DEVELOPMENT OF A MULTI- PURPOSE DRYER

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ABSTRACT
A multi-purpose dryer was developed in National Root Crops Research Institute Umudike for drying vegetables and fruits. The dryer consists of two compartments, one for producing thermal energy and the other for spreading the products to be dried. The novel design uses heat sources from electric burners and it is located beneath the product spreading chamber. This prevented the problem of discoloration due to direct heat from the burners. A thermostat was used for its temperature control and light indicators were introduced to monitor the operation of the dryer with a standard switch control panel. A digital multi-tester was used to measure the quantity of current and voltage inflow and outflow to the dryer. An axial flow fan was provided in the air inlet which accelerates the drying rate. The dryer has ten perforated trays for loading the material. The burners of the dryer attained a temperature of 120°C when it was studied under no load conditions. The maximum air temperature in the dryer under this condition was 110°C. The dryer was loaded with 10kg of cassava chips having an initial moisture content of 63% and final desired moisture content of 7% was achieved within 3hrs without losing the product color and it took 10hrs for open sun drying depending on the intensity of the sun.

KEYWORDS: Multi-purpose dryer, burners, thermostat, flow fan, control panel.

INTRODUCTION
Drying is the science of producing and maintaining temperatures above that of the surrounding atmosphere. Dryers are appliances that remove moisture from objects by heating or through any other process. Its main purpose is to transfer heat from a hot chamber which is at a temperature higher than its surroundings.

In Nigeria and in most African countries many of their agricultural products are exported in their dried forms. This ensures that these products last for a long time and are easily transported. Some of these products are pepper, beans, ginger grits, cassava chips, starch, flour, vegetables, fruits and so on. The increase in the population of developing countries is by far greater than the increase in food production. The calorie intake of most populace depends on cheap and easily available starch based foods as they cannot afford the expensive animal based meal. Most of these perishable products cannot be stored in their present form except in their dried forms due to insufficient and/or lack of storage facilities. They are best utilized as raw materials in their dried forms as well as meeting the demands of indigenous Agro-allied industries. Researchers over the years have developed dryers which base their mode of operation on heat sources generated from kerosene (kerosene dryers), Coal (coal dryers), electricity (electric dryers), (Holman, 1997). These designs did not proffer solutions to the common problems associated with dryers. The problems include;

Unequaled precision temperature control

Uniform and homogenous air flow (no temperature stratification) to all areas of the drying boxes.

Indefinitely variable air flow control from full off to full open.

Efficiencies less or equal to 60%.

Color change.

Efforts are being made to improve the performance of dryers through modifications in designs and by optimization. The systems should be designed to operate effectively and efficiently anywhere from tropical environments to the cold temperature climates. To increase production of dried agricultural products in developing countries there is need to develop dryers that are unsurpassed in their level of safety precision control, reliability, durability, ease of operation, high efficiency and low cost. It is on this premise that this study was founded.

MATERIALS AND METHODS

2.1 Design of the Multi-purpose dryer

2.1.1 Description of the Multi-purpose dryer.

The main components of the dryer are burners, thermostat, flow fan, light indicators, control panel, perforated plates and digital multi-tester as shown in figure1. Various components of the dryer were designed using standard formula. The frame was constructed from 45 x 45mm angle bar to give rigidity and stability that will withstand load. The dryer has a volume of 2.0 x 1.8 x 1.4m^3 and it is divided into two compartments having ten trays each. The trays are made of aluminum sheets of 0.95 x 0.80 x 0.10m^3. The choice of aluminum trays for the dryer is as a result of its high thermal conductivity of 229W/MK. The dryer consist of a thermostat for temperature regulation, a thermometer for measuring the operating temperature of the heating chamber. The heating compartment where the incoming hot air dries the wet product is located beneath the perforated trays or plates. The flow fan is powered by an electric motor via pulley arrangement. The dryer has a 3-phase electrical connections, light indicators incorporated to the design to monitor the level of operation of the dryer. Four electrical heating elements with power ratings of 3.125kw each and a standard control switch panel were used in the design. The design has a convectional heat extraction mechanism with a chimney on top of the dryer. This facilitates escape of moisture generated to the atmosphere in order to optimize drying and sustain the color of the end product (Young & Freeman, 2004). Galvanized sheet metals were used for the body construction and the trays racks with 38mm angle iron (Yunus 1998). Fiber glass was used as a lagging material for the dryer (Gere & Tinoshenko, 1998) with thickness of 50mm.

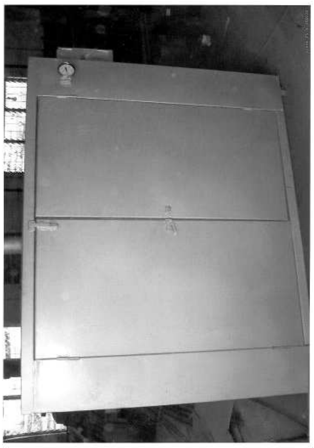

Fig 1 : Picture of the Multi Purpose Dryer for drying fruits, chips, grains and vegetables .

2.1.2 Operation of the Dryer

The operation of the machine was based on heat transfer from a hot chamber which is at a temperature higher than its surroundings. 1.0hp electric motor was used to power the flow fan. The heating compartment is connected to electricity by a flexible cable and switch. The wet products are fed into the trays and the electric motor and burners are switched on. The flow fan starts to rotate and conveys heat by convection throughout the drying chamber. The chimney located at the top of the dryer serves as exhaust for escape of moisture to the surroundings.

2.1.3 Evaluation

Cassava chips from cassava variety TMS59/159/335 collected from National Root Crops Research Institute Umudike was used for the evaluation of the machine. Evaluation of the machine was carried out at temperatures of 100, 105 and 110°C and on three hours time periods. The cassava roots were peeled, cut into chips and washed. Samples were then weighed to determine the weight before loading into the dryer. The weighed samples were then allowed to pass through the pre heated chamber to dry the chips. The dried chips were also weighed after drying to know the quantity of moisture that evaporated to the surroundings. Statistical analysis was done using ANOVA, linear and nonlinear regression, Duncan New multiple range test.

RESULTS AND DISCUSSION

Table1. Mean Performance of the Multi-purpose Dryer

Temperature °C	Time (hrs)	Cassava chip weight (kg) (before drying)	Cassava chip moisture content (kg)	Cassava chip weight (kg) (after drying)	Expected Weight (kg) (after drying)	Drying efficiency (%)
100	3	10.12	6.38	4.20	3.74	89.1c
	3	9.98	6.29	3.90	3.63	93.1b
	3	8.45	5.32	3.30	3.13	94.9a
105	3	10.00	6.30	4.10	3.70	90.2c
	3	9.75	6.14	3.89	3.61	92.8b
	3	8.20	5.20	3.12	3.00	96.2a
110	3	10.00	6.30	4.00	3.70	92.5b
	3	9.50	5.99	3.85	3.51	91.2b
	3	8.00	5.04	3.10	2.96	95.5a

Total mean = 92.83 Standard error = 0.5490

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Table 1 is the summary of the results of the performance of the developed multi-purpose dryer with cassava chips samples at different temperatures. The drying rate was observed to increase with an increase in temperature. The same pattern was observed in the efficiency from 92.35% at a temperature of 100°C to 93.06% at a temperature of 110°C.

Table 2. Mean effect of temperature on Drying efficiency of the Multipurpose dryer.

Temperature °C	Mean	Standard error	95% confidence Interval Lower Bound	Upper Bound
100	92.365b	0.3590	92.060	93.104
105	93.060b	0.3590	93.110	94.1 54
110	94.908a	0.3590	93.825	94.869

The result suggest that the performance of the machine is highly depended on temperature with drying efficiency at its peak of 94.869% at 110°C. Analysis of variance indicated significant differences at 5% level of significance in drying efficiency due to temperature increase. The highest drying efficiency of 93.8 94.8% is within the permissible standard level of 90 100% obtained (Ezebuiro C.N, 2003).

CONCLUSION

A multipurpose dryer with a capacity of 100kg was developed. Evaluation of the machine on the cassava chip gave a drying efficiency of 94.8% at a temperature of 110°C. Improvement in the design of the heat extraction mechanism and lagging system is expected to greatly improve the performance efficiency of the machine. The power requirement of the flow fan of the machine is 1.0hp and can be adapted to dry all types of crops.

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