DEVELOPMENT OF AN ELECTRIC DRYER FOR BIOMATERIALS

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ABSTRACT

To maintain the quality of a number of farm produce during storage they must be dried before or/and during storage. This paper presents the development of an electric batch automatic dryer for biomaterials of high moisture content. The dryer is simple in construction, made of wood coated from inside with aluminum foil. Results of performance tests show that there was 32.31% weight loss after 70 minutes drying of fresh corn. Tomatoes and okro lost 89.12% and 48.78% after 470 minutes and 240 minutes of drying respectively. Drying curves have thus been established for corn, tomatoes and okro.

Key Words: corn, tomatoes, okro, drying cure

INTRODUCTION

Drying is a major form of preserving and improving the storage quality of biomaterials which entails the process of reducing the moisture content of these materials. As more and more high moisture crops are produced and the desire to have all crops through out the year preservation methods take an increased importance. Traditionally, drying is achieved by putting the crops in the sun in South East Asia, Africa and a host of third world countries. Mechanical or artificial drying methods are not common in these areas due to the lack of appropriate drying technology for tropical conditions and comparatively high cost of procurement and installation of such technologies imported from overseas. Hence, the dire need for locally developed but efficient dryers.

Kishida, (1981)[3] reported the design of a batch dryer called "batti" in Nepal. The dryer was quite efficient but was characterized with thick smoke which contaminated the dried product. Relying on the sun for drying is a common method in Nigeria. This has associated problems of discontinuity in the sun's energy as a result of changes in environmental conditions. With the recent campaign and deliberate efffotts by the Federal Government of Nigeria to increase food production at all levels, the need for dryers that are efficient and independent of changes in environmental conditions can not be over emphasized. One of the common alternatives to this need is the dryer using elecricity. Apart from the uncertainties involved in sun drying, the dry process/rate can not easily be controlled. Similarly, the difficulties involved in spreading and packing the farm produce make the process very labour intnesive. Since food preservation is very important and drying is one way of preserving food espeically vegetables, it is pertinent to have simple portable equipment that help in solving such problems. Development for such a dryer is also in line with the current capaign for the development of simple tools and equipment for the cottage industries being advocated by Governement for the "Family Economic Advancement Programme (FEAP)."

MATERIALS AND METHODS

Description of the Dryer

The dryer is designed to dry agricultural produce using the principle of direct heating from the heating elements connected to a source of electricity. The heat generated by the heater is conducted through the metal sheet that constiuted the drying chamber. Hence the selection of the materials and the desired capacity of the dryer was guided by the heat conduction equation given by Fourier's law (equation 1)[1-2]

$$\frac{Q}{A} = K\frac{dt}{dx}$$

where,

Q:	heat flow rate [Joules/s]
A:	cross sectional area normal to the direction of heat flow [m^2]
$\frac{Q}{A}$:	heat flux in the x-direction [w/m^2]
dt:	temperature difference between the hot and cold bodies (°K)
dx:	distance through the conducting medium (m)
k:	thermal conductivity [w/m° K]
$\frac{dt}{dx}$:	temperature gradient in the x-direction [°K/m)

The schematic diagrams of the dryer are shown in Figures 1 and 2. The dryer is made up of a 32 x 30 x 55 cm^3 3/4 ply wood as the outer most layer and zinc sheet coated with aluminum foil from inside to prevent absorption of heat by the wood and the zinc sheet.

2.2 Dryer components

The dryer consists of the following parts:

a) **Top cover:** It has an area of 9.61 x 10^{-2} m^2 with a variable resistor switch which controls the dryer at on off positions; It has vents which allow in air to cool the fan's coil and a lock which locks it with the rest of the dryer.

b) **Heating Chamber:** Below the top cover is the heating chamber with a hole of 1.96 x 10^{-5} m^2 area on top through which air from the vents gets to the fan's coil and also provide a hanging place for the fan and the heating elements. The fan and the two heating elements work independently. The two elements help to quicken the drying action of the dryer. A thermostat is connected to the heating elements to control their heating.

c) **Fan, electric motor and Heating elements:** The drying air is moved by an axial flow fan which is powered by a 30 W two phase electric motor: The fan rotates at 1500 rpm to deliver a measure of air quantity of 53.6 gallons. The fan assembly is positioned between the heating elements and the drying chamber to suck the heated air discharge into the drying chimney. The two heating elements produce 1500 W of power.

d) **Drying chamber**: The 31 x 31 x 10 cm^3 drying chamber is constructed of wood and has wire mesh at the top and bottom ends. The wall of the chamber is coated with zinc and aluminum foil to act as heat reflector. The wire mesh on top allows heated air from the heating chamber into the drying chamber while the lower wire mesh serves to hold the material for drying and also allows heated air from heating chamber passage to the chimney. The heated air delivered by the fan has a temperature in the ranges of 75-80°C.

e) **Stand:** Two flat wooden stands of 12 x 12 x 3 cm^3 were constructed as a base for placing the dryer.

f) **Chimney**: It is constructed of wood and zinc sheet of dimension 31 x 31 x 7cm^3 and has an air vent of 31 x 5cm^2. It allows the vapour carrying heated air escape to the atmosphere.

g) **Handle:** To ensure portability of the dryer, a handle made of mild steel was incorporated so as to facilitate easy transportation.

Testing

A performance test was conducted using the fabricated prototype so as to determine its efficiency. Three biomaterials (corn, tomatoes and okro) freshly harvested were used for the performance test. Two samples of corn, samples A and B each weighing 23 grams were used. Samples of okro and tomato were also dried. Sample B of corn was dried with only one of the heating elements on. Other samples were however dried with the two heating elements engaged.

During drying of corn, readings were taken at 10 minutes intervals and drying lasted for 70 minutes. Both tomatoes and okro required longer drying time. Accordingly, tomatoes were dried for 7 hours with readings taken every 30 minutes. The okro sample was divided into two, samples C and D each weighing 127.6g. Sample C was dried in the dryer while Sample D was sun dried since sun drying is a particularly popular method of drying this crop in this part of the country. The two drying tests were conducted simultaneously. The tests were conducted in the laboratory. The relative humidity of the laboratory was 65% on the average while that inside the dry chamber was 50% on the average. The temperature of the heated air inside the drying chamber was between 75°C and5 85°C an average of 80°C.

RESULTS AND DISCUSSION

The dryer was tested using corn, tomatoes and okro. The performance tests carried out on the dryer showed some remarkable results. Figures 3, 4 and 5 are the drying rate curves of the produce tested. It was observed that as the drying time increases, the rate of which water is lost from the produce decreases. The dryer was more efficient in drying vegetables as is evident from the drying curves of tomatoes and okro (Figs. 3 and 4).

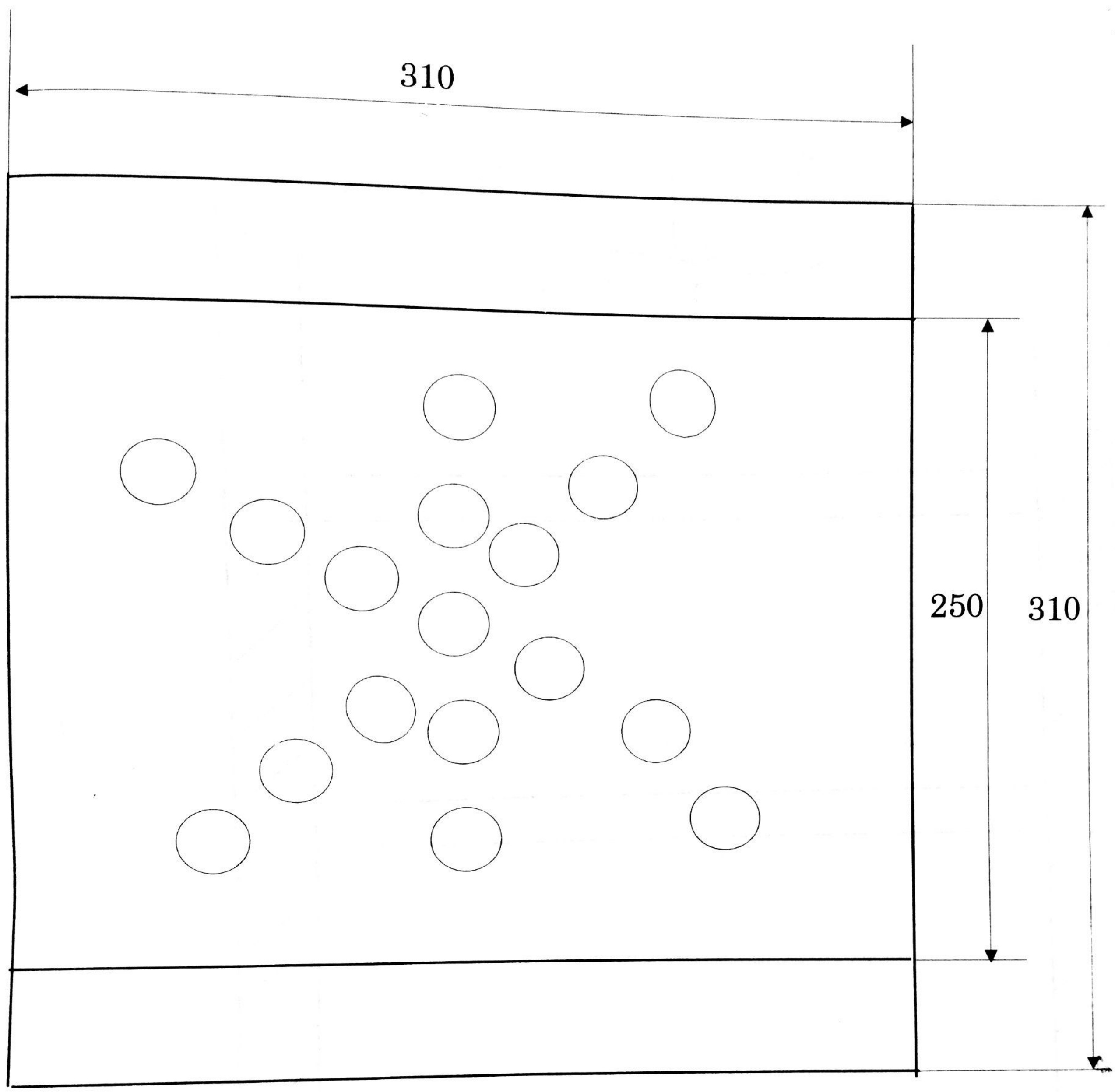

Fig. 1 Top plan of the electric dryer

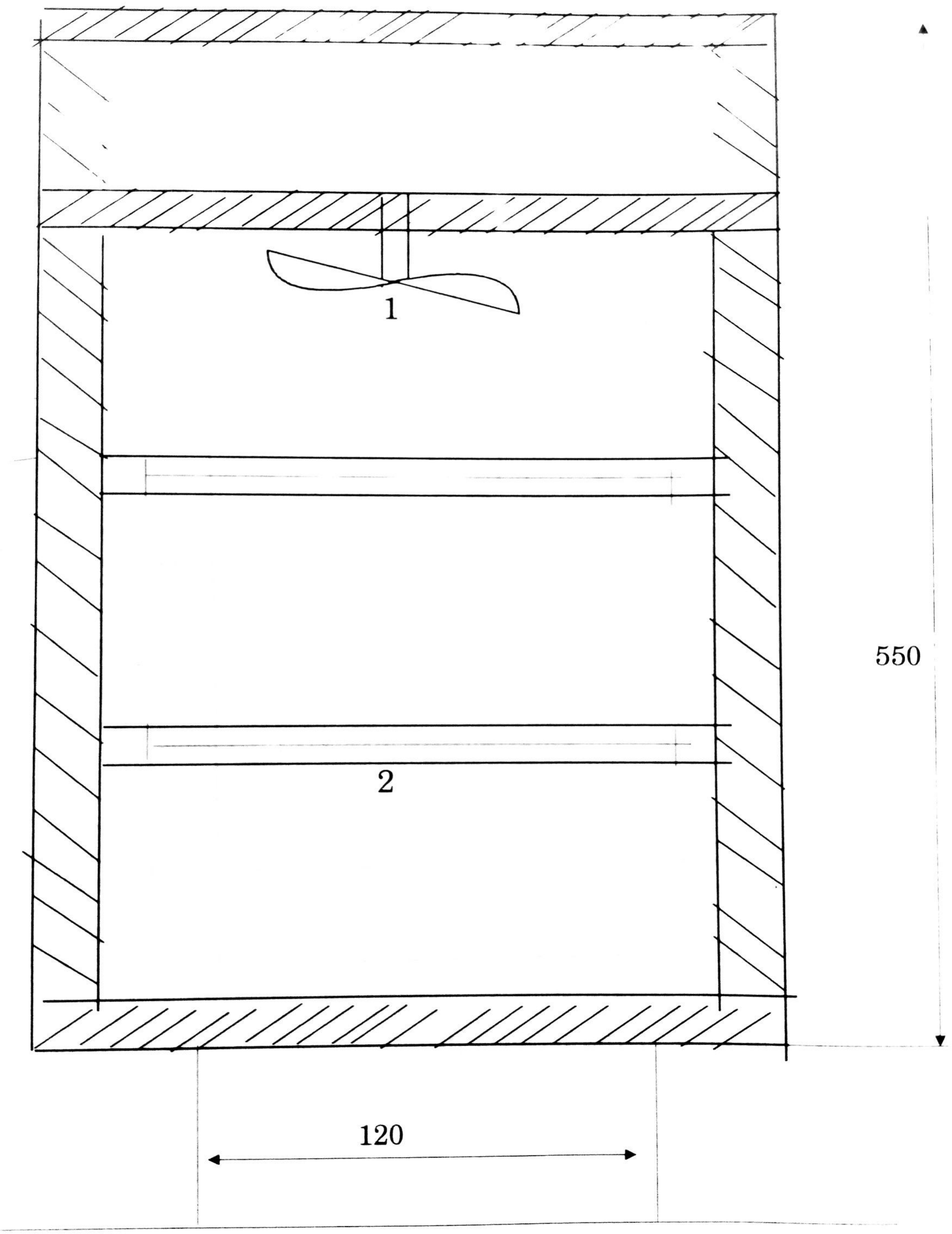

Fig. 2 Cross-section of the electric dryer
1. Electrical fan 2. Protector

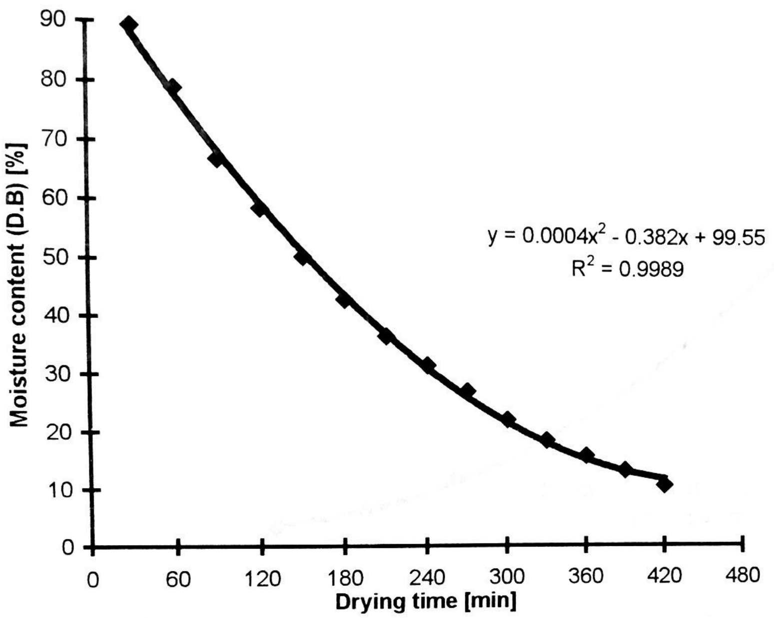

Fig. 3 Drying curve for fresh tomatoes

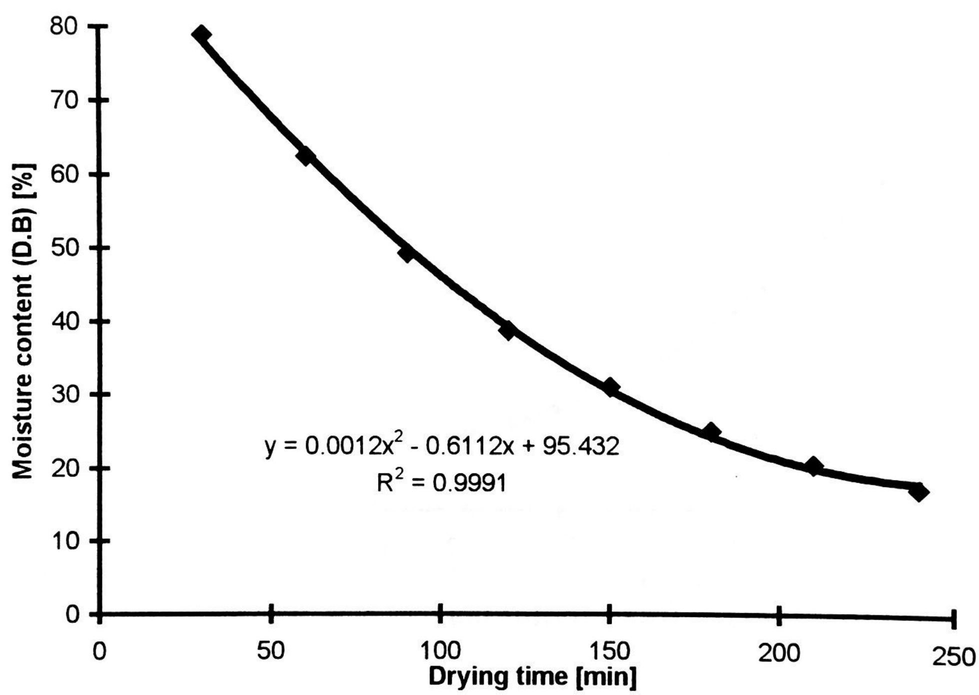

Fig. 4 Drying curve of fresh okro

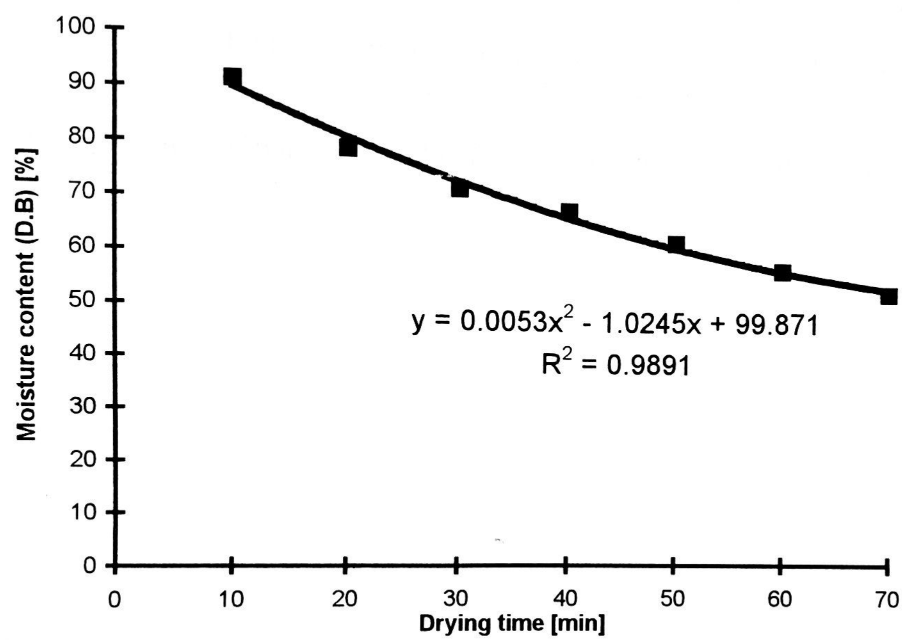

Fig. 5 Drying curve of corn

CONCLUSION

An improved technology in the area of crop drying was developed. The design which is simple and compact can be fabricated using locally readily available materials. With the current drive towards electrification of the rural areas, this design can conveniently fit into the cottage industries in the area of food preservation. The outcome of the dried produce is neat and free from contamination by smoke or other agents. The dryer was more efficient for drying vegetable with high moisture content. It was observed that the higher the initial moisture content of the crop the more efficient the dryer was.

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