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THIN - LAYER DRYING CHARACTERISTICS OF CASSAVA (*MANIHOT ESCULENTUS*)

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ABSTRACT

This paper describes an experimental investigation of thin-layer drying characteristics of cassava for a two-day period vis-à-vis a flat-plate dryer, rock-bed dryer and the traditional open air drying layouts respectively. The experiments were carried out at Sokoto Energy Research Centre (SERC) sunshine hours of diffuse insulation ranging from 240.6 to 977.9 W/m², relative humidity ranging from 36.9 to 82.0%, ambient temperature ranging fro 35.6 to 66.7°C and 35.4 to 69.3°C respectively. The experiments started at 8:00 pm to end at 5:00 pm local time on each day of two days of exposure conditions. Microbial tests revealed neither fungi nor bacterial attacks. Proximate analysis of the dried cassava showed that initial moisture content of the dried samples range between 5.0 to 5.5% contents, ash content ranging between 1.0 to 3.5% contents, fat ranging between 2.0 to 7.0%, crude fiber ranging from 1.4 to 4.4%, crude protein ranging 2.36 to 5.53% and carbohydrate ranging from 84.34 to 88.24% while the fresh samples consisted of ranging from 59.0 to 66.0%.

Key words:- *Thin-layer drying, Cassava, Manihot esculentus*

INTRODUCTION

In most developing countries there is an increased emphasis on rural development which undoubtedly requires an increase in energy demands in the rural areas. Food processing and preservation by drying and storage could be achieved by using solar dryers. the use of solar dryers for drying agricultural produce in both urban and rural areas is of significant importance and economic value in the sense that only non- depletable energy sources such solar and wind are being utilized. Unlike the traditional open air drying system the use of solar dryers is far more hygienic and free from vandalisation by children and contamination by insects and microorganisms (Garba *et al.*, 1990).

There are three main recognized ways of producing energy directly from the sun in most parts of the world including Nigeria. The first two methods are described as passive

and active respectively, absorb the heat and store it be used; for instance for space and water heating. The third method converts sunlight to electricity using photo-voltaic (PV) cells, a method which is flexible since electricity can be converted and used in many ways. Additionally, there are other methods for producing energy from sun's direct rays (e.g. the production of hydrogen from water which are more applicable to warmer regions).

However in our changeable climate the sun's intensity varies from moment to moment, and from season to season. This implies a need for storage and for it to be used in conjunction with other energy, so that the necessary supply rate can be evened out. In addition to that, solar energy certainly seems to be a practical possibility in the Nigerian context. Although the suppliers of photo-voltaic (PV) solar panels claim that the costs are already low, we have to be convicted. Nevertheless, as with some other forms of alternative, costs are falling and the technology is becoming more efficient at a steady rate so we are very optimistic, indeed excited, that solar energy could be at the forefront in meeting the Kyoto ideals, and may be more than that (http://www.organicdownunder.com/solar dryer.html). The range of application is enormous from micro generation to major energy production although we have to say that the emphasis is still on potential rather than commercially realizable.

Finally, with respect to other countries where there is continuous abundance of sun then there is real potential for renewable energy production on a truly major, commercial scale. Research on solar drying had resulted in the development of a prototype known as green house effect (GHE) solar dryer. The new prototype was found to far less expensive than the conventional solar dryer using solar heat collection, since the function and solar components have been integrated in the transparent structure. Several types of drying bins have tested namely ,the stationary rectangular bin, vibrating racks and cylindrical bin with mechanical stirrer. If such system can be applied in the eastern part of the country where solar radiation is high and available almost all year round, it can help the farmer in processing their product and stored for longer periods.

Surely, the greenhouse effect is important for without it the earth would not be warm enough for humans to live on it. But if the GHE effect becomes stronger, it could lead the Earth be warmer than usual. Even a little extra warming may cause problems for humans, plants and animals (Kamaruddin,1998).Dehydration of vegetables and other food crops by traditional methods of open air drying is not satisfactory because the product deteriorates rapidly. In addition, traditional method does not protect the produce from contamination by dirt, debris, insects and germs. Listed below are the objectives of this study ie. A suitable thin-layer drying curve equation which fits the data and

i. To apply appropriate GHE dryer technology to help the people in the rural areas to increase added value of their farm products, thereby leading to improvement in their economic conditions.

ii. To compare open-air drying with and without blanching with the GHE-dryer technology.

iii. To attain sustainable development through the utilization of our local materials in the construction of solar dryers.

iv. To make recommendations for the most efficient to the local environment.

MATERIALS AND METHODS

Materials

The experiment consisted of five samples of fresh cassava slices of mass 1kg each (Salahudden and Mustapha, 2006). Each sample comprised of cassava slices of approximate size of 2cm x 2cm x 0.5cm.The drying system consisted of two GHE type solar dryers viz: flat plate absorber dryer and rock bed absorber solar dryers described by (Garba *et al.*, 1997) as shown in Fig. 1 and Fig. 2 respectively. The third and fourth samples were dried in the open air of which one of was blanched into 100°C hot water for 6 minutes. The sample that was not blanched or OA however was allowed to dry at the mercy of the ambient environment. The experiment was carried out for a two-day period viz: between 17th to 18th October, 2006 at SERC. The fifth sample consisted of a fresh cassava sample as a control on the various dried produce (first four samples) in comparing the nutritional values from proximate analysis and microbial growth.

During the drying test three categories of data were recorded viz :meteorological parameters,(wind speed, diffuse radiation, ambient temperature and relative humidity),dryers'

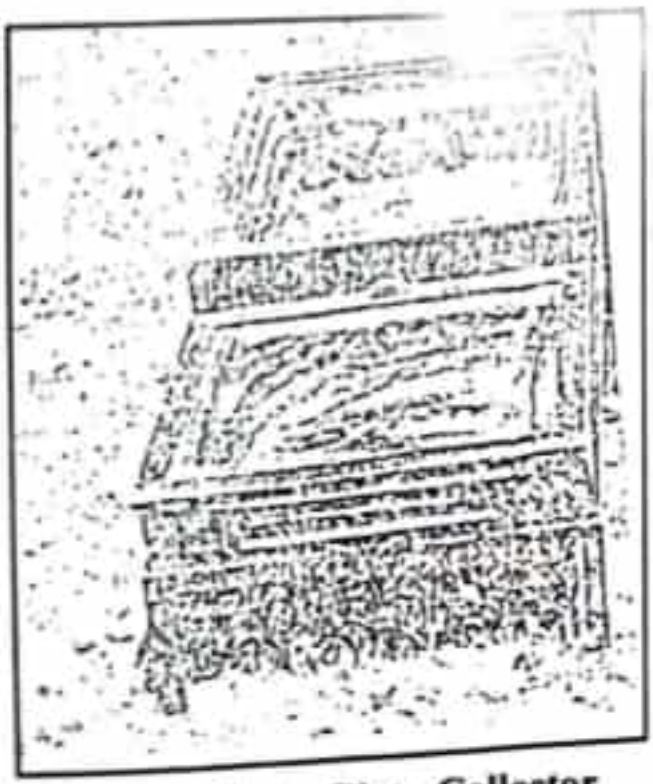

Fig. 1 : Flat - Plate Collector Solar dryer

Fig. 2 : Rock bed Collector Solar dryer

inlet and outlet temperatures, glass cover temperature ,drying chamber temperature and weight of each cassava samples along the course of drying on hourly basis. The wind speed was recorded using an electronic wind speed meter, the diffuse insolation was taken using a pyranometer model No:ML-020Vm with a sensitivity of 7.69μV/Wm^{-2}, temperature was taken using a digital multimeter fitted with an inbuilt thermocouple thermometer of K-type probe while the relative humidity was taken using a four-speed hygrothermograph. Weight of cassava samples was taken using a 5.0- 500.0g spring balance. Time was recorded using a stopwatch.

METHOD

With the setup described above, the drying experiment started on 17th October 2006 at 11:30 am. After recording the first data set at 11:30 am, another set of data was recorded at 12:00 noon. The drying data went on being recorded on hourly basis up to 5:00 pm in the evening, when we closed to start up at 8:00 am the following day. This exercise went on until there was no further moisture loss of the produce.

ESTIMATION OF DRYNESS

Prior to attaining the dryness of the cassava samples, the instantaneous percent initial mass M(t) on hourly basis was obtained using equation 1 below:

$$M(t) = \frac{Recorded\ mass\ (Kg) \times 100\%}{1Kg} \quad \text{---------- (1)}$$

The dry mass was obtained using the argument in equation 1.

MATERIALS AND METHOD FOR MICROBIAL TEST

Four dried samples viz: flat plate(FP), rock bed (RB),open air(OA) and open air blanched (OA_{bl}) as well as one fresh sample(FS) were analyzed for the presence of micro-organisms at the mycology laboratory of the department of biological sciences ,Usmanu Danfodiyo University-Sokoto.

Sterilization of Glassware

All the glassware used in this experiment were washed in detergent solution and then in several changes of tap water. They were left to air-dry completely. They were all put in the hot air oven and sterilized at 160°C for three hours. The sterilized plates were then used in pouring the media into them.

Media Preparation

The media used in this analysis were 2 potato dextrose agar (PDA) and the nutrient

agar(NA). They were prepared according to the manufacturers instructions. The prepared media contents were poured into 1-litre conical flask separately. They were again plugged with cotton wool and capped with aluminium foil. The 2two flasks containing the different media were put on the autoclave and sterilized at 121°C for 15 minutes .After sterilization the were left on the bench to cool down to 47°C before they were poured into sterile Petri-dishes. The plates were allowed to solidify then inoculation followed.

INNOCULATION AND INCIBATION OF THE SAMPLES

The four samples were singly placed in a clean mortar and pounded d with pestle until they have turned to powder. A fine sieve was used in draining the fine powder. Each was separated and dissolved.10g was dissolved in 50 ml of sterile distilled water. The suspension was allowed to soak for 15minites .From each of the stock, 1ml was pipetted and serially diluted .This gave the serial dilution of 10^{-1} to 10^{-9} .From then 10^{-1} was used to culture the fungi and the 10^{-9} dilution was used for bacterial.1ml was pipetted and inoculated directly on the plates of PDA and NA for each sample. The potato dextrose agar plates were all incubated at room temperature (30°C).While the incubated nutrient agar plates were incubated at 37°C in the incubator. The fungal plates were left on the table top for 7days and 24 hours for the bacteria plates. The 24 hors incubated plates for bacteria were further sub cultured on plain plates to obtain a pure contaminated growth.

PROCEDURE FOR PROXIMATE ANALYSIS

Determination of Moisture in C

Apparatus: Moisture can (Silica dish or C ucible), hot air drying oven, desiccator

Procedure: The empty moisture can was weighed and recorded as W_o. Then 2g material was weighed and moisture can ,was weighed again with material W_1 hot air was dried in an oven at about 105-110°C for 24 hours, the desiccator was cooled .The dry sample was weighed W_2. Furthermore the dried sample was returned to oven for further 24 hours, to make sure that the drying is completed and weighed again the weight, W_2,which was constant value. The constant was determined equation 4.

$$\% \, MOISTURE = \frac{W_1 - W_2}{W_1 - W_o} \times 100 \qquad \text{---------- (2)}$$

DETERMINATION OF ASH IN CASSAVA

Apparatus: Crucible or silica dish, weighing balance, muffle furnace, spatula and desiccator

Procedure

The crucible was weighed empty (W_o). The crucible was weighed with the sample

after drying (W_1). The crucible was used to cool the sample then crucible was reweighed, (W_2).Percent ash was obtained using equation 3.

$$\% ASH = \frac{W_2 - W_0}{W_1 - W_0} \times 100 \qquad \text{---------- (3)}$$

DETERMINATION OF FAT IN CASSAVA

Apparatus: Condenser, soxhlet extraction unit, hot air drying oven ,extraction of boiling water flask-250 ml capacity, desiccator, balance, dry porous thimble, water bath or mantle heater, shaped No. 4 filter paper, cotton wool.

Procedure: In the determination of fat in cassava the following steps were taken. 250 ml extraction flask was dried in oven at 105-110°C. After allowing it to in the desiccator, the extraction flask was weighed. 2g of the ground sample was weighed into a porous thimble. 200ml of petroleum ether was added into the 250 ml extraction flask.The sample was extracted for about 6 hours.The thimble was then removed with care and the petroleum ether in the top of the extraction tube was removed and reused. The extraction flask containing the oil (fat), was then dried at 150°C for 1 hour, cooled in the desiccator and reweighed after cooling. Equation 4 below gives the pert cent fat content.

$$\% FAT = \frac{W_3 - W_2}{W_1 - W_0} \times 100 \qquad \text{---------- (4)}$$

Weight of empty porous thimble = W_0

Weight of thimble-ground sample = W_1

Weight of ground sample = $W_1 - W_0$

Weight of empty extraction flask = W_2

Weight of extraction flask + ether = W_3

DETERMINATION OF CRUDE PROTEIN IN CASSAVA

Using the kjeldahl procedure ,the amount of crude protein is obtained by multiplying the nitrogen content by 6.25.This factor was based on the assumption that all the food proteins contain 16% nitrogen and that all the nitrogen in the tissue is present as protein.

DETERMINATION OF CRUDE FIBRE IN CASSAVA

Apparatus: Muffle furnace, one litre conical flask, weighing balance, poplin cloth, hot air oven, heater, Bouchner filtration unit, crucible and spatula.

Procedure:

The drying ground a sample of 2.00g was weighed into 1 liter conical flask (W_o).1.25% H_2SO_4 was added to the 200ml of distilled water and was boiled gently for 30minutes using cooling fingers to maintain a constant volume. The mixture was filtered through muslin cloth material stretched over 9cm Bouchner funnel. It was rinsed well with hot distilled water , and the materials were scrapped back into the flask with spatula.200ml of boiling 1.25% NaOH was added and allowed to boil gently for 30minutes using cooling fingers to maintain a constant volume. using cooling fingers to maintain a constant volume. Poplin cloth was used for filtration. The residue was washed thoroughly with hot distilled water and rinsed once with 10% HCl and twice with industrial methylated spirit. Finally it was rinsed thrice with petroleum ether (Bp 40-60°C).Also, it was allowed to drain dry and then the residue was scrapped into a crucible dried overnight 105°C in the oven to constant weight. The desiccator was cooled and that sample was reweighed (W_1).Ash at 600°C was maintained for 2 hours in a muffle furnace and cooled in a desiccator and reweighed again (W_2). Per cent crude fiber is given in the equation 5.

$$\% \ CRUDE \ FIBRE = \frac{W_1 - W_2}{W_o} \times 100 \qquad \text{---------- (5)}$$

DETERMINATION OF CARBOHYDRATE IN CASSAVA

This procedure does not require any apparatus for its determination as it can be determined directly. The nitrogen-free extractive (NFE) which is referred to as soluble carbohydrate was determined by obtaining the sum of ash ,protein ,crude fat and crude fibre and subtracting it from 100 (Bakare, 1985, Tell,*et al.*, 1984) and described in equation6 below..

NFE=100%-(%ASH+%CRUDE FIBRE+%CRUDE FAT+%CRUDE PROTEIN)-3.6%

---------- (6)

RESULTS AND DISCUSSION

On the first day of drying equal samples of 1Kg of fresh cassava were spread for the open air drying as well as inside the two solar dryers. A summary of the drying exercise as per moisture content is shown in Table1.That showed that the rock bed collector dryer was the fastest as far moisture removal is concerned, followed by the flat plate collector dryer. It took the flat plate collector dryer 13hours to dry cassava from 1.0Kg to 0.35Kg;while it took the rock bed collector dryer 14 hours and open air layout (blanched sample) 13 hours of normal sunshine exposure before drying the produce to the above stated dry mass. The percent age moisture removal (described in equation1above) is a factor relating the water content the fresh produce to its dry mass.

Table1: Moisture Content of the Fresh Samples

Date:17th-18th October 2006	Sample			
	R_b	F_p	O_{abl} (blanched)	O_a(not blanched)
Moisture Content of Fresh Samples (%)	66	65	59	65
Sunshine Drying Time(hours)	12	13	13	14

Key

R_b: Rock Bed Absorber Dryer

F_p : Flat Plate Absorber Dryer

O_a : Open-Air Layout(not blanched)

O_{abl} : Open-Air Layout Blanched

RESULTS AND DISCUSSION OF THE PROXIMATE ANALYSIS

The results obtained from the analysis showed that the percent moisture in the samples as shown in Table 2 indicated that the fresh sample had the highest moisture content viz: 66.0% compared to the open-air (O_a),open-air blanched (O_{abl}), flat plate (F_p) of respective 5.5% moisture content each ,last but not least the rock bed absorber (R_b) sample with 5.0% moisture content.

Table 2: Proximate Analysis of the Cassava Samples

Sample	Moisture Content (%)	Ash (%)	Fat (%)	Crude Fibre(%)	Crude Protein (%)	Carbohydrate (%)
F_s	66.0	01.0	07.0	1.40	2.36	88.24
R_b	05.0	03.5	02.0	4.60	5.53	84.34
F_p	05.5	03.0	03.0	4.40	4.27	85.33
O_a	05.5	02.5	03.0	4.00	4.13	86.37
O_{abl}	05.5	02.0	02.5	3.70	4.00	87.8

Key:

F_s: Fresh Sample

R_b, F_p, O_a and O_{abl} are as described in Table1.

The percentage ash content of the samples indicated that the rock bed absorber (R_b) sample had the highest ash content of 3.50% compared to the flat plate(F_p) of 3.00%, open-air(O_a) of 2.50%,open-air blanched(O_{abl}) of 2.00% while the fresh sample(F_s) had 1.00% ash content. The superiority of R_b in ash content over the rest of samples might be due to its heat storage facility.

For ether (fat), the drying of the samples could be seen to have the ether level significantly; as the fresh sample had 7.00% fat content followed by F_p and O_a 3.00% each while O_{abl} and R_b had 2.50% and 2.00% respectively. viz:1.40% mostly carbohydrate .The discrepancy range is not much for the rest of the samples as R_b was highest with 4.60% followed by F_p, O_a, and O_{abl} with respective crude fibre contents of 4.40%,4.00% and 3.70%.

Similar trend was maintained for crude protein as for crude fibre contents discussed above. R_b was highest with 5.53% followed by F_p, O_a, O_{abl} and F_s with respective crude protein contents of 4.27%,4.13% ,4.00% and 2.360%.

As for the percent carbohydrate contents O_{abl} seemed to be the best option because it presented highest value content of 87.8% followed by O_a, F_p and R_b with respective contents of 86.37% ,85.33% and 84.34%.However, F_s had an overwhelming carbohydrate content of 88.24%.

RESULTS AND DISCUSSION OF THE MICROBIAL TEST

Table 3 and Table 4 respectively show the fungi and bacterial test results isolated for the five different cassava samples viz: F_s(control), R_b, F_p, O_a and O_{abl}. The four species of organisms isolated were fungi viz: *Aspergillus niger, Mucor racemasus* and *Fusarium oxysporum* and bacteria: *Staphylococcus aureus* Table3 shows that the first three organisms are present in the fresh cassava samples. This is reasonable because fungi generally require moisture for their survival .The open-air layout however was found to contain *Mucor* racemasus while the remaining samples do not contain any of the fungal organisms. This indicates that open air layout is less efficient compared to other drying techniques since the remaining samples do not contain any organism.

Table 3: Fungi isolated from the different Samples.

	Samples				
Isolated fungi	F_s	O_a	O_{abl}	R_b	F_p
Aspergillus niger	+	-	-	-	-
Mucor racemasus	+	+	-	-	-
Fusarium oxyporum	+	-	-	-	-

Table 4: Bacteria isolated from the different Samples

Isolated fungi	Samples				
Staphylococcus aureus	F_s +	O_a +	O_{abl} +	R_b +	F_P +

Key:
+ :Present
- :Absent
R_b, F_p, O_a and O_{abl} are as described in Table1

From Table 5 it can be seen that only one organism viz: *Staphylococcus aureus* was shown to be present in all the samples. This as the result of the fact that the organism is an important normal flora of human body, so it might have sneaked into the sample through manual handling within the course of drying.

CONCLUSION

A research has been carried out on the drying characteristics of cassava using simultaneously the open air, flat-plate collector dryer and rock bed collector dryer for 2-day period. Solar energy is available in abundance in the tropics particularly the Northern part Nigeria can be harnessed for a variety of applications of which solar drying is amidst .It was also deduced R_b showed highest potentials for nutritional values followed by F_p and O_{abl} respectively and therefore could be harnessed as a means of cassava treatment for sustainable development.

RECOMMENDATION

Dry cassava roots abound in our locality [illegible] most of which quality leaves much to be desired. Government, non-governmental organizations and the private sector should encourage the establishment of more pilot projects, workshops and training in the area of solar energy through awareness campaigns via extension services. This option seems more prominent in solar drying of agricultural crops as we are yet to fulfill our basic millennium goals. However research and development efforts should be focused in the proper understanding of solar-GHE dryers technologies vis-à-vis our agricultural patrimony.

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