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Development of Low Cost Batch Drier to Enhance Value Chain Cassava Chips Production

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ABSTRACT
A small size cassava chips batch dryer was designed, constructed and evaluated at the Department of Agricultural and Bio-Environmental Engineering of the Federal Polytechnic, Ado Ekiti. The system consists of the following components: frame, drying chamber, electric heater, blower, drying trays and controlling unit.
The system works on a heating coil of 500watts as the source of heat and a circulation fan that runs at 60 watts. The compartment was holed up at a chimney to allow for escape of moist air. The cost is moderate and affordable.
KEYWORDS: Fabrication, Cassava-ships, Dryer, Drying, Moisture**.**

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I. INTRODUCTION

Drying is the oldest method of preserving food. It is a mass transfer process consisting of the removal of moisture or another solvent by evaporation from a solid, semi-solid or liquid. (Greenwich, 1998). Drying is an excellent way to preserve foods that can add variety to meals and provide delicious, nutritious snacks.

Cassava (Manihot esculent) is a root crop, a single species plant belonging to the family of Euphorbiaceae and is the most important root crop in the tropics (Anikwe and Onyia, 2005). It is a source of energy for 200 to 300 million people all over the world (Adeluyi et al 2006). It carbohydrate-rich root can be processed into a wide variety of products from food to industrial starch, which make cassava important economically. Food and Agricultural Organization (FAO) estimated cassava global harvest in 2012 at more than 280 million tones, a sixty 60% increase to that of 2000. With better crop and soil management and higher yielding varieties that have more resistant to drought, pest and diseases, cassava could produce average yields of 23.2 tonnes per hectare (FAO 2013).

Cassava is the fourth most important energy staple food in the tropics and the six global sources of calories as human diets apart from rice and wheat (FAO 1999). In southern Nigeria, it was reported that cassava contributes about 70% of the total energy requirement of over 50% of the population. It is utilized as food for humans in processed form such as gari, lafu and fufu, while some sweet (low cyanide) varieties are eaten raw, boiled or roasted as snacks (Ugwu et al, 2002).

Dried cassava chips are non-fermented chips of about 3.5mm diameter from freshly harvested cassava tubers. The dried chips are usually white or creamy brown. The chips are considered dried when they are easily broken but too hard to be crumbled by hand. Processing fresh cassava roots into chips is to increase the shelf-life of the roots, improve palatability and reduce their cyanogenic potential. Cassava chips are used for the following purposes:

i. For edible purpose and for cassava flour
ii. For animal feed formulation
iii. Industrial use as raw material for manufacturing starch, dextrin, glucose and ethyl-alcohol.
iv. Base product for industrial material such as medicine, gum etc.

Despite the importance of cassava and high yielding potentials, cassava in Nigeria has not been fully exploited due to inadequate processing technology as obtained in the other developing countries. Storage of cassava tuber is very difficult due to high moisture content. Farmers have resulted in sun-drying which takes chips two to three days to dry. Unreliable climatic condition renders continuous sun-drying difficult, contamination by airborne, dust and other contaminants are the limitations of open sun-drying. All these could be avoided using artificial drying such as the batch dryer. Besides, batch dryer saves time, floor space and allows for continuous drying even at night time. This has necessitated the need for the design and construction of a tray-batch dryer for cassava chips using the electric heater with a thermostat control medium.

II. MATERIALS AND METHODS

The batch dryer is a cabinet type with perforated trays to hold the chips. The dryer has the electric heater, fan (blower) thermostat for temperature regulation. It is a rectangular shaped structure with a door as shown in Figure 1.

Important Design Features

Frame:

The steel pipe (1 × 1 inch) was used as the dryer frame as a result of its availability, ease of construction, good heat conductivity and durability. It has a dimension of 1000 × 500 × 500 mm

Drying component:

It consists of 500W electrical heater and blower to circulate the heat in the chamber. The blower blade is made of aluminum that easily conducts heat**.**

Drying cabinet tray

The tray is made of stainless steel to endure good quality product that is free of contamination. Stainless steel does not react with the product in any condition. The body of the cabinet is made of mild steel plate because it is durable, available and cost-effective. The surrounding of the body of the cabinet is lagged with lagging materials to prevent heat loss during drying. On top is a chimney where excess heat could be dissipated.

Control unit: The dryer consist of control unit there is on and off switch. There is also thermometer to measure the temperature of the dryer.

Door: Two doors are designed with the handle to allow for easy access to the trays and for a frequent checkup of the drying products.

Design for the drying capacity. The dryer was designed to take 2kg per tray of cassava chips at 70% moisture content on a wet basis at a time. The moisture content to be removed from the chips is calculated using the formulae

$$M_w = M\left(1 - \left(\frac{1-M_{ci}}{1-M_{cf}}\right)\right)$$

Where:

M_w = Amount of water to be removed

M = Mass of chips in kg

M_{ci} = initial moisture content of the chip

M_{cf} = Final moisture content of the chips

Drying time (T) is calculated using the formulae:

$$T = \left(\frac{m_1 - m_2}{\frac{dw}{dQ}}\right)$$

W = dry material in chips (kg)

M_1 = mass of initial moisture

M_2 = mass of final moisture

dW/dQ = rate of mass transfer (M_c

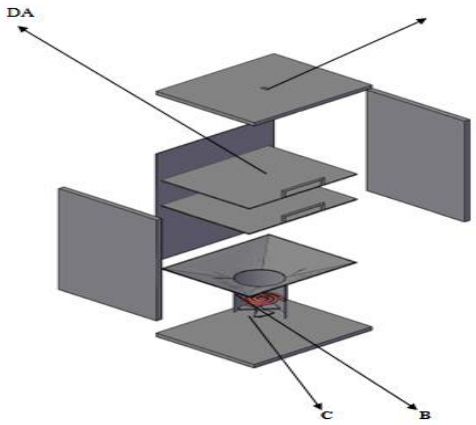

FIGURE 1: the Labelled component of the dryer 'Exploded'

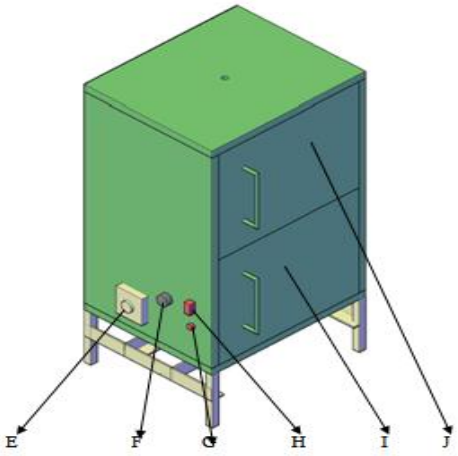

FIGURE 2: Labelled components of the dryer in Pictorial view

Key	Representation
A	Chimney
B	Heater
C	Fan (Blower)
D	Tray
E	Fan regulator
F	Thermostat knob
G	Indicator light
H	Dryer switch
I	Lower door
J	Upper door

III. RESULTS

The results of the tests are shown in table 1 and 2. The moisture contents of cassava at the one-hour interval. The graphical representation is equally shown in figure 3 and 4.

Table 1 shows the result obtained during the testing of the heater empty.

S/N	Time (sec.)	Time (mins)	Temp (^{0}C)
1	300	5	49
2	600	10	54
3	900	15	55
4	1200	20	55.5
5	1500	25	56
6	1800	30	58
7	2100	35	60

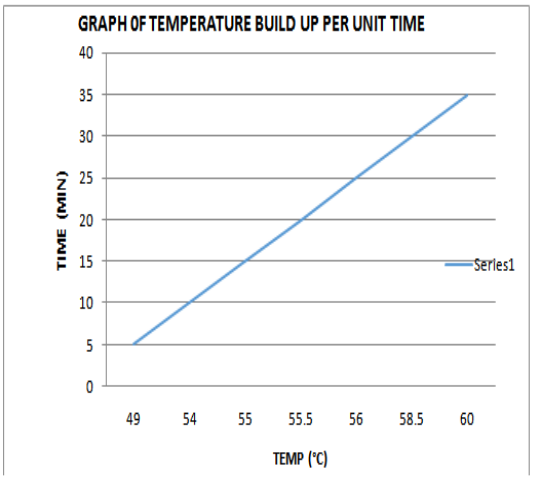

Figure 3: Plot of Time (mins) against Temperature (^{0}C)

Table 2: Moisture content of cassava at one hour interval

S/N	Time (hrs)	Moisture content (%)
1	0	69.2
2	1	57.1
3	2	34.6
4	3	35.5
5	4	27
6	5	13.8

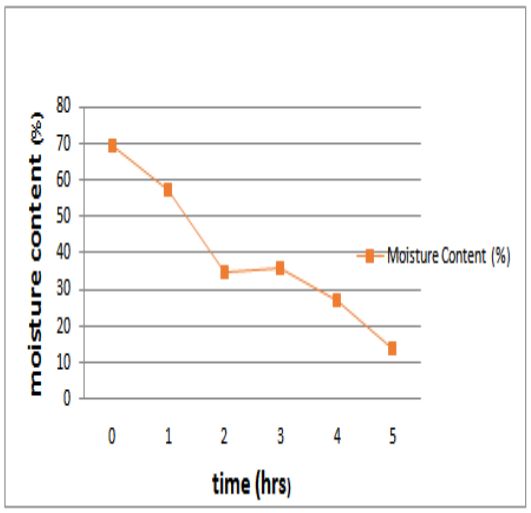

Fig. 3: Graph of Moisture Content against time.

IV. DISCUSSION

From the result obtained from the performance evaluation, cassava chips of an initial moisture content of 69.2% were successfully reduced to 13.8% a stable shelf life which will make the chips to be stored for longer period. The actual time taken is 5 hrs instead of the calculated 6 hrs. This was achieved due to ease of regulating the heat produced by the heater and even circulation through the installed fan speed. The working efficiency of the dryer was found to be 80% which could be improved upon. The dried cassava chips produced were of high quality in term of colour and aroma because the process was fast and free from contaminations resulting from smoke, dust, fermentation processes and other contaminants from the atmosphere as a result of the source of power used (electricity) which does not produce either of the contaminants.

V. CONCLUSION AND RECOMMENDATION

Standard method and technology have been employed in the design and construction of the dryer. The capacity of the dryer is 4kg per loading. The drying rate is a function of the chemical composition of the cultivars; the drying time is a function of the moisture content and surface area of the chips. It was observed from the cassava dries significantly chips at an interval of 1hr the moisture content reduces to an appreciable level. This is a plus for a design that works on the electrical system working at an efficiency of 80%. It could be concluded that the system could be improved upon with the efficiently run fans and insulation system within the design. The dryer could also be used to dry chips of other tubers such as yam, potato etc.

RECOMMENDATION

This dryer is good for small-scale chips drying. However with further works higher capacity could be achieved**.**

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