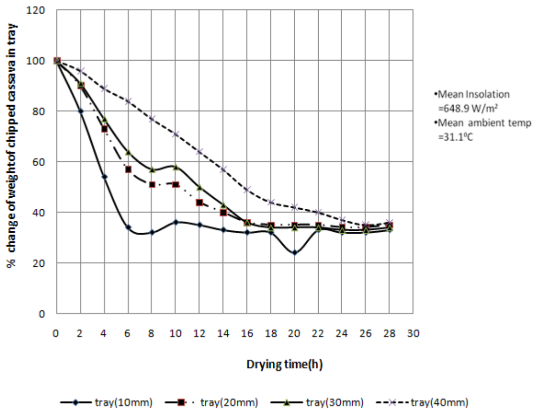

Figure 5: % change of weight of chipped cassava in tray versus drying time for different drying depths at same weather conditions

surface colour was shielded from the sun radiation by the sample so the effect of colour on heat absorption could not be exploited here. The woven mat surface showed higher performance than the black and white polythene covered surfaces due to the fact that its pores although smaller than those of wire mesh, were able to allow some air to pass through and facilitate the removal of moisture from the cassava chips and hence the higher drying performance.

In the case of drying bed depth, the 10mm drying bed depth performed better compared to all other drying depths. This complies with the theory that the thinner the drying bed depth of the materials being dried the higher the drying rate and vice versa.

Recommendations

For fast sun drying of cassava chips the use of perforated surface such as wire mesh tray or a woven mat on a platform raised off the ground to allow free passage ofthe drying air both at the top and from the bottom surface through the sample is recommended. Also drying bed depth of 10 mm should be used for fast drying of cassava chips. However, there is need to investigate on whether there is significant quality difference between cassava sun dried at different bed depths investigated in this study.

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