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Design, Fabrication and Performance Evaluation of Cabinet Dryer for Okra, Chili Pepper and Plantain at Different Temperature, Relative Humidity and Air Velocity

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Abstract:
A cabinet dryer for Okra, Chili Pepper and Plantain was designed, fabricated and the performance evaluated to improve the storage conditions and help constrain wastage.
It consists of three units: drying chamber, blower and heat exchanger. The performance test and evaluation was done using Okra, Chili pepper and Plantain as the test material at drying chamber temperatures of 40, 50, 60 and 70 ºC for safe drying. The moisture of Okra, Chili pepper and Plantain decreased with increase in drying time. Also for all the vegetables, at all drying time levels, moisture content decreased with increase in air flow rate. But for the relative humidity check, increase in relative humidity increases the drying time; the higher the relative humidity, the longer the drying time.
The performance evaluation was carried out using Okra, Chili pepper, and Plantain at temperatures of 40, 50, 60 and 70 ºC, at relative humidity of 65%, 70%, 75%, 80%, 85% and air velocity of 0.49m^3/s, 1.89m^3/s, 2.49m^3/s, 3.58m^3/s and 3.89m^3/s. the equipment was designed for a mean capacity of 10kg per batch.

1. Introduction

Fruits and vegetables are agricultural products commonly eaten as food throughout the world and are known for their different nutrients and health benefits. However, most of the harvested vegetables and fruits are susceptible to deterioration and there are lots of wastages involved from the harvesting stage, transportation, preservation and to the delivery to the end users. The moisture content in the agricultural produce contribute greatly to the deterioration of vegetables, and fruits, for the produce to be stored for long period, it is necessary to reduce the moisture content to a certain well defined level. This will prevent the production of undesirable chemical prepositional change in the produce by bacteria, molds and enzymes which will spoil the fruits and vegetables. Fruits and vegetable can be successfully preserved by reducing their moisture content to a level that will prevent the activities of micro-organisms and fungi from deteriorating them.

In most developing countries, dehydration of agricultural produce such as pepper, yam, plantain, okra, cassava, and others using the sun (natural drying) is a very common practice. Here the materials are spread on the floors such as the rock surfaces, soil (clay) grounds, cemented pavements, raise mesh tray, and other devices. (Jeon, and Halos, 1991). This method is a slow process which could take four to six days for the product to get dried. Product quality suffers because of prolonged drying which makes the product susceptible to contamination. Losses are also incurred due to repeated handling and direct consumption by animals.

The use of solar dryers as an improved means of natural drying using the sun's energy is gradually gaining popularity and replacing the direct sun drying. Solar dryers produce better quality products within a relatively shorter period. Odogola, (1991) observed that the natural convection solar dryer in clear and sunny weather produces mold-free chips when dried between two to three days up to 12-13% moisture content. Drying using solar dryer or direct sun drying depends mainly on the weather and, therefore, not reliable and unattractive during the rainy season or wet weather (Gyanwali, *et al*, 2014).

Hot air cabinet dryer does not have the negative tendencies mentioned above. It is more efficient, permits closer control of the drying operations, produce quality products and does not depend on the weather (Daniel, 1996). Cabinet dyer produces uniformity in air temperature and velocity throughout the chamber. Airflow shutters are provided for uniform air distribution to all the trays inside the drying chamber, and very compact to reduce the material cost. Often digital temperature controller is attached to ensure that the drying temperature is kept constant throughout the drying process (Bolaji, *et al*, 2008).

Drying is removing a large portion of the moisture content contained in a product in order to considerably reduce the reactions which lead to the deterioration of the products. The removal of moisture arrests the growth and the reproduction of microorganism that would cause decay and minimizes many of the moisture-mediated deterioration reactions. This can be done by simultaneous heat and mass transfer and is a classical method of food preservation that provides longer shelf life, reduce weight and volume (Malaisamy, and Sabanayagam, 2014).

Many dryer types have been used in the domestic and industrial sectors. The dryers that are commonly used are tray dryers, tunnel dryers, drum dryers, fluidized bed dryers, spray dryers, flash dryers, rotary dryers, belt dryers, vacuum dryers and freeze dryers. Among these dryers, the tray dryer is the most extensively used because of its simplicity and economic design. The fruits and vegetables are spread out on trays at an acceptable thickness so that the product can be dried uniformly. Drying heat may be produced by hot air stream across the trays, conduction from heated trays, or radiation from heated surfaces. In a tray dryer, more products can be loaded as the trays are arranged at different levels (Ibrahim, *et al*, 2014). The key to the successful operation of the tray dryer is uniform airflow distribution over the trays. The tray dryer may be applied to a solar dryer or any conventional dryer that uses fossil fuel or electrical allow energy. Good airflow distribution will ensure the final moisture content of the dried products on the trays is uniform.

A forced air circulation with various ranges of temperature, relative humidity and volumetric air flow rate with a diffusion method was selected to obtain the uniformity in distribution of air velocity and temperature. The design requirement for the airflow distribution unit is to: (i) provide uniform distribution to all the trays inside the drying chamber. (ii)compact the dryer in order to reduce the material cost. Additional attention and operation are needed to prevent uneven drying patterns, hence an important design consideration was taken to facilitate even distribution of hot air throughout the drying chamber to ensure uniform moisture removal process. The design also include devices with temperature, air velocity and humidity measurement which does not exist in other drying equipment. This work is therefore aimed at reducing fruits and vegetable wastage and improving their storage conditions with the specific objectives of designing and developing a cabinet dryer, fabricating the dryer and testing the performance of the dryer.

2. Design and Development Considerations of the Cabinet Dryer

2.1. Design Considerations

(i) The dryer should be able to handle the drying of other fruits and vegetables apart from the ones being considered.
(ii) High quality dried products without contamination by tray materials.
(iii) Overall cost of the dryer must be very low and affordable to farmers.
(iv) The dryer must be properly lagged to avoid heat losses during drying.
(v) Air circulating fan must be effective for even heat distribution within the drying chamber.

The dryer has the following features for effective functionality.

(i) Drying chambers to house the trays.
(ii) Hot moist air exhaust.
(iii) Heaters.
(iv) Fan
(v) Thermostat.

2.2. Design and Development Analysis

The design of the cabinet dryer was analyzed in accordance with the following: Amount of moisture to be removed, quantity of air required to effect drying, volume of air to effect drying, blower design and capacity, quantity of heat required, heat transfer rate and the actual heat used to effect drying.

2.2.1. Dryer Design Equations and Calculations

Design was done on 10 kg plantain wet basis. The plantain density was determined using the formula:

$$\rho = \frac{M}{V} \qquad 1$$

Where

M= mass of plantain in the tray (10kg)

$V = \pi r^2 h$ = volume of plantain slice 2

r = radius of the fresh cylindrically cut plantain

h = height of the fresh cylindrical cut plantain

π = constant with the value of 3.142

Density is given by mass/volume i.e. m/v

Density = 460kg/m^3 (Abioye, *et al.*, 2011)

Volume of tray = $Volume = \frac{m}{\rho}$ 3

Where m = mass of product in the trays (plantain) 10kg

$Volume = \frac{10kg}{460kg/_{m^3}}$ 4

Volume = 0.022m^3

Assuming 3 trays in the cabinet Volume of each tray = 0.00370m^3

Considering a fillage factor of 66%

Total volume will be

V_{total} = 0.0112 x 100/66 = 0.0170 m^3

Each tray volume will be

V_{single} = 0.0037 x 100/66 = 0.0056 m^3

Considering a rectangular shape of depth 5 cm as recommended by Fellows, (1998),

$Volume = L \, x \, B \, x \, D$ 5

When L = length
B = breadth
D = depth

At a depth of 0.05m

Volume of tray is given by:

Volume = LBD 6

Where L = length
B = breadth
D = depth

- Design of drying chamber

The dimensions of the drying chamber were determined with the assumption that the configuration is cuboid and 10kg mass of plantain.

The density of plantain = 460kg/m^3 (Abioye, *et al.*, 2011)

1 kg of plantain slices occupies a volume of $\frac{1}{460kg/m^3} = 0.0022\, m^3$

Therefore, 10kg will occupy 0.022m^3

- Volume of the drying chamber

$V = lwh$ 7

Where V = Volume of the chamber, L = Length = 0.5, W = width = 0.4, h = height = 0.6

$V = 0.5 \times 0.4 \times 0.6 = 0.12\, m^3$

- Moisture content determination

$MC = 100\frac{(w_1 - w_2)}{w_2} = 100\frac{(84.997 - 3.001)}{3.001}$ 8

$$MC = 2732.289$$

Where M_C= Moisture content
M= Mass of dryer content
W_1 = Initial moisture of plantain before drying
W_2= Final moisture of plantain after drying

Initial moisture content of chili pepper, plantain and okra were determined to be 84.997%, 62.042% and 86.692% respectively. Hence:

Average initial moisture content for chili pepper, plantain and okra

$M_{avi} = 77.692$

$T_{wm} = 0.7019 + 0.01676(77.692) - 0.0011598(77.692)^2 + 0.00001824(77.692)^3$

$$T_{wm} = 3.557 g/cm^3$$

Final moisture content of chili pepper, plantain and okra are 9.916%, 9.04%, and 9.62% respectively were initially determined experimentally in the laboratory with small oven dryer. Bearing in mind, from literature, to obtain a longer shelf life, the final moisture of the dried product should be of the range between 9% to 10%.

Average final moisture content for chili pepper, plantain and okra

$M_{avf} = \frac{9.916 + 9.04 + 9.62}{3} = 9.525\%$

Where M_{avf} =average final moisturecontent

(b) Amount of Moisture to be removed in kg (M_R)

$M_R = M\left[\frac{Q_1 - Q_2)}{1 - Q_2}\right]$ 9

where, M is dryer capacity per batch (10.0kg), Q1 =initial moisture content of the plantains to be dried (77.69%), Q2 = maximum desired final moisture content based on experimental results (Ehiem, 2008) which is 9.28%. MR is therefore determined to be 7.54kg.

(c) Quantity of air required to effect drying
This can be calculated using
$Q_a = \left[\frac{M_R}{H_{r2} - H_{r1}}\right]$ 10
H_{r1} *and* H_{r2} are initial and final humidity ratios (kg/kg) respectively and MR is as determined in Eq. (1). The average ambient temperature and relative humidity are 31ºC for dry bulb temperature, 280 ºC for wet bulb temperature. The initial humidity ratio (Hr_1) is determined to be 0.01 kg/kg dry air using the psychometric chart. After the heat has been supplied, the temperature of the productrises to 50 ºC giving the final humidity ratio (Hr_2) as 0.028kg/kg dry air. Substituting, the quantity of air required to effect drying (Qa) is 418kg.
(c) Volume of air to effect drying
$V_a = \frac{Q_a}{\rho_a}$ 11
Where, ρ_a is the density of air determined at 0 ^oC to be 1.115 kg/m^3 .The volume of air to effect drying is therefore calculated to be 376.92 m^3

2.2.2. Blower Design and Capacity
The selection was based on the characteristics of centrifugal fan performance curve based on the Equations (4) – (6):
$N_2 = N_1 \left[\frac{q_1^{0.5}}{H_1^{0.75}}\right]\left[\frac{q_1^{0.75}}{H_1^{0.5}}\right]$ 12
$D_2 = D_1 \left[\frac{H_1^{0.25}}{q_1^{0.5}}\right]\left[\frac{q_2^{0.5}}{H_2^{0.25}}\right]$ 13
$h_{p2} = h_{p1} \left[\frac{D_2^5}{D_1^5}\right]\left[\frac{N_2^3}{N_1^3}\right]$ 14
where N is the rpm of the electric motor, H is thestatic pressure (pa), q is the volumetric flow rate of air(m3/min), D is the diameter of the blower blade (m) and hp isthe motor horse power
the blower capacity is calculated from
$BC = Q_a + Q_a(n)$ 15
$Q_a = Q_m + R_e + Z_k$ 16
$Q_m = \rho \times q$ 17

$$Q_m = \frac{1.109kg}{m^3} \times \frac{70.79m^3}{min} = 78.51\ kg/min$$
$$R_e = 0.25Q_m = 19.63\ kg/min$$
$$Z_k = 0.02Q_m = 1.5702\ kg/min$$

$n = 15\% = 0.15$ (n= percentage safety factor that ensures an adequate supply of air in all operating conditions

$$Q_a = 78.51 + 19.63 + 1.57 = 99.71$$
$$B_c = 99.71 + 99.71(0.15) = 114.69\ kg/min$$

Selection of fan was done based on Greenheck fan selection chart models

2.2.3. Quantity of Heat Required for Effective Drying
$H_r = (M_x H_k) + (H_L M_R)$ 18
where M_x = dryer capacity per batch; HK =CT (T2-T1), whereas CT is specific heat of plantains = 4.6 KJ/kg^{o}C; HL = latent heat of vaporization; and MR = amount of moisture to be removed (kg) = 7.54 kg. Substituting.
$H_r = (10 \times 71.46) + (2093 \times 7.54) = 16495.82KJ$

- Actual heat used to effect drying

The quantity of heat used in effecting drying H_D in KJ can be determined using equation below

$H_D = C_a T_c M_R$ 19
Where, $C_a = specific\ heat\ capacity\ of\ air = 1.005\ kg/kg^oC$; $T_c = temperature\ difference = (50 - 32) = 18$; $M_R = moisture\ to\ be\ removed = 7.54$; substituting, the quantity of heat is therefore calculated to be 136.39KJ.

2.3. Fabrication, Assembly, Description and operation of the dryer

2.3.1. Choice of Materials

Material	Specification	Quantity
1. Aluminum Sheet	thickness 1mm	$2^1/_2$
2. Stainless steel mesh	thickness 2mm(30cmX40cm)	3 pieces
3. Pairs of hinges	size 5cm	1 pair
4. Fan	0.25hp Centrifugal Fan	1piece
5. Heater	183 watts	1piece
6. Thermostat	0^0C- 100^0C	1piece
7. Lagging materials	Ammaflex	$^1/_2$ roll
8. Heater cable	3mm thickness	10 m
9. Aluminum Foil	0.5mm	2 Rolls
10. Fan regulator	SMC Board	1piece
11. Copper Wire	2mm	6m
12. Castol Wheel	7cm diameter	4 pieces
13. Angle Iron	6mX4cmX4cm	1 piece

Table 1: Material selection and specification for Cabinet dryer construction

Putting in mind the environmental factor, economic factor and availability of this dryer to Nigerians, the materials used were sourced locally and they were selected based on some factors like ability to withstand heat, vibration, humid air fatigue and stress. Electric heater and thermostat were purchased and used in the fabrication.

Using the guillotine machine, the two standard sized aluminium sheets of 121.92cm x 243.14cm were cut into eight pieces of 50cm x 60cm sheet, and four pieces of 50cm x 40cm sheet. And also using the same guillotine, standard length of angle iron 18ft (6 meter) was cut into four pieces of 60cm, two pieces of 50cm, and 2 pieces of 40 cm for the framing of the structure for the cabinet dryer. Using hacksaw, half a roll of armaflex insulator was also cut into eight pieces of 50cm x 60cm and four pieces of 40cm x 50cm.Heat resistant aluminium foils were also cut into sizes with the ammaflex insulators to wrap the insulators. The aluminium sheets were used to form the outer and the inner walls, top cover and the base of the dryer chamber. The ammaflex insulator was inserted in – between the inner plate and the outer plate. In the same manner, the locking device and the shutter were constructed using 0.1cm mild steel gauge and 0.1cm aluminium gauge respectively. The vertical column (Trays) which hold the fruits and vegetables were fabricated with stainless steel mesh reverted to pieces of aluminium which was cut to 50cm x 40cm x 5cm size. The various components were joined together by revelting and assembled, except the stand which was clamped with castol wheel for easy movement of the dryer. Figures 1a-e shows the isometric drawing of the cabinet dryer.

2.3.2. Description of the Cabinet Dryer

The dryer consists of a rectangular chamber, containing three shallow trays spaced 10 cm apart. A low capacity fan of 0.25hp is attached to an opening at the back of the lower bottom of the dryer. In front of the fan, a 183 watts heating element was installed to supply heat to the dryer at a position which ensures uniform hot – air circulation within the dryer.

A duct work with diffuser (shutter) was introduced to direct part of the air towards the heating element and part of the exhaust duct. The heating element was fixed right at the lower part of the dryer in front of the fan and then connected to electric power source on the element terminal box at the upper right side of the dryer leaving a spare one on standby. A control box (panel) installed at the top right side, controls the operation of the dryer and ensures constant temperature in the dryer and also has the facility to predetermine the operation periods. This control box consists of devices such as: temperature controller, with thermocouple probe contactors with overload relays, timer, starter, and on and off Switches.

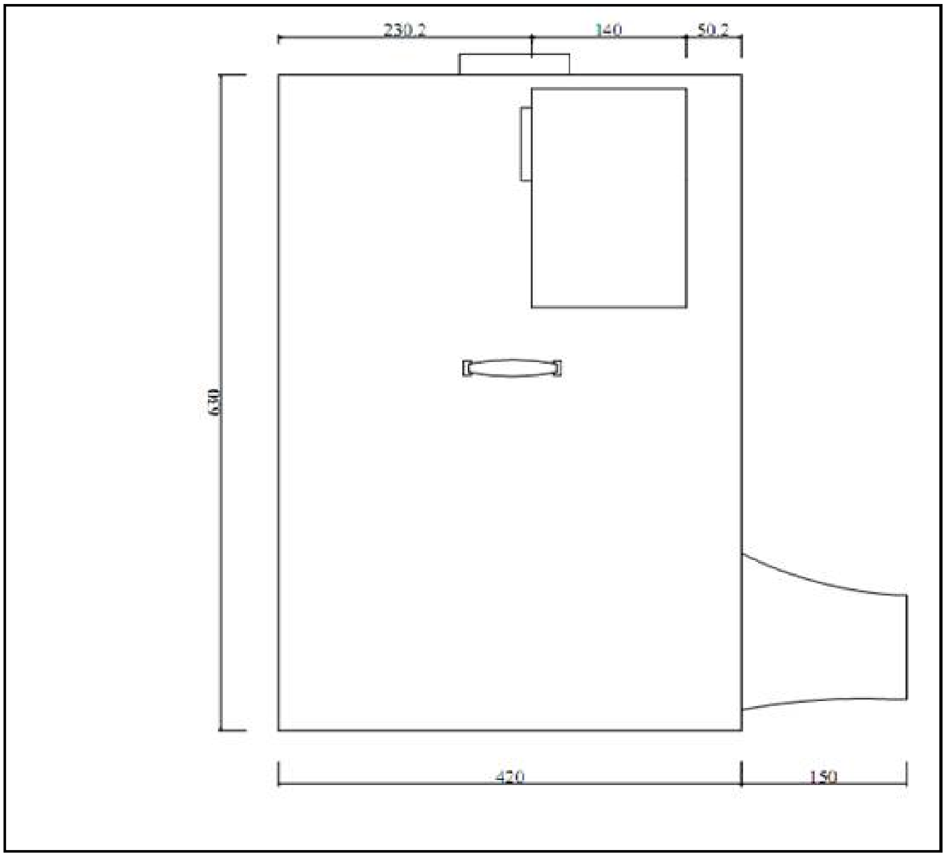

Figure 1a: Plan View of the Dryer

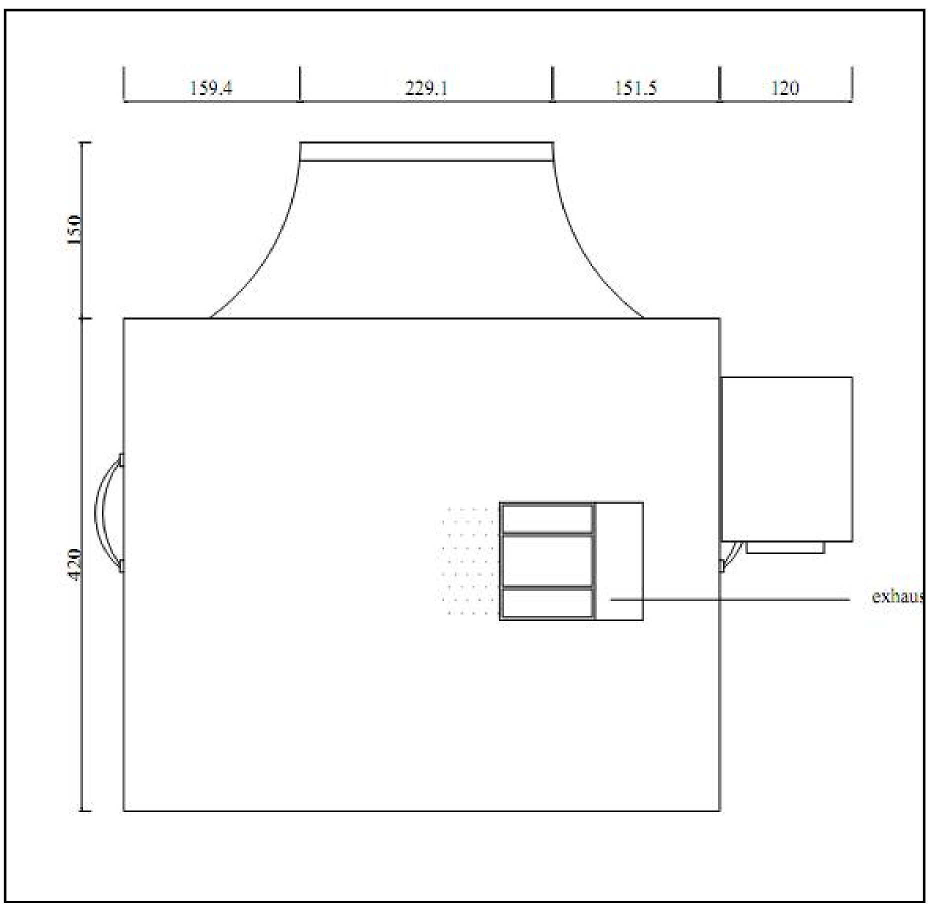

Figure 1b: Side View of the Dryer

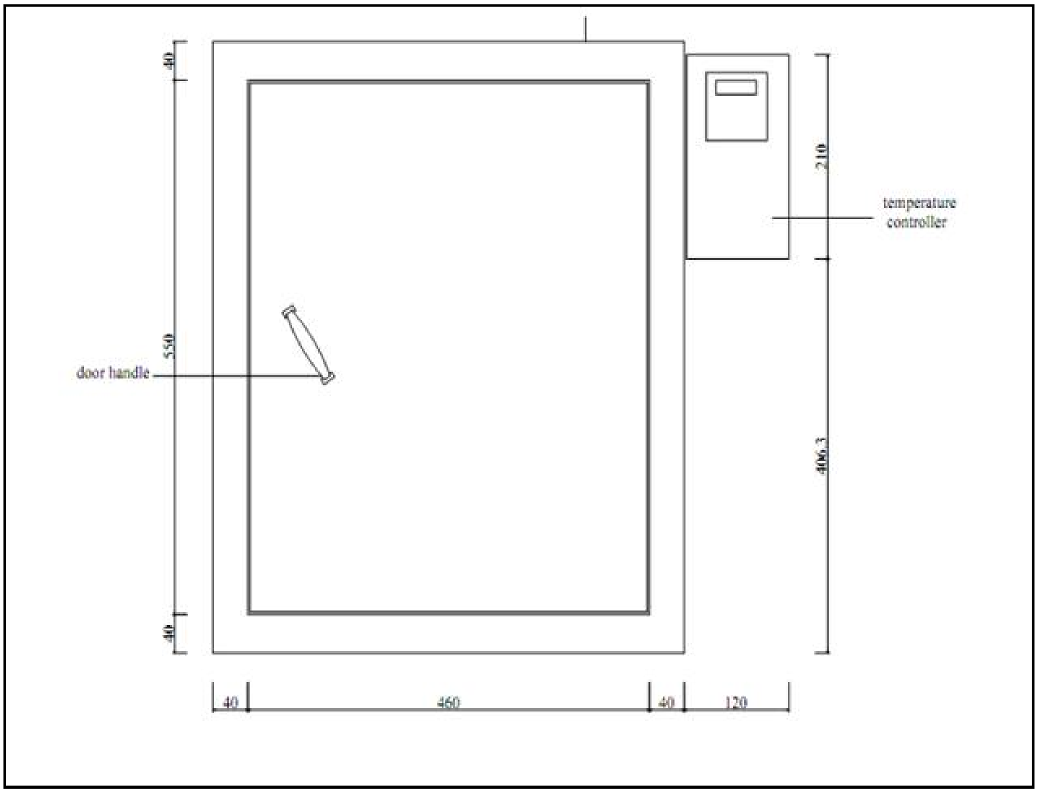

Figure 1c: Front View of the Dryer

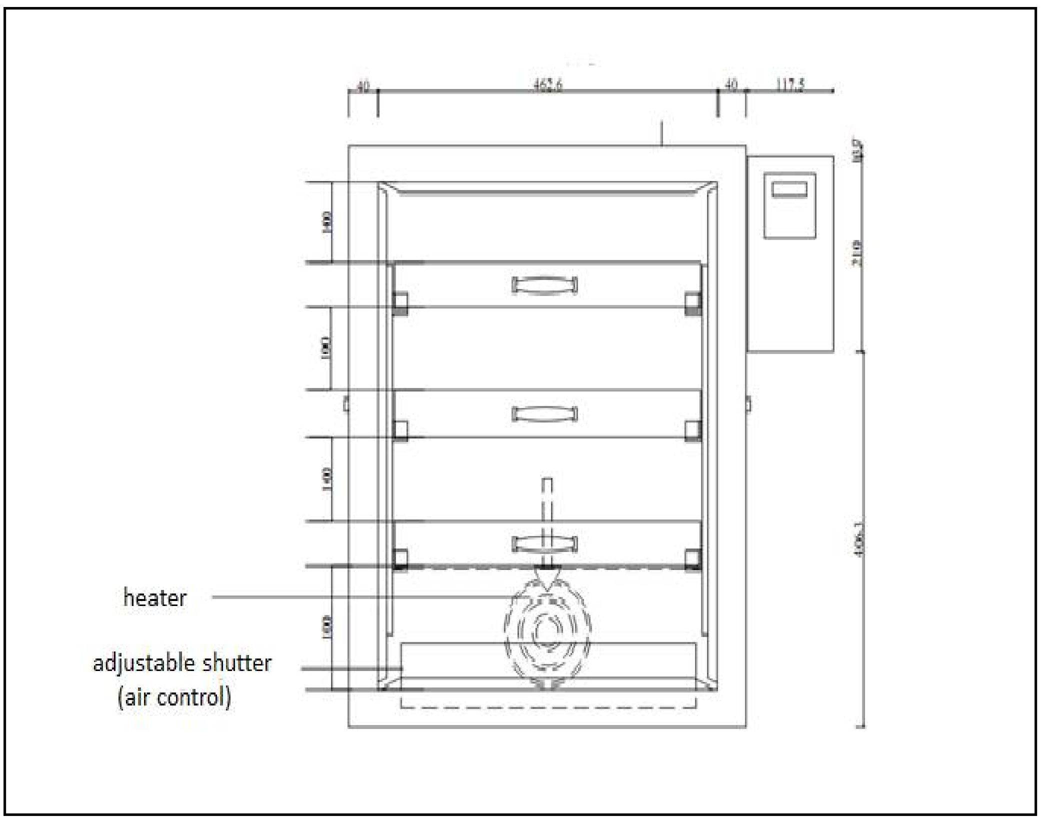

Figure 1d: Sectional View of the Dryer

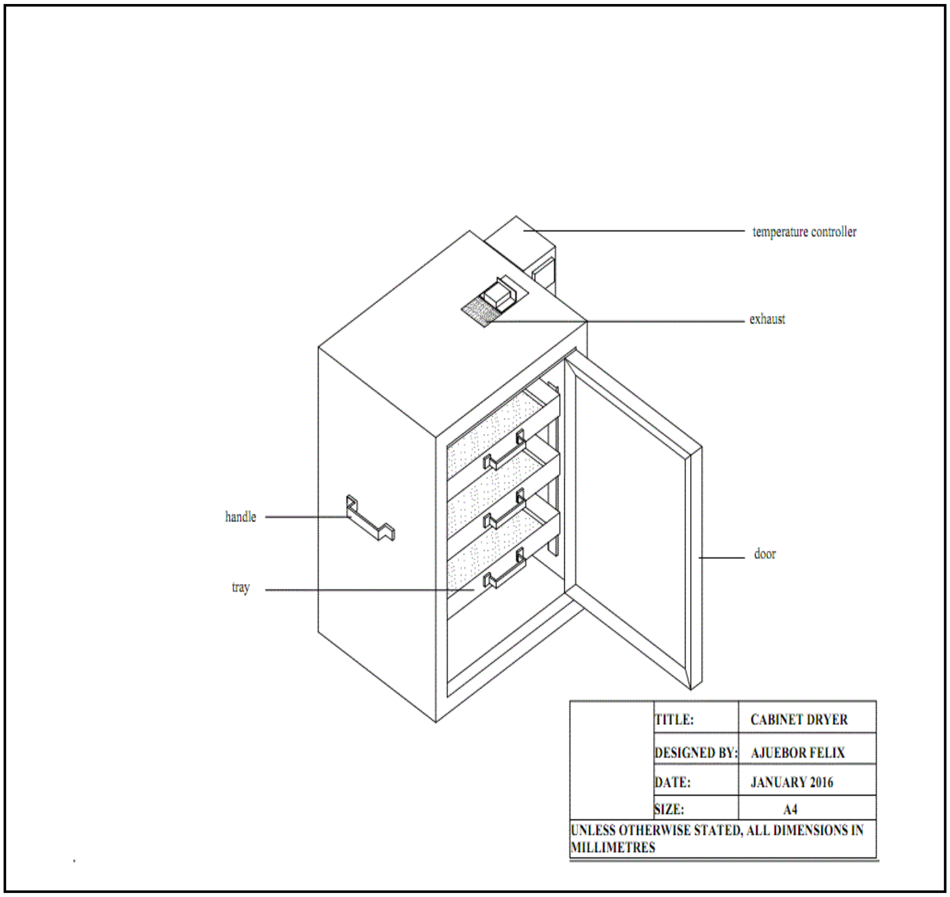

Figure 1e: Isometric View of the Dryer.

- Performance test and evaluation: The materials used for testing of the equipment include chili pepper, plantain, okra, weighing balance, mercury-in-bulb thermometer, hydrometer, knives.
- Samples Collection: The fresh plantain, okra, and chili pepper samples were purchased from local suppliers at Idi-oro, Lagos, South-West Nigeria. The selected samples were sorted, cleaned with brushes and then weighed. The samples were kept in for some hours to achieve equilibrium temperature with the environment before usage.
- Experimental Design: The experimental design for this work is divided into two main parts. First of all, single factor experiments were conducted to determine the suitable range of conditions for drying the selected materials, namely; drying chamber temperature, drying time, relative humidity, and air flow velocity. Each independent variable was varied over a range while keeping the others constant.

2.4. Drying Procedure

The experiments were carried out using fresh chili pepper, okra and unripe plantain with average moisture content of 84.997%, 86.037%, 62.04% respectively. The materials were cleaned with soft brushes to remove any form of dirty, no pretreatment was done. The materials were cut into 2mm thick. The slices materials were weighed and loaded into each of the three trap after cleaning the weight on each tray was 1000gm (1kg).The dryer was cleaned and heated up to the required drying temperature before the trays were put in the dryer. The temperature level in the dryer was set at 40^0c, 50^0 c, 60^0c, and 70^0c and was regulated by temperature controllers for each of the above temperature. The hot air velocity and the relative humidity were initially constant $3m^3/_s$ and 60% respectively for the testing of the equipment (dryer). The drying process was monitored at every 30 minutes intervals. The second stage of drying the temperature was kept constant at 70^0c while the hot air velocity and relative humidity were varied at $0.49m^3/_s$, $1.89m^3/_s$, $2.49m^3/_s$, $3.58m^3/_s$, and $3.88m^3/_s$, and 60%, 65%, 70%, 75%, and 80% respectively. The drying process continue as the change in weight is constantly removed at 30 minutes interval until a constant weight is obtained in any of the experiment. The reading (experiment) is terminated at equilibrium weight was achieved.

Figure 2a:View of plantain in the cabinet dryer

Figure 2b: View of chili pepper in the cabinet dryer

Figure 2c: view of Okra in the cabinet dryer

3. Results and Discussion

3.1. Effect of Drying Parameters on the Plantain, Okra and Chili Pepper Drying

The effect of the drying parameters (drying temperature, hot air velocity, and relative humidity) on the drying of plantain, okra, and chili pepper slices are shown in Figure

4. Discussion

4.1. Effect of Temperature on Drying of Plantain, Okra and Chili Pepper

It was observed that as drying air temperature increases, the drying time decreased. From Figure 3, the shortest drying time for okra drying is obtained at 70^{o}C, which is 480 minutes, followed by 60^{o}C, which is 600 minutes, then 50^{o}C, which is 870 minutes and finally 40^{o}C, which is 990 minutes. It was also observed from Figure 4 that the shortest time plantain drying is achieved at 70^{o}C, which is 360 minutes, followed by 60^{o}C, which is 480 minutes, then 50^{o}C, which is 600 minutes and finally 40^{o}C, which is 840 minutes. The effect of drying temperature on chili pepper drying is presented in Figure 5. The same trend was observed for other materials. For chili pepper at 40^{o}C, time of drying was 960 minutes, at 50^{o}C, time of drying was 690 minutes, drying time was 480 minutes at temperature of 60^{o}C and it was 420 minutes at 70^{o}C. It was equally noticed that the lowest drying time was achieved at the highest temperature (70^{0}C) and at the lowest drying temperature (40^{0}C), the higher drying time was obtained.

From the above analysis of temperature effect on drying time, it was observed that plantain slices dried faster than okra and chili pepper slices. Slow rate of drying of okra and chili pepper could be attributed to high fibre content of the okra and chili pepper. During the drying of okra at 40^{o}C, the drying time was 960 minutes and at 70^{o}C, the drying time was 450 minutes representing a reduction in drying time of 53.13%.For chili pepper, on the other hand, drying time was 960 minutes at a temperature of 40^{o}C. At 70^{o}C, the drying time reduced to 420 minutes representing 39.13% reduction. For plantain drying at 40^{o}C, the drying time was 840 minutes, but at 70^{o}C, the drying time reduced to 300 minutes representing a reduction of 64.3%.The initial moisture content of okra was 6.162 kg/kg dry matter, for chili pepper, it was 5.665 kg/kg dry matter and for plantain, it was 1.634 kg water per kg dry matter. Equilibrium moisture content was reached when no more change in weight was observed.While the relative humidity and airflow rate were kept constant. These results explained that temperature played a significant role in the selected product during dehydration. This is probably due to the fact that at higher temperature, there is a greater difference in the partial pressure between the plantain, okra and chili pepper slices and their surroundings which result in higher moisture migration from internal region and the evaporation at the product surface (Tunde-Akintunde, and Oyelade, 2014).

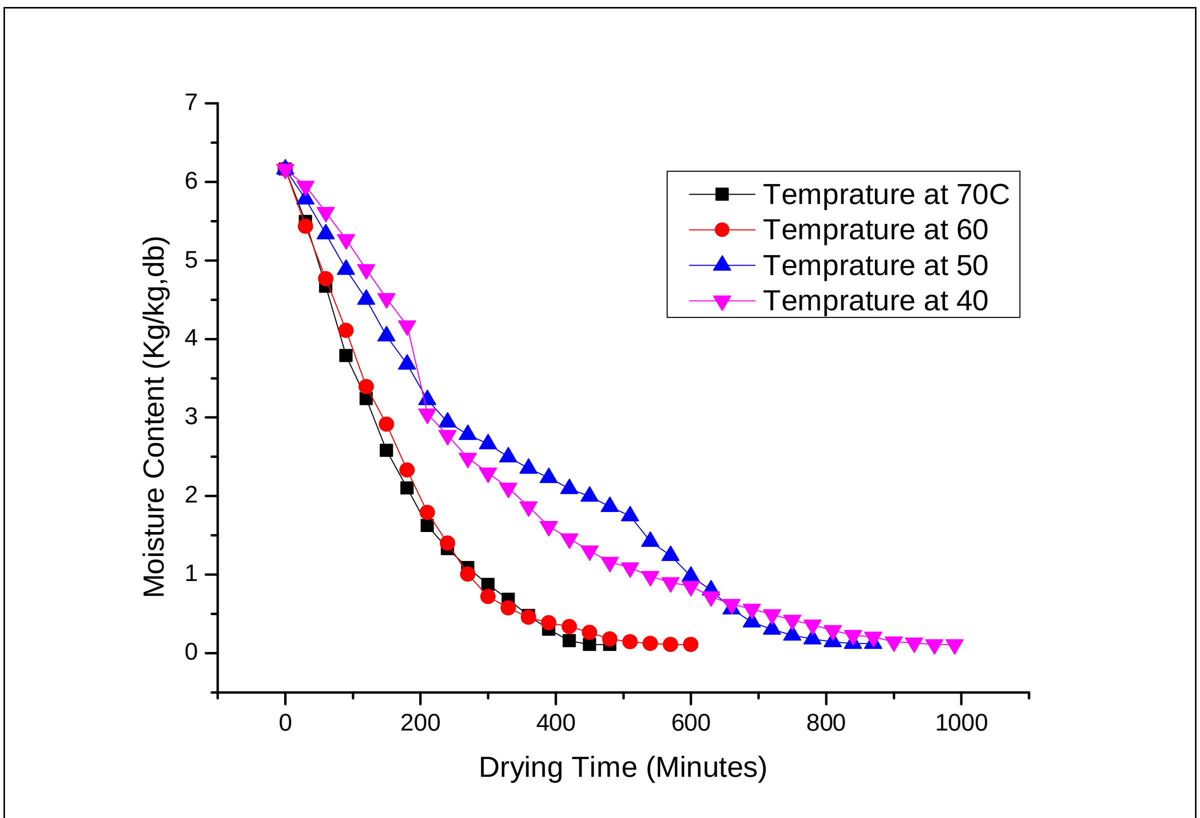

Figure 3: Drying Curves of Okra Slices at Different drying temperatures from 40^{0}C-70^{0}C

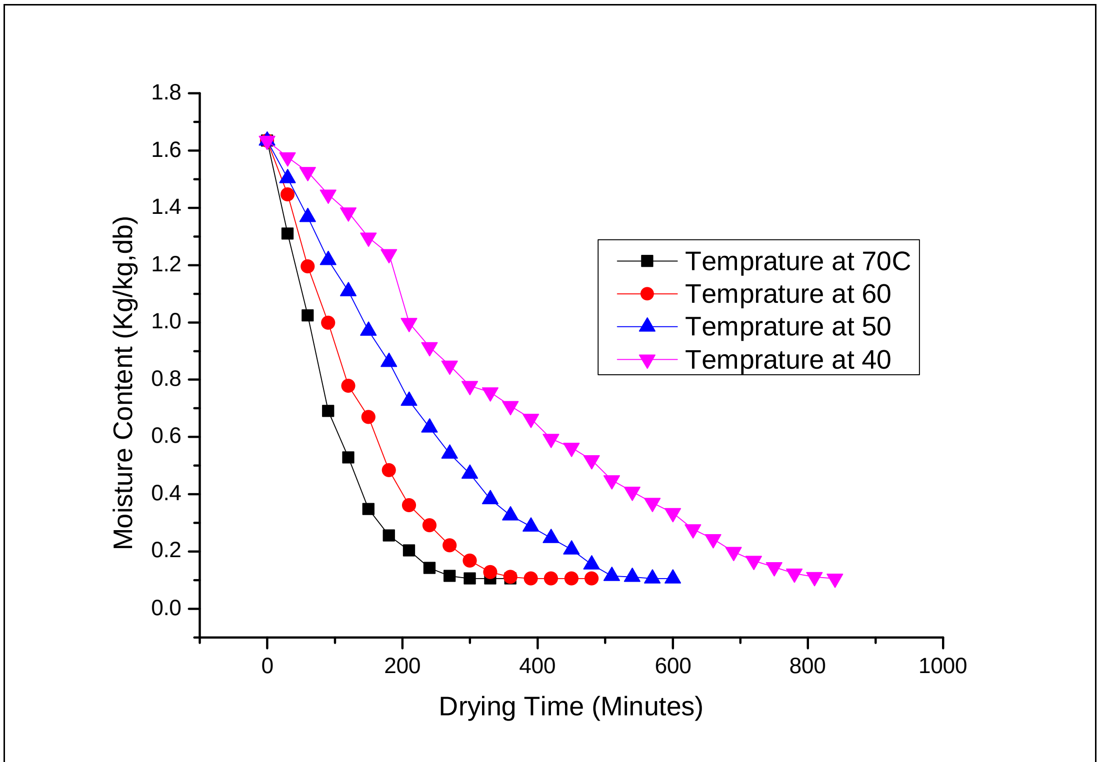

Figure 4: Drying Curves of Plantain Slices at Different drying temperatures from 40^{0}C-70^{0}C

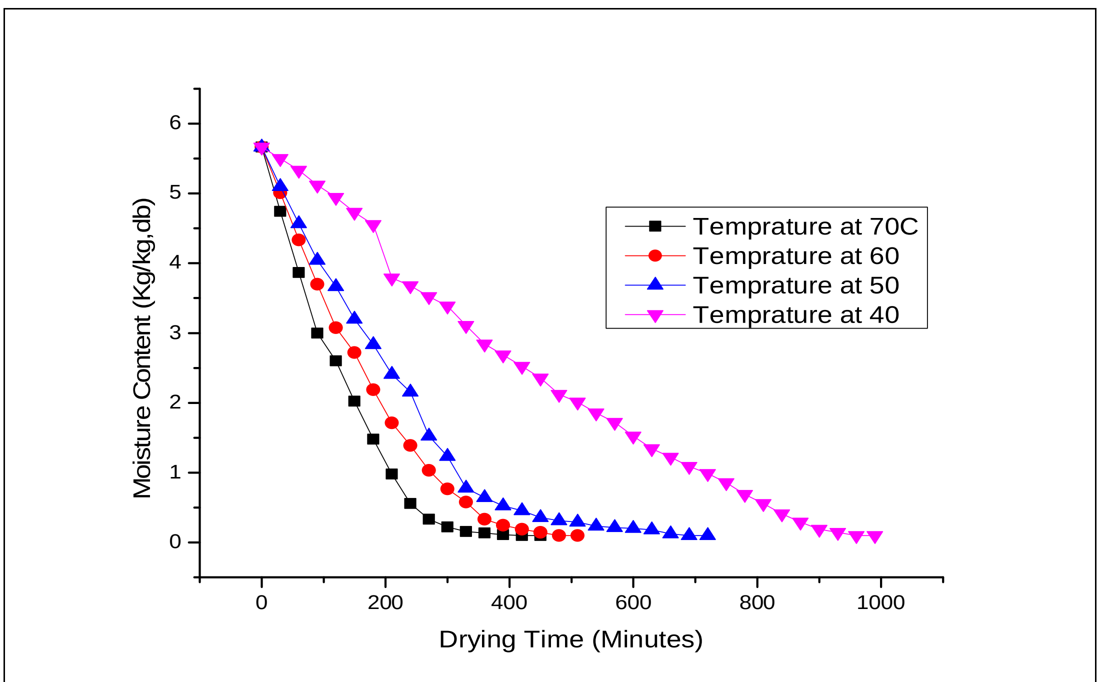

Figure 5: Drying Curves of Chili pepper slices at Different drying temperatures from 40^{0}C-70^{0}C

Effect of relative humidity and air velocity on Drying of Plantain, Okra and Chili pepper

The result of the kinetic curves of drying Plantain, Okra and Chile pepper at different temperatures and humidity and air velocities of 60,65,70,75 ^{o}C;65, 70, 75,80, 85% and 0.49, 1.89, 2.49, 3.58 and 3.89m^3/s are shown in Figure 6-11.

The drying curve shows the profile change in moisture content and drying time (t). Drying rate curve shows the drying rate profile dx/dt versus product moisture content dry basis. It was observed from the experiment that at higher relative humidity, the drying time increases. At the different relative humidity, the drying time was increasing with increase in relative humidity and this also slows down the drying rate.

In contrast, at higher drying temperature and low relative humidity, the moisture content wasbeing rapidly reduced. This observation agrees with Indholi *et al*, (2011).

In the profile of the drying rate versus drying time, the drying rate is higher at higher temperature and low humidity. This means that the time required to dry the materials to reach equilibrium moisture content is shorter. The higher the drying temperature and relative humidity, the lower the rate of evaporation of moisture from the material. This is because at higher temperatures and low humidity, the vapour pressure of pure water will be higher, so the difference in partial pressure of water vapour with water vapour pressure of pure water is great. Pure water vapor pressure difference of partial pressure of water vapour at the appropriate temperature is the driving force for the water to evaporate into the air. The greater the driving force, the greater the rate of evaporation of water into the air (Yahya 2007). From the result, air velocity has a considerable influence on the variation of the drying rate with drying time. At high air velocity, transfer of heat and mass is high and water loss is excessive (Taheri- Garavand *et al.*, 2012).

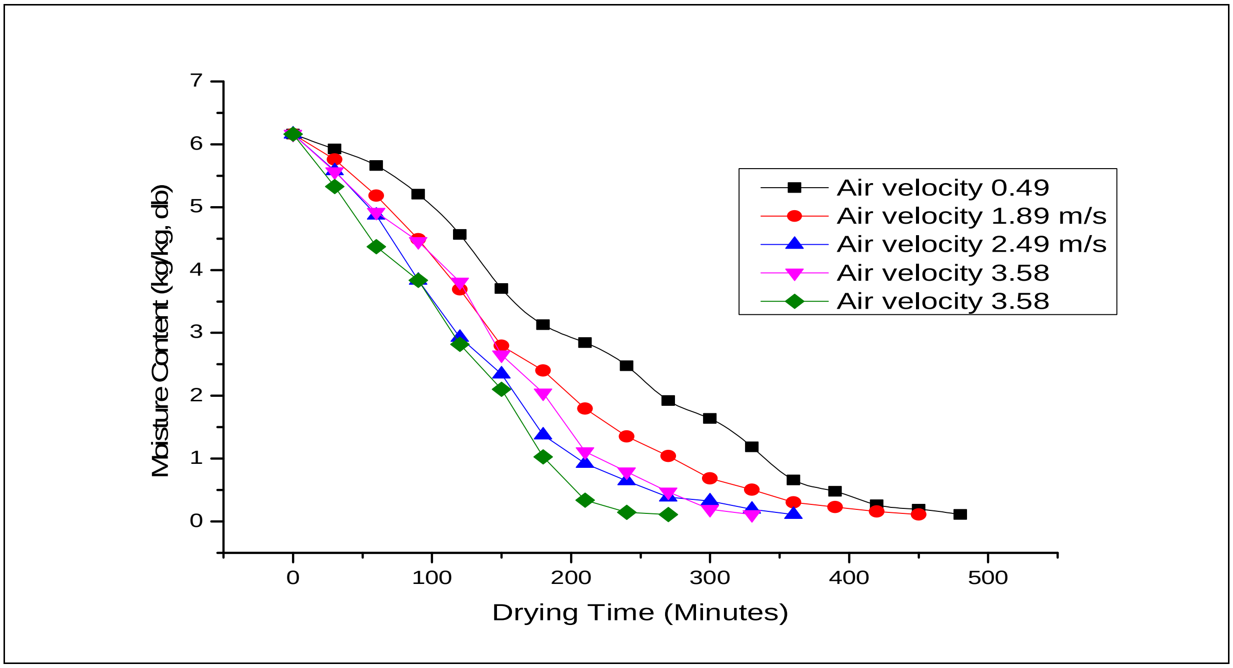

Figure 6: Drying Curves of Okra Slices at Different Air Velocities

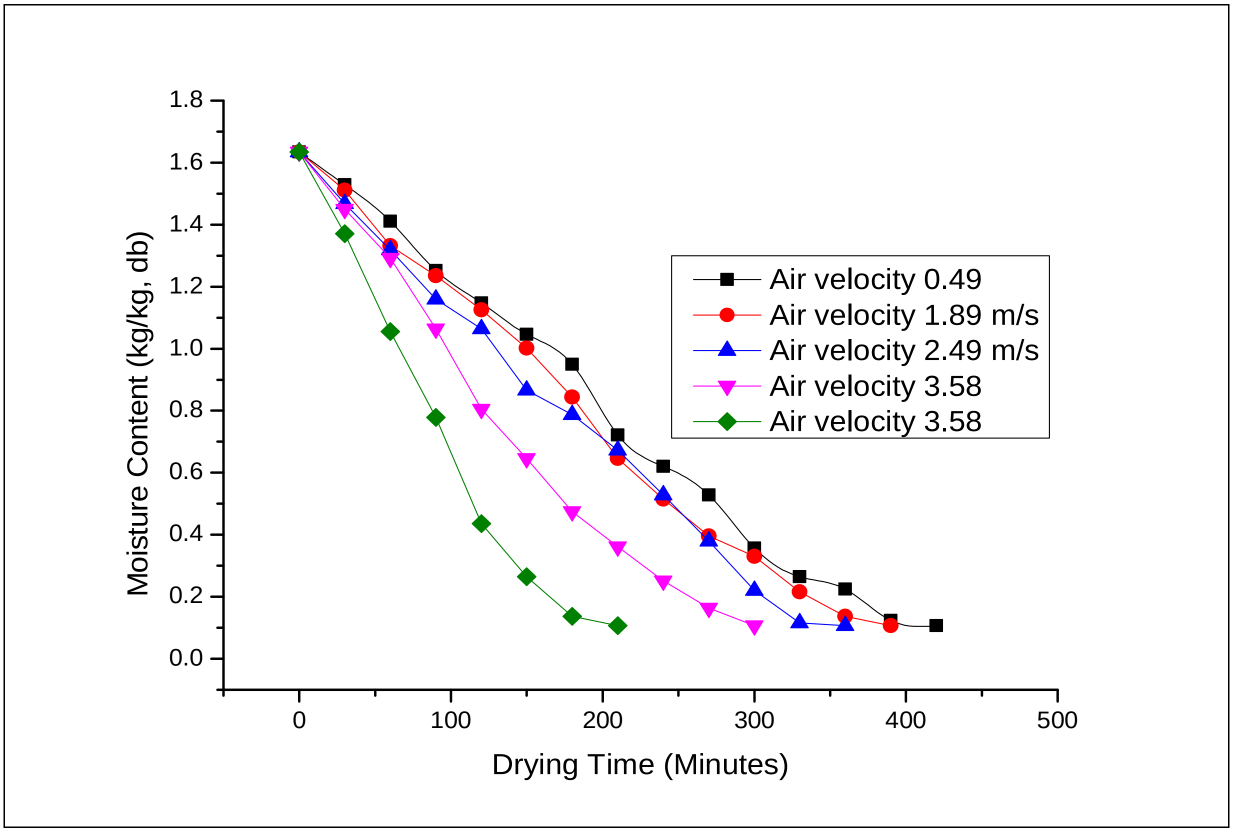

Figure 7: Drying Curves of Plantain Slices at Different Air Velocities

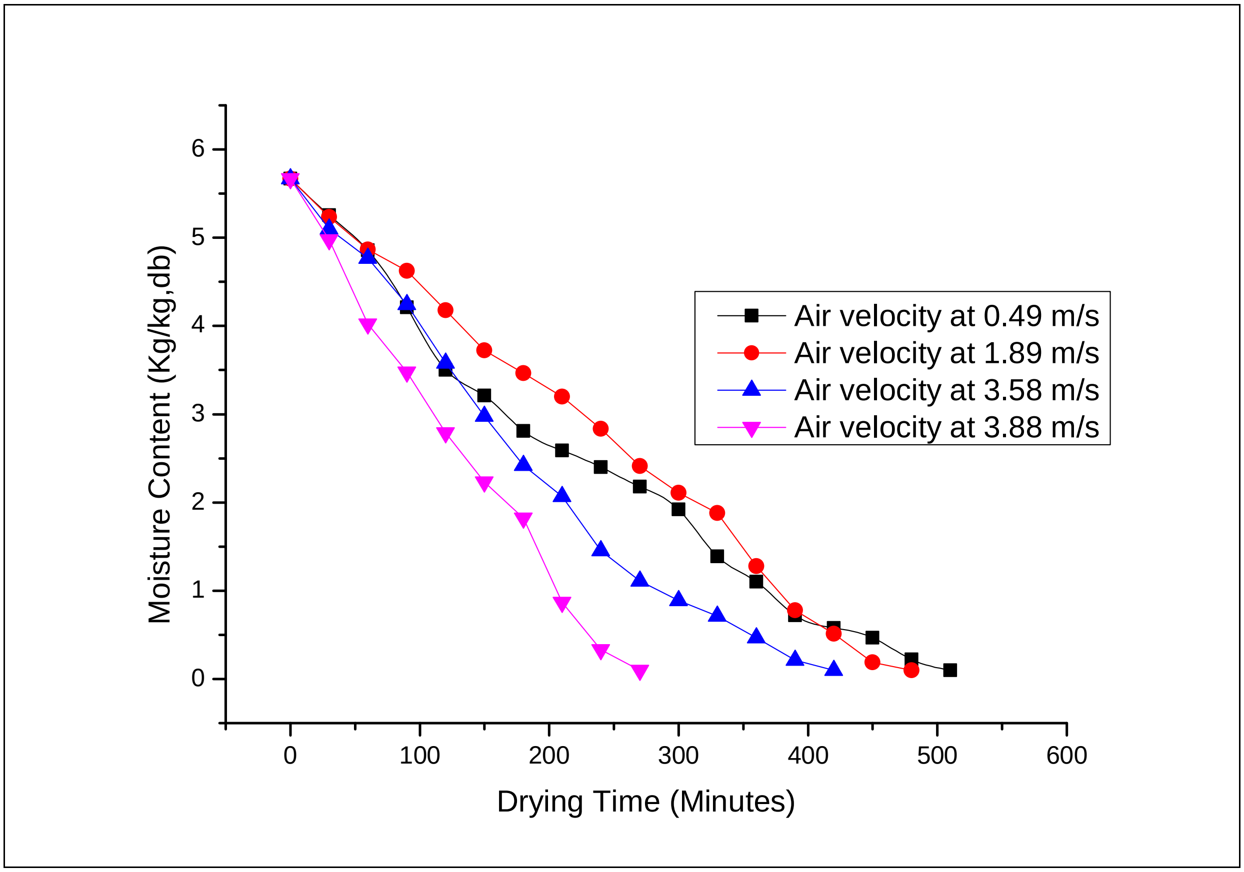

Figure 8: Drying Curves of Chili Pepper Slices at Different Air Velocities

4.2. Effect of humidity on Drying Behaviour of Plantain, Okra and Chili pepper

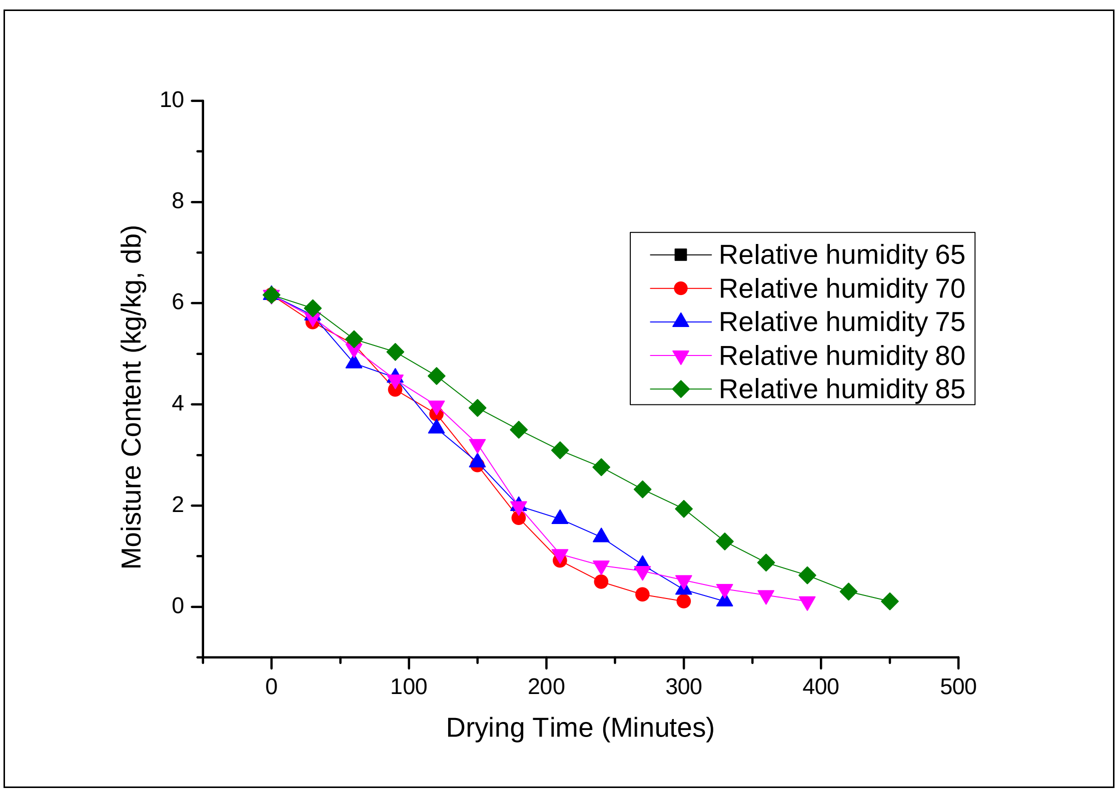

Figure 9: Drying Curves of Okra Slices at Different Relative humidity

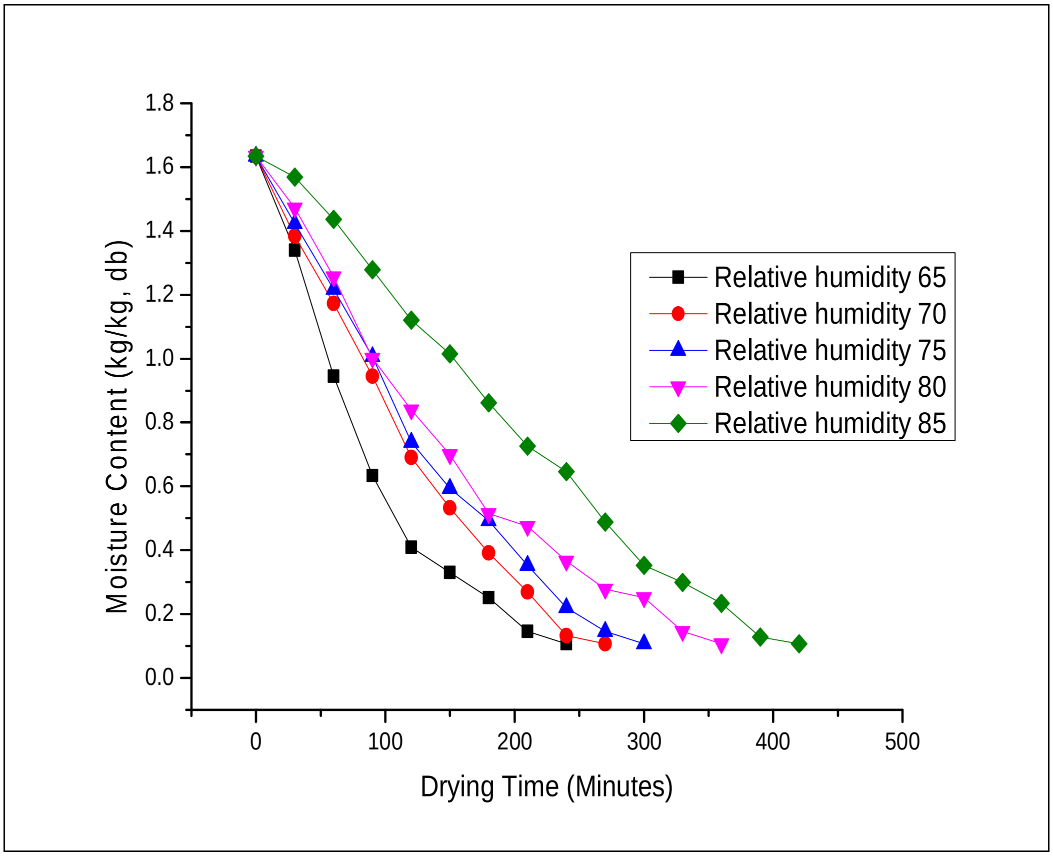

Figure 10: Drying Curves of Plantain Slices at Different Relative humidity

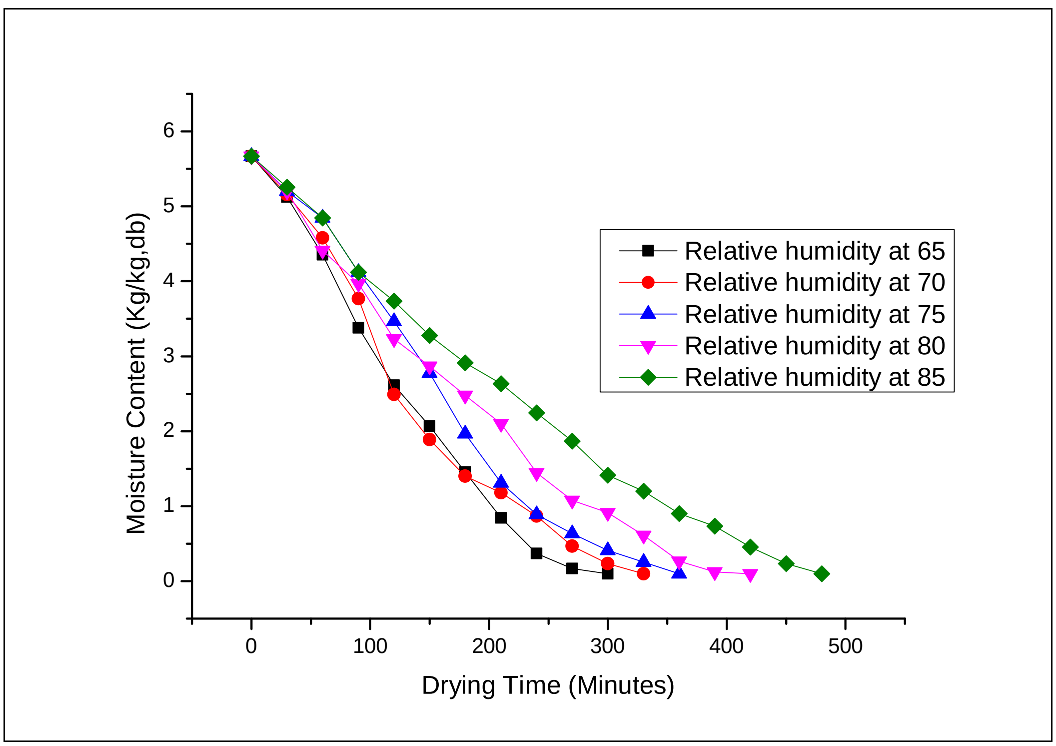

Figure 11: Drying Curves of Chili Pepper Slices at Different Relative humidity

5. Conclusion

A dryer for Okra, Chili pepper and Plantain was designed and constructed using low price materials that can easily be assessed and maintained. For the study so far the interaction between the process parameters, temperature, air velocity, and relative humidity shows that the equipment performed optimally at the 70 ^{0}C, relative humidity of 60%, and air velocity of 3.0 m/s. At these values of the process parameters the drying time was shorter and of all the analysis carried out, the result obtained was better at this point. The moisture content of Okra, Chili pepper and Plantain decreased with increase in drying time. Also for all the vegetables, at all drying time levels, moisture decreased with increase in air flow rate while the reverse was the case for drying with increase relative humidity. As the relative humidity increases, the drying time increases.

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