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Development of A Flat Plate Solar Store

Oluwasegun M. Ayoola[1], Olawale J. Abidakun[2], Taofeeq O. Olajire[3], Oluwatimilehin E. Oluwajire[4], Adekoya Oluwaseun Abiodun[5]
[1]Department of Mechanical Engineering, Federal University of Technology, Akure, Ondo State, Nigeria
[2]Department of Agricultural and Environmental Engineering, Federal University of Technology, Akure, Ondo State, Nigeria
[3]Department of Agricultural Engineering, Ladoke Akintola University of Technology, Nigeria
[4]Department of Mechanical Engineering, Federal University of Technology, Akure, Ondo State, Nigeria
[5]Department of Mechanical Engineering, University of Cincinnati, Ohio, USA

ABSTRACT

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The most noteworthy advantage of solar power as compared to other forms of energy is that it is clean and might be supplied with no contamination to the environment. Over the past centuries, it is believed that energy from fossil fuels is less expensive and more helpful than energy from other sources. This research thus results to the successful fabrication of a solar dryer with tests distributed for various performance comparisons like No-load and load performance of the dryer. Direct sun-drying comparisons depicted discernable contrasts within the final moisture content specified. The utmost temperature recorded within the drying chamber and solar dish for No-load are 44.5°C and 52 °C respectively. Whereas when the cupboard is loaded, the highest temperature of 34.5°C and least temperature of 23°C are recorded. An average temperature of 27°C was obtained, thereby giving the solar dryer an exegetic efficiency between 70% and 80%. Performances of the tests were done from 9am to 5pm. The solar store that was designed to heat to the drying chamber within the night was found to possess its most elevated temperature at 43°C. These performance results were achievable due to daily precipitation, and in some cases, cloudy days when the sun was not shining at its peak. The load outcome was done with red-sweet pepper and yam food items.

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I. INTRODUCTION

The sun is a sphere of heightening hot gaseous matter with a diameter of 1.39×10^{9} m. The solar radiation strikes our planet a within 8 minutes and 20 s after leaving the large furnace, the sun, which is 1.5×10^{11} m away [1]. The sun incorporates a great black body temperature of 5762 K. The temperature within its central region is far higher and is estimated at 8×10^{6} to 40×10^{6} K. In effect the sun is a continuous thermonuclear reactor within which hydrogen is changed into helium. The sun's total energy output is 3.8×10^{20}MW which is equivalent to 63 MW/m^2 of the sun's surface. This energy emanates outwards in all directions. Only a little fraction, 1.7×10^{14} kW, of the whole radiation emitted is captured by the earth [2]. However, even with this small fraction it is estimated those 30 minutes of radiation falling on earth is up to the globe's energy demand for one year. Man realized that a decent use of solar power is in his benefit, from the ancient times. The Greek historian Xenophon in his, 'memorabilia' records a number of the teachings of the Greek Rationalist Socrates (470–399BC) regarding the proper orientation of dwellings to own houses which were cool in summer and warm in winter [3].

Since ancient times, the sun has dried and preserved man's food. It has additionally gaseous ocean water to produce salt. Since man started to reason, he has recognized the sun as a source of motion behind every marvel in nature. As a result, many of the prehistoric tribes considered Sun as a "god ". Numerous scripts of Old Egypt say that the incredible Pyramid, one amongst the man's prominent engineering accomplishments, was built as a stairway to the sun [3]. Basically, most forms of energy in the world are solar in origin. Oil, coal, fuel and woods were naturally created by chemical processes, followed by advanced chemical reactions throughout that decaying vegetation was susceptible to terribly high temperatures associated with pressures over an extended period [4]. Even the wind and tide energy has a solar origin since they occur as a result of contrasts in temperature from one region of the planet to another. Until as of late, natural contamination and pollution of the environment has been of little concern to the inhabitants of the earth [5]. Twelve winter days of 1973 changed the financial connection of fuel and energy when the Egyptian army raged over the Suez Canal on October the 12th provoking a global crisis, and for the first time, involved as a part of Arab strategy, the danger of the "oil weapon ". Both the worth and therefore, the political weapon concerns quickly came to a climax when the six Gulf members of the Organizations of Petroleum Exporting Countries (OPEC), met in Kuwait and quickly abandoned the thought of holding to any extent further price consultations with the oil companies, announcing that they were raising the value of their crude by 70% [5]. The rationale for the rapid increase in oil demand occurred mainly because increased quantities of oil, produced at a very low cost, became available during the 50s and 60s from the Middle East and North Africa [5]. For the devouring nations, imported oil was cheap compared with indigenously produced energy from solid fuels [5].

In expansion to the thousands of how the sun's energy has been captured by both nature and man through time, to grow food or dry clothes, it has also been deliberately harnessed to perform variety of other tasks. Solar power is employed to heat and make buildings cool (both actively and passively), to heat water for domestic and industrial use to warm swimming pools, power refrigerators to power engines and pumps, desalinate water for drinking purposes, generate electricity, for industrial applications, and much more.

There are numerous different energy sources which might be used rather than fossil fuels. The choice on what sort of energy source should be utilized must, in each case, be made on the premise of financial, environmental and security contemplations. Due to its alluring environmental and safety aspects, it is widely believed that solar power should be utilized rather than other energy forms, even when the prices involved are marginally higher [5].

II. MATERIALS AND METHOD

Figure 2.1 shows the concentrating solar panels and the mixed-mode solar dryer used for the project. The reflective panels were constructed from wooden frame planks. In order to obtain the peak radiation reflection the panels were designed to ensure ease of movability and also adjustable angle of tilt [6]. As for the reflective material, aluminized Mylar sheeting was used stapled on the wooden panels. This material can easily be replaced in developed countries with less costly aluminum foil, or even reflective spray paint. A previous study found that when compared to aluminized Mylar, solar energy obtained by a small-scale solar dryer using aluminum foil as a reflective medium shows no substantial difference.

Two primary components consist of the dryer: the drying chamber and the collector of solar radiation. Inside the drying chamber are two parts that allow two trays to be placed in place, one above the other. Furring strips can be regarded as the raw material used for the construction of the tray while at the frame of the trays; a food grade plastic screen was stapled to it. Furring strips and timber were used to create the frame [6]. To insulate the bottom and back side of the dryer, foam board insulation was used and black polyethylene film was applied to the bottom insulation, where it acted as the material of the absorber. As the glazing material for the collector region, transparent polycarbonate with a 90 percent transmission of near infrared and visible wavelengths was used and was responsible for filtering UV radiation, which may induce vitamins, color and flavor degradation in tomatoes [6].

For easy detachment or removal during maintenance services or tray loading, polycarbonate sheets were fixed to the dryer frame with industrial strength Velcro. The pyramidal shape of the collector chamber is pyramidal is to allow a large surface area for the black polyethylene absorber [6]. In addition, an angle of inclination of about 45^0 was ensured for each face of the chamber. For the purpose of an air outlet and a stack, a black PVC pipe was added to the drying chamber. Also as a rain shield, the chimney has a bent piece of polycarbonate added to the top. The inlet was mounted on the underside of the dryer and the inlet was sealed with aluminum mesh to keep rats from accessing the inlet. [6].

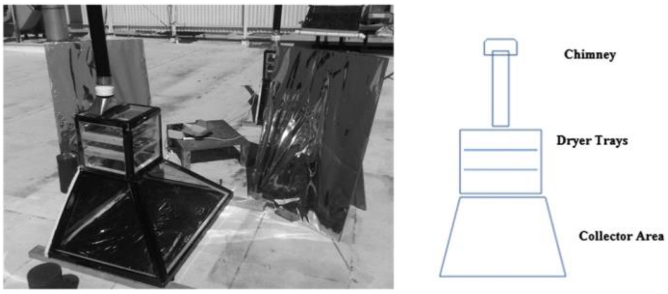

Figure 2.1: Concentrating solar panel

A sun screen fabric or 100% natural burlap was used to cover the entire dryer so as to simulate cloudy conditions. The sun screen fabric, according to the manufacturer, allowed the dryers to be incident upon by 25 to 30 percent of solar radiation in the visible and infrared wavelengths and blocked 81 to 87 percent of ultraviolet radiation [6]. In contrast with the sun shield cloth, the 100 percent natural burlap fabric blocked less radiation. The burlap did not have a listed amount of sun cover, but based on a visual estimation of porosity and experimental insulation results, we determined that about 50 percent of the solar irradiation was made to go through the net.

III. DESIGN CALCULATIONS AND CONSTRUCTION

3.1 Design Considerations

- **Collector's Tilt Angle:** For evaluating the performance of solar collectors the position of the sun - the declination angle - plays a vital role. Akure is on latitude 7.25°, longitude 5.08°E. Using the best all year round performance orientation, the design tilt angle is about 17 degrees to the horizontal.
- **Absorber Plate:** For the determination of the collector’s efficiency, the absorber plate cannot be

overemphasized. In order to attain the absorption of higher proportion of incident radiation, the absorptivity of the absorber plate has to be high also.

- **Glazing Material:** The transmissibility of the glazing material is considered for the design of the transparent surfaces.
- **Heat Losses:** Heat losses from the dryer are considered.
- **Air Circulation:** Air is supplied by 'Natural convection'. Air circulation by natural convection makes use of the fact that hot air has a lower density than cold air, and thus tends to rise [7].
- **Air Leakage:** Air leakage through joints could be a source of heat loss; as the heated air and the heat trapped through the transparent surfaces will be exhausted without removing any moisture. Thus, air leakage has to be prevented by making all joints air-tight as much as possible.
- **Air Temperature:** The dryer is meant to dry different types of foods, and each food product has specific drying temperature.
- **Dryer Capacity:** The dryer capacity is the maximum load expected to be dried per batch in the dryer. This depends on the designer's choice, and a 60kg capacity dryer is to be designed. The calculation of the dryer size is based on this criterion.
- **Drying Time:** The dryer will be operated for eight hours a day between 0900 and 1700 hours local time.
- **Energy Storage:** The choice of storage material depends on the thermal and chemical stability of the storage medium to be used.

Table 3.1: Maximum Temperature Allowable for Drying; and the Moisture Contents of Various Food Products

Product	Moisture Content (%)		Maximum Temperature Allowable for Drying (°C)	Mass of water to be removed (kg)
	Initial	Final		
Maize	35	15	60	14.12
Corn	24	14	50	6.98
Carrots	70	05	75	41.05
Rice	22	11	50	8.76
Onions	80	04	55	47.50
Sweet Potatoes	75	07	75	43.87
Cassava	62	17		32.53
Yams	80	10	65	46.67
Groundnuts	40	09	50	20.44
Okra	89	11	65	52.58
Water Leaf	91	12	65	53.86
Red sweet pepper	91	13	70	53.79

Source: Bansal, N. K et al. (1990) [7]

The kilogram of water to be removed from the product was calculated based on the mass of product to be dried, (60kg).

3.2 Design Calculations

Basic to any design, calculation of a solar dryer is the capacity of the drying air to carry the evaporated moisture from the product. This would be used to calculate the area of the drying cabinet.

3.2.1 Initial Data

Initial Moisture Content ………………….m_i %
Final Moisture Content …………………..m_f%

Maximum temperature allowable for the drying material …..t_d°C
Ambient temperature ……..t_a°C
Latitude of Akure ………….7.25°N*
Average wind velocity 'V_a' ……….0.1ms^{-1}*
Relative Humidity 'θ' ……….0.6*

*These values were obtained from the Meteorology department of the Federal University of Technology, Akure.

3.2.2 Computation of the Transparent Area of the solar Drying Chamber

The dryer is being designed for a maximum batch load of 60kg and a maximum drying temperature of 80℃. The quantity of heat required to evaporate the moisture from the product's surface can be estimated from the relation;

$$Q_w = m_w C_p (t_d - t_a) \quad \ldots\ldots\ldots\ldots (3.1)$$

Where:
Q_w = Heat required (W), m_w = mass of water to be evaporated (kg), C_p= specific heat capacity of water (4200 J kg^{-1} k^{-1}), t_d= Drying temperature (℃), t_a= Ambient temperature (℃).

The mass of water to be evaporated from the product is calculated using equation (3.2) given by [7].

$$m_w = \frac{w\,(m_i - m_f)}{(100 - m_f)} \quad \ldots\ldots\ldots\ldots (3.2)$$

Where;
w = mass of wet product (kg), m_i= initial moisture content (%), m_f= final moisture content. (%)

From the Table 3.1 of moisture contents of various food products, the highest initial moisture content is 91% (for red sweet pepper) [7]. Using this value for the design, with final moisture content of 13% [7], and putting values into equation (3.2), then;

$$m_w = \frac{60\,(91-13)}{(100-13)} = 53.79 \text{ kg}$$

This value is rounded up to 54 kg. i.e., m_w= 54 kg.
Substituting for m_w, in equation (3.1), and using an ambient temperature of 27°C, then;

$$Q_w = 4200 \times 54 \times (80-27) = 12020400\text{Wh}$$
$$Q_w = \frac{12020400}{3600} \text{ Watts} = 3339\text{W}$$

It is assumed that heat gained through transparent surfaces is equal to the heat required to evaporate moisture from the product's surface. That is, it is assumed there are no heat losses. Then;

$$Q_{sg} = Q_w \quad \ldots\ldots\ldots\ldots (3.3)$$

Where: Q_{sg}= Solar heat gain through transparent surface.
Using equation (3.3), the solar energy passing through a transparent surface, 'Q_{sg}' can be obtained.

Q_{sg}= (SHGF) (SC) A.

For single glass (clear) of 6mm nominal thickness, the shading coefficient (SC) is 0.94 [9].

Designing for September, and using half-day totals of Solar Heat Gain Factor (SHGF), the following values are obtained [9].
North = 402 Wm^{-2}
South = 1772 Wm^{-2}
West = 404 Wm^{-2}

East = 2637 Wm-2

The basic area of the cabinet 'A_b' is given by: A_b =

$$\frac{Volume\ capacity\ of\ air}{(Air\ velocity)} \text{ ……… (3.4)[7]}$$

As given by [7], the maximum air flow rate is determined by dividing the drying rate of the product by the difference of the final and initial humidity ratios. The drying rate of the product is obtained using the relation;

$$A_b = \frac{Volume\ capacity\ of\ air}{(Air\ velocity)} \text{ ………………………….. (3.4)}$$

$$m = \frac{m_w}{t_{dr}} \text{……………………………………………..(3.5)}$$

Where: m_w= mass of water to be evaporated (kg), t_{dr}= drying time.

Putting in values, m = $\frac{54}{8}$ = 6.75kg/hr

Hence, the mass of air needed per hour is;

$$m_i = \frac{m}{m_f - w_i} \text{ ………………………………………..(3.6)}$$

Where: m_i= mass of air needed per hour, w_f = final humidity ratio, w_i= initial humidity ratio

The values of w_f and w_i are obtained from enthalpy - humidity ratio (h-w) diagram.

$m_i = \frac{6.75}{0.027-0.0135}$ = 500kg/hr

The air density (ρ_a) is 1.2 kg/m^3. Therefore, the required volume capacity is given by;

$$V_b = \frac{m_i}{\rho_a} \text{…………………………………………….. (3.7)}$$

Where; V_b= volume capacity (m^3), m_i= mass of air needed per hour (kg/hr), δ_a= air density (kg/m^3)

Putting in values;

$V_b = \frac{500}{1.2}$ = 416.67m^3/hr; V_b = 416.67m^{3}hr^{-1} or 0.116m^{-3}s^{-1}

The desired air velocity through the product is 0.lm/s^1 [7]. Hence, using equation (3.4),

$A_b = \frac{v_b}{v_a} = \frac{0.116}{0.1}$ = 1.16m^2

For standardization however, an area of 1.00m^2 is chosen.

Considering the SHGFs', it is highest through the Eastern side. As such, transparent surface will be fixed to the Eastern side, and the roof.

3.2.3 Calculation of the Collector's Area

To calculate the required collector area, the solar radiation reaching the earth must first be determined. This depends on the following quantities:

- Sun's declination, 'd'
- Hour Angle, 'H'
- Solar Altitude, 'β'
- Solar 'Azimuth, 'Φ'
- Surface Azimuth, 'φ'
- Solar-Surface Azimuth, 'υ'
- Angle of Incidence, 'θ'
- Tilt Angle, 'α_t'= 17^0

3.2.3.1 Sun's Declination 'δ'

This is the angular distance of the sun's rays North or South of the equator. It is estimated from the formula;

$$\delta = 23.47 \sin \frac{360}{365} (284 + N) \text{ ……………………..…. (3.8)}$$

Where;

N = day of the year counting from January 1st.

For September 19, N =262.

δ= 23.47 sin $\frac{360}{365}$ (284 + 262); δ = 0.606^0

3.2.3.2 Hour Angle, 'H'

This is the angle through that the earth should intercommunicate to bring the meridian of the purpose directly in line with the sun's rays.

$H = \frac{360T}{24}$ = 15T

Where;

T = hours Number earlier or ahead of noon. At noon, T=0; Hence, H=0

3.2.3.3 Solar Altitude, '$\boldsymbol{\beta}$'

This is the angle measured from the horizontal plane on earth up to the sun. Mathematically;

$\sin\beta$ = cos L cosH cosδ + sin L sinδ.

L = 7.25°, H = 0, and δ= 0.606°

$\sin\beta$= cos 7.25 cos 0 cos (0.606) + sin 7.25 sin (0.606);

$\sin\beta$= 0.9932 = 83.33°

3.2.3.4 Solar Azimuth, '$\boldsymbol{\phi}$'

This is the angle between sun's rays and the south.

$$\sin\phi = \frac{\cos\delta \sin H}{\cos\beta}$$

$$\sin\phi = \frac{\cos (0.606) \sin 0}{\cos 83{,}33} ; \phi = \sin^{-1} 0 = 0$$

3.2.3.5 Surface Azimuth '$\boldsymbol{\phi}$' and Solar- Surface Azimuth '$\boldsymbol{\nu}$'

Surface Azimuth 'ϕ' is the angle that a plane normal to the vertical surfaces makes with the south; and Solar-Surface Azimuth 'ν' is the angle between the solar azimuth and the surface azimuth,

$\nu = \phi \pm \varphi\phi$ φ= 0 ± 45°

φ = 45° for surfaces facing south [9]

ν= 45°

3.2.3.6 Angle of Incidence '$\boldsymbol{\theta_i}$'

This is the angle between the incoming solar rays and aligns normal to that surface.

Cos θ_i = cosβ cos ν sin α_t + sinβ cosα_i

Where

α_t= Tilt angle= 17° , β = Solar altitude = 83.33° , ν=Solar- surface azimuth = 45°

cosθ_i = 0.9738

i.e., θ_i = 13.14°

3.2.3.7 Direct Normal Solar Intensity; 'I_{DN}'

The radiation from the sun reaching the earth's surface is given by

$$I_{DN} = \frac{A}{\exp\left({}^{B}/_{\sin\beta}\right)} \text{ W/m}^2 \ldots\ldots\ldots\ldots\ldots\ldots \text{(3.9)}$$

Where: A = Apparent solar irradiation at air mass, B = Atmospheric extinction coefficient, β = Solar altitude

The values of A and B can be obtained from Table 3.2 [9]

Table 3.2: Extraterrestrial Solar radiation Intensity (Wm^{-1}), and Related Data for Twenty-first day of each month

Month	A (Wm^{-2})	B	C
January	1209	0.142	0.058
February	1193	0.144	0.060
March	1164	0.156	.0.071
April	1115	0.180	0.097
May	1084	0.196	0.121
June	1069	0.205	0.134
July	1066	0.207	0.136
August	1088	0.201	0.122
September	1131	0.177	0.092
October	1172	0.160	0.073
November	1199	0.149	0.063
December	1212	0.142	0.057

For the month of September;

A= 1131 Wm^{-2}

B = 0.177

$$I_{DN} = \frac{1131}{\exp\left({}^{0.177}/_{\sin 83.33.}\right)}$$

I_{DN} = 946.36 Wm^{-2}

However, when this radiation is incident on the collector's surface, part is absorbed, part reflected and part diffused. The total radiation therefore is given by;

$$I_T = I_b + I_d + I_r \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.10)}$$

Where;

I_T= Total radiation, (Wm^{-2})

I_b= Absorbed radiation (direct beam), (Wm^{-2})

I_d= Diffused radiation, (Wm^{-2})

I_r= Reflected radiation, (Wm^{-2})

For a surface tilted at an angle of incidence θ_1, the direct beam (absorbed radiation) is given by:

$$I_b = I_{DN}. \sin\beta \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(3.11)}$$

= 946.36 sin 83.33 = 939.95 Wm^{-2}

The diffused portion is given by;

$I_d = I_{DN}.C.\frac{(1+cos\alpha)}{2}$ …………………………. (3.12)

From Table 3.1, C = 0.073, at = 17^0

$I_d = 946.36 \text{ x } 0.073 \text{ x } \frac{(1+cos17)}{2}$

$I_d = 67.57 \text{ Wm}^{-2}$

The reflected portion is given by:

$I_r = I_{DN} (C + \sin\beta) (1 - \cos \alpha_t)/2$ …….. (3.13)

= 946.36(0.073 + sin 83.33) (1 - cos17)/2

= 20.54 Wm^{-2}

Therefore, the total radiation on the collector, I_T becomes

$I_T = I_b + I_d + I_r$

=939.95 + 67.57 + 20.54

= 1028.06 Wm^{-2}

The solar length per day can be obtained from

$S_L = \frac{24H}{180}$ ……………………………………. (3.14)

Where

H = 15T, and T = 5 hours (1700 hours local time after noon)

$S_L = \frac{24H}{180} = 10$ hours

The total amount of radiation collected by the solar collector working on an average of 8 hours a day can be estimated from:

$I_i = \frac{I_T \, x8}{S_L}$ ……………………..…………… (3.15)

$= \frac{1028.06 \, x \, 8}{10} = 822.448 \text{ Wm}^{-2}$

According to [7], the collector's temperature can be estimated from;

$t_c = t_d - \frac{t_a}{2}$ ……………………………… (3.16)

Where: t_c= Collector's temperature (°C), t_d= Drying temperature = 48.5°C,

t_a= Ambient temperature = 27°C , t_c= 35°C

From equation (3. 15), energy per unit area of the collector, q_u;

$q_u = (\alpha\tau) I_T – U_L (t_c – t_a)$ ……………………..….. (3.17)

$(\alpha\tau)$ = the conversion factor (transmissivity and absorptivity product)

From equations, Transmissivity, τ = 0.9175, and according to [7], for an absorber, α= (1 - r). Therefore, α= (1- 0.0425) = 0.958

U_L= Overall heat transfer coefficient, combining the effects of radiation, convection and conduction losses; = 6.5 Wm^{-2}.K [8], I_T = Solar constant = 1400 Wm^{-2} [10].

Putting U_L= 6.5 in equation (3.17) gives:

q_u= (0.9175 x 0.958)1400 - 6.5(35-27) = 1178.55 Wm^{-2}

i.e., q_u= 1178.55Wm^{-2}

The thermal efficiency of the collector is defined as:

$\eta_c = q_u / I_T$ ……….. (3.18)

$\frac{1178.55}{1400} = 0.8418;$

= 84.18%

The required collector area is given by [7] as:

$A_c = q_u / (I_T . \eta_c)$ ………..… (3.19)

$A_c = \frac{1178.55}{1028.06 \, x \, 0.8414}$

A_c= 1.36 m^2

An area of 1.0m^2 is chosen.

3.2.4 Collector's Inclination: Vertical and Slanting Heights

The collector's inclination (angle of tilt) is 17° to the horizontal, and has an area of 0.8 m^2 (1 m x 0.8 m). The vertical height of the collector is obtained from the right-angled triangle ABC.

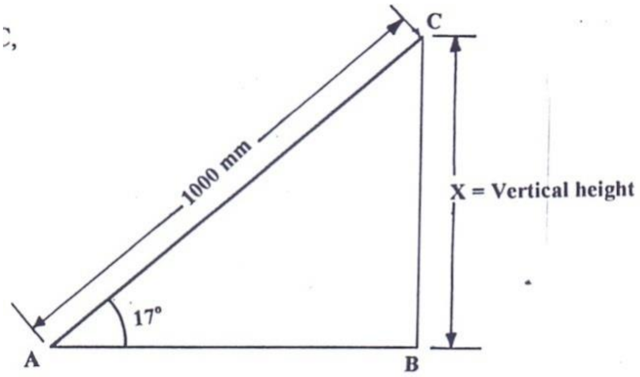

Figure 3.1: Collector inclination

$\sin 17^0 = \frac{X}{1000}$

X = 1000 sin 17

X = 292.4 mm

A vertical height of 295 mm is used, and the slanting edge is 1000 mm.

3.3.1 Material Selection

In the selection of a material for a specific application, it is necessary to consider:

(a) The ability of the material to withstand service conditions,
(b) The method(s) by which it will be shaped, and
(c) The general value and accessibility of the material.

In some cases, a number of materials may be satisfactory in respect of fulfilling the service requirements. However, the above may not fully be satisfied by a single material before it is selected, as the cheapest material may not be readily available.

- **Transparent Surfaces:** An ideal cover permits the passage of sunlight, but not the longer infra-red radiation emitted by the absorber surface.
- **Absorber Plate:** A good absorber plate should give little resistance to the passage of air. One amongst the lot of usually used absorbers is dark-painted metal sheets.
- **Thermal Storage Material:** A good sensible thermal storage material should possess the following properties:
- **Thermal Insulators:** Thermal insulator is necessary to prevent heat losses.
- **Drying Cabinet:** The drying cabinet houses the food being dried. As such, it must be strong enough to withstand the weight of the food product(s).
- **Drying Trays:** Drying trays holds the food being dried. As such, the tray materials should be perforated to allow for air movement, and moisture drainage. For low cost, perforated iron net strengthened with wood was used. The net made of iron has the advantage of absorbing heat and transferring such heat to the food, thus contributing positively to the drying process.

3.3.2 Equipment Description

The dryer is made up of three main parts namely;
(i) Solar collector,
(ii) Drying cabinet, and
(iii) Thermal store.

Figure 3.2 : Drying cabinet with the tilted solar collector

3.3.2.1 Solar Collector

(i) The solar collector was fabricated from corrugated iron sheet 1000 mm x 960 (rnm) painted black. It (collector plate) was housed by a wooden box of dimension 990 x 870 x 230 (mm).

Figure 3.3: (a) drying tray loaded with fresh pepper

(b) solar dried pepper

Figure 3.4: Solar Collector and Solar store

3.3.2.2 Drying cabinet

The drying cabinet's frame was fabricated from wood of size 25.4mm x 50.8mm. It has the roof (1000 x 960) mm covered with glass, inclined at 7.25° (the latitude of Akure).

IV. RESULTS AND DISCUSSION

This chapter deals with various readings and most of the data observed are plotted against time in order to make expertise deductions on how they vary. Values are observed for No-load (i.e. when the cabinet is empty) and Load (when loaded with the food item).

4.1 RESULT OF VARIOUS DATA

4.1.1 Result of no-load readings: SOLAR STORE MORNING: 32°C ; EVENING: 37°C

Table 4.1: Data reading for No-load

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber, T_d (°C)	Ambient Temp,T_a (°C)
0900	44.0	38.0	34.0	36.0	28.0
1000	46.0	41.0	37.0	39.0	28.0
1100	49.0	43.0	39.0	41.0	30.0
1200	52.0	47.0	42.0	44.5	29.0
1300	42.0	45.0	41.0	43.0	28.0
1400	46.0	43.0	39.0	41.0	28.0
1500	42.0	41.0	38.0	39.5	27.5
1600	45.0	44.0	39.0	41.5	28.0
1700	32.5	33.0	33.0	33.0	24.5

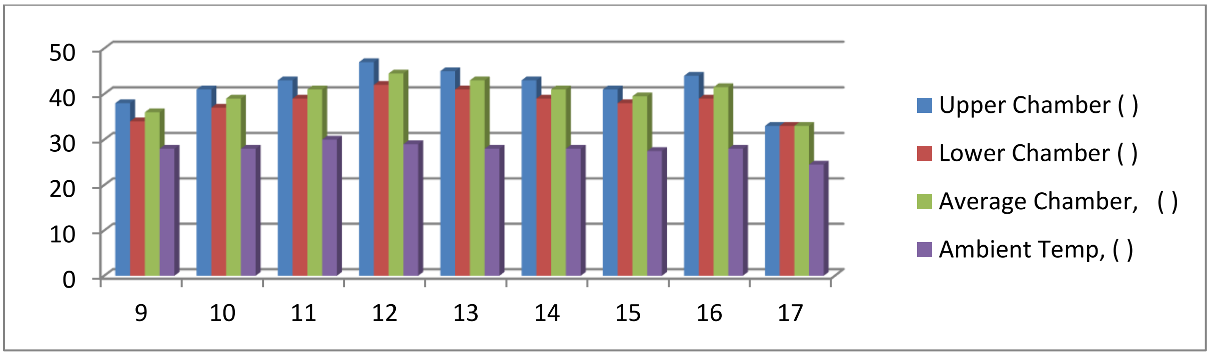

Figure 4.1: Upper, lower, average chamber and ambient temperature (°C) against Time (hrs) for NO-LOAD

4.1.2 Result of load readings (YAM)

DAY-1: SOLAR STORE MORNING-32℃ ; EVENING-37℃

4.2: Data reading for YAM Day 1

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	35.0	30.0	32.0	31.0	25.0
1000	45.5	36.5	35.5	36.0	26.0
1100	46.0	41.5	38.0	39.8	27.0
1200	71.0	54.0	43.5	48.8	30.0
1300	71.5	54.0	45.0	49.5	31.0
1400	72.5	59.0	48.0	53.5	33.0
1500	55.0	52.0	45.0	48.5	31.0
1600	32.0	34.0	32.0	33.0	24.0
1700	29.5	28.5	28.5	28.5	23.5

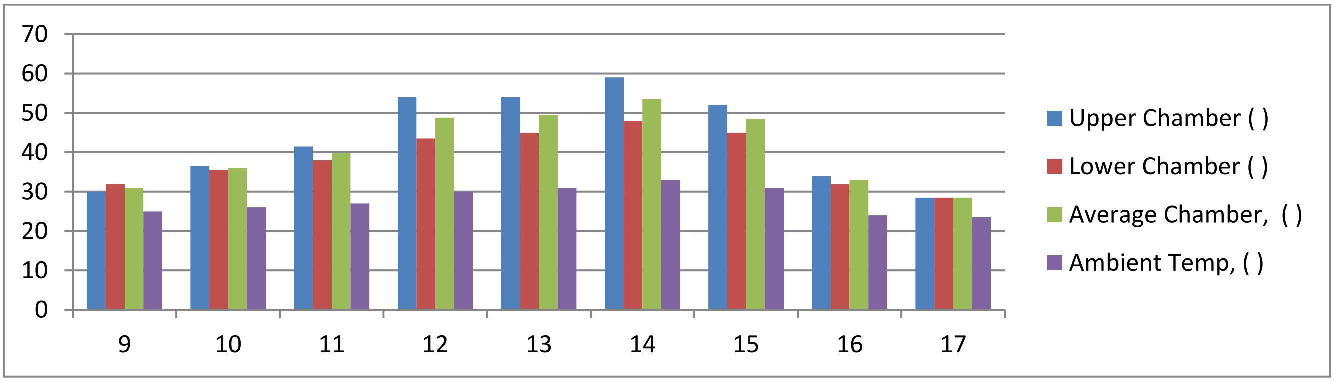

Figure 4.2: Temperature (°C) against Time (hrs) for Day 1 (YAM)

DAY-2: SOLAR STORE MORNING- 28℃ ; EVENING- 38℃

Table 4.3: Data reading for YAM Day 2

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	35.5	33.0	32.5	32.8	25.5
1000	43.0	38.0	35.0	36.5	28.0
1100	55.5	45.5	39.5	42.5	29.0
1200	52.5	47.0	41.0	44.0	30.0
1300	58.0	49.0	42.5	45.8	30.0
1400	69.5	59.0	48.0	53.5	32.0
1500	61.0	60.0	48.0	54.0	33.0
1600	45.0	45.0	39.0	42.0	29.5
1700	35.0	35.5	34.5	35.0	26.5

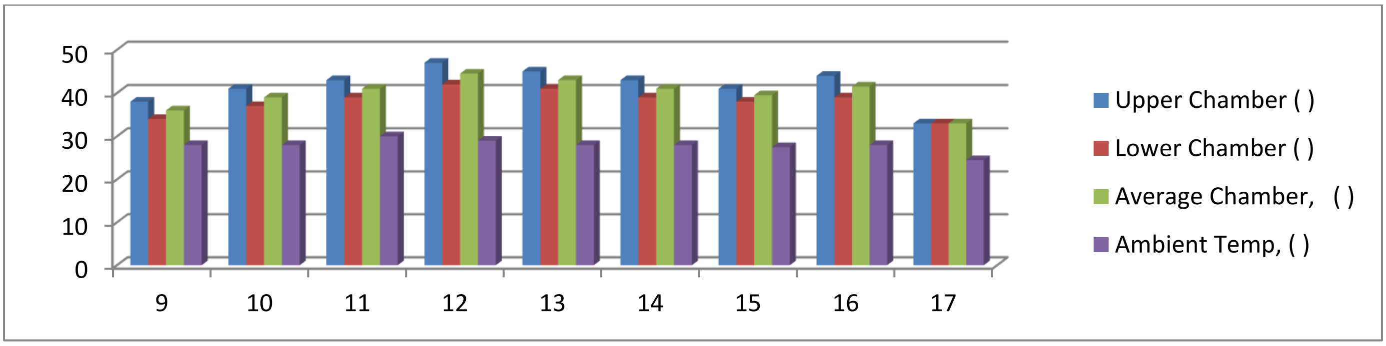

Figure 4.3: Temperature (°C) against Time (hrs) for Day 2 (YAM)

DAY-3: SOLAR STORE MORNING- 27.5°C ; **EVENING- 40**°C

Table 4.4: Data reading for YAM Day 3

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	35.5	33.5	31.5	32.5	25.5
1000	39.0	37.5	34.5	36.0	27.0
1100	52.5	49.0	41.0	45.0	30.0
1200	62.0	52.0	43.0	47.5	29.5
1300	73.0	59.0	41.0	50.0	32.5
1400	69.5	58.5	48.0	53.3	32.5
1500	51.5	49.0	42.0	45.5	32.0
1600	51.0	50.5	45.0	47.8	31.0
1700	40.0	39.5	37.5	38.5	29.5

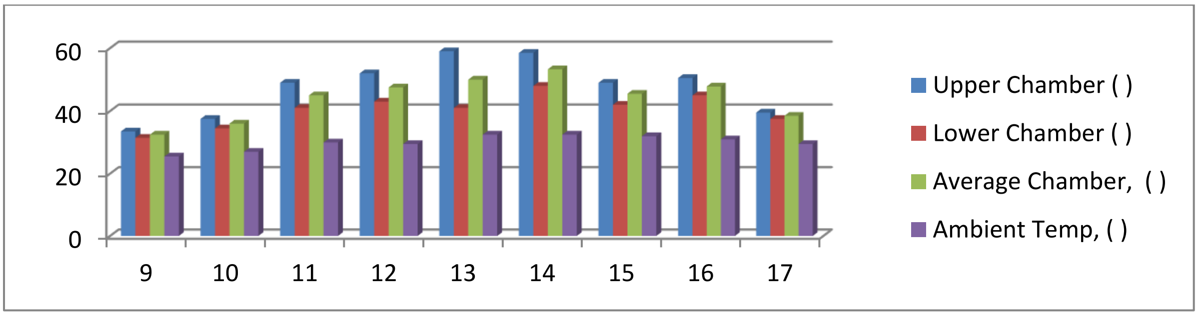

Figure 4.4: Temperature (°C) against Time (hrs) for Day 3 (YAM)

DAY-4: SOLAR STORE MORNING- 29°C **; EVENING- 33**°C

Table 4.5: Data reading for YAM Day 4

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	34.0	32.0	31.0	31.5	25.0
1000	36.5	35.0	33.0	34.0	26.0
1100	37.0	36.0	34.0	35.0	27.0
1200	52.0	46.5	41.0	43.8	29.0
1300	65.0	50.5	44.5	47.5	31.0
1400	54.5	50.0	43.0	46.5	30.5
1500	49.0	47.0	41.0	44.0	31.0
1600	32.0	31.0	29.5	30.3	23.0
1700	30.0	29.0	28.5	28.8	23.5

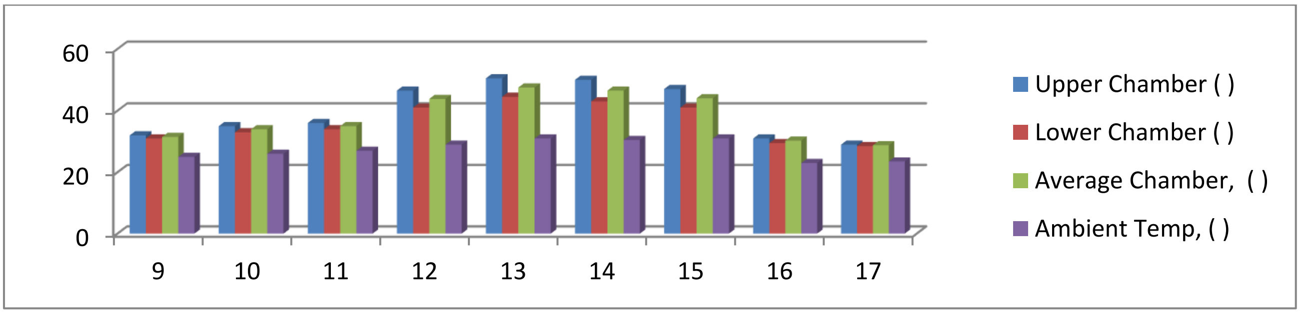

Figure 4.5: Temperature (°C) against Time (hrs) for Day 4 (YAM)

DAY-5: SOLAR STORE MORNING- 27°C **; EVENING- 40**°C

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber, T_d (°C)	Ambient Temp,T_a (°C)
0900	43.0	46.0	34.0	40.0	27.5
1000	58.0	46.0	42.0	44.0	30.0

1100	63.0	52.0	44.0	48.0	31.0
1200	53.5	51.0	43.0	47.0	31.5
1300	53.5	62.0	47.0	54.5	33.0
1400	69.5	58.0	47.5	52.8	34.0
1500	55.5	58.0	47.0	52.5	32.0
1600	48.0	47.0	42.0	44.5	31.0
1700	37.0	38.5	37.0	37.8	28.5

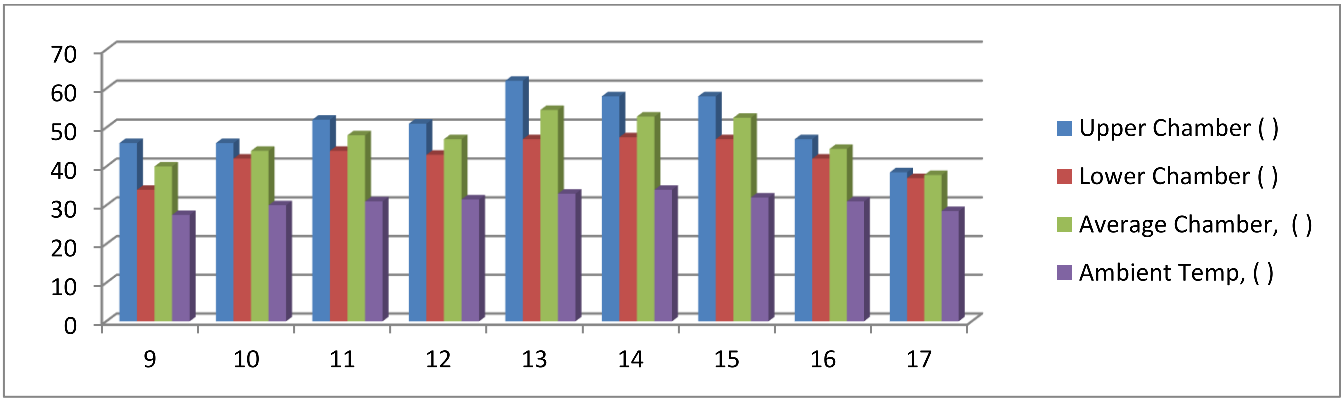

Figure 4.6: Temperature (°C) against Time (hrs) for Day 5 (YAM)

DAY-6: SOLAR STORE MORNING- 27°C ; **EVENING- 38** °C

Table 4.6: Data reading for YAM Day 5

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	33.0	32.0	30.5	31.3	26.0
1000	45.0	41.0	38.0	39.5	27.0
1100	61.0	51.0	43.0	47.0	30.0
1200	58.0	49.5	42.5	46.0	30.5
1300	65.0	54.0	46.0	50.0	30.5
1400	59.0	53.0	45.0	49.0	31.0
1500	71.0	66.0	51.0	58.5	33.0
1600	42.5	42.5	39.5	41.0	30.0
1700	38.0	35.5	35.0	35.3	28.0

Table 4.7: Data reading for YAM Day 6

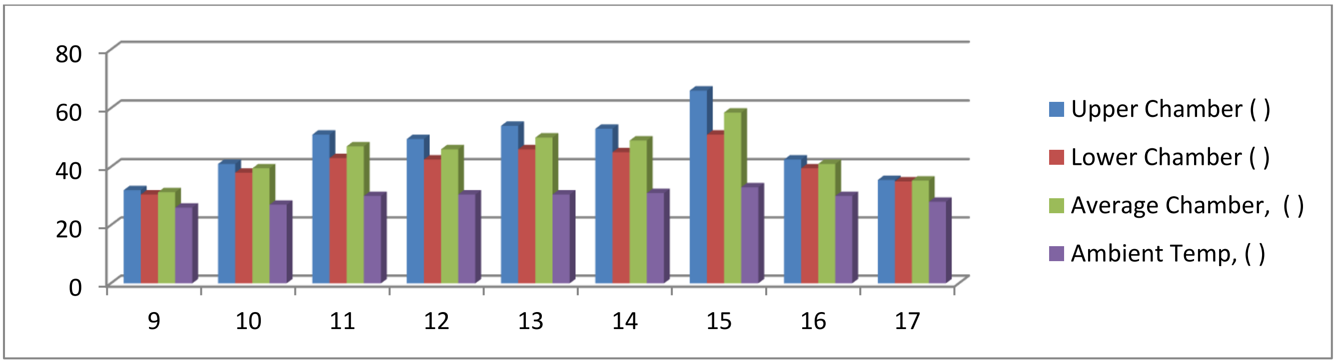

Figure 4.7: Temperature (°C) against Time (hrs) for Day 6 (YAM)

4.1.3 Result of load readings (PEPPER)

DAY-1: SOLAR STORE MORNING- 28°C ; EVENING- 38°C

Table 4.8: Data reading for PEPPER Day 1

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	36.0	33.5	31.5	32.5	26.0
1000	46.5	38.0	36.0	37.0	28.0
1100	47.5	43.0	39.0	41.0	29.5
1200	65.0	52.0	45.0	48.5	30.0
1300	76.5	58.0	47.5	52.8	34.5
1400	53.5	48.5	43.0	45.8	31.5
1500	64.0	58.0	48.5	53.3	32.0
1600	44.0	42.0	39.0	40.5	31.0
1700	38.0	37.0	36.0	36.5	29.5

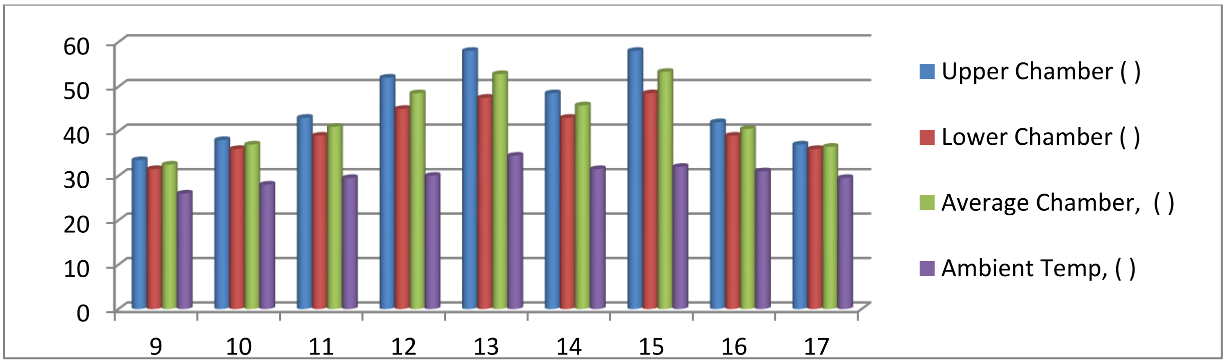

Figure 4.8: Temperature (°C) against Time (hrs) for Day 1 (PEPPER)

DAY – 2: SOLAR STORE MORNING- 30℃ ; EVENING-43 ℃

Table 4.9: Data reading for PEPPER Day 2

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	38.0	35.0	33.0	34.0	25.5
1000	46.0	40.0	37.0	38.5	28.5
1100	67.5	54.0	45.0	49.5	32.5
1200	71.0	56.0	46.0	51.0	32.5
1300	58.0	54.0	46.0	50.0	32.0
1400	50.0	51.5	43.5	47.5	32.5
1500	63.0	58.0	49.0	53.5	34.5
1600	56.0	55.0	47.5	51.3	34.0
1700	42.0	44.0	42.5	43.3	30.0

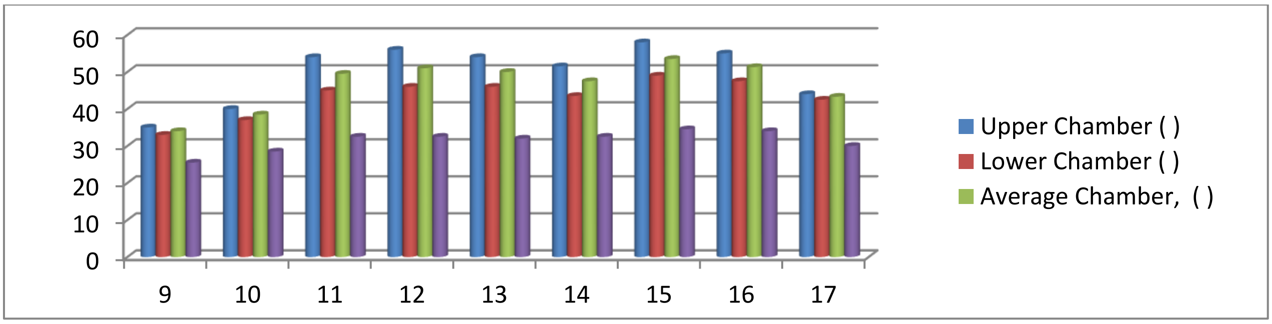

Figure 4.9: Temperature (°C) against Time (hrs) for Day 2 (PEPPER)

DAY – 3: SOLAR STORE MORNING-29℃ ; EVENING- 44℃

Table 4.10: Data reading for PEPPER Day 3

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	40.0	37.0	35.5	36.3	26.0
1000	50.0	43.0	39.0	41.0	30.0
1100	48.0	41.0	37.5	39.3	28.5
1200	46.0	44.5	40.0	42.3	29.0
1300	47.0	44.5	40.0	42.3	30.0
1400	41.5	41.5	37.5	39.5	28.5
1500	52.0	48.0	41.5	44.8	30.0
1600	45.5	45.5	40.5	43.0	30.0
1700	44.0	48.0	44.0	46.0	31.0

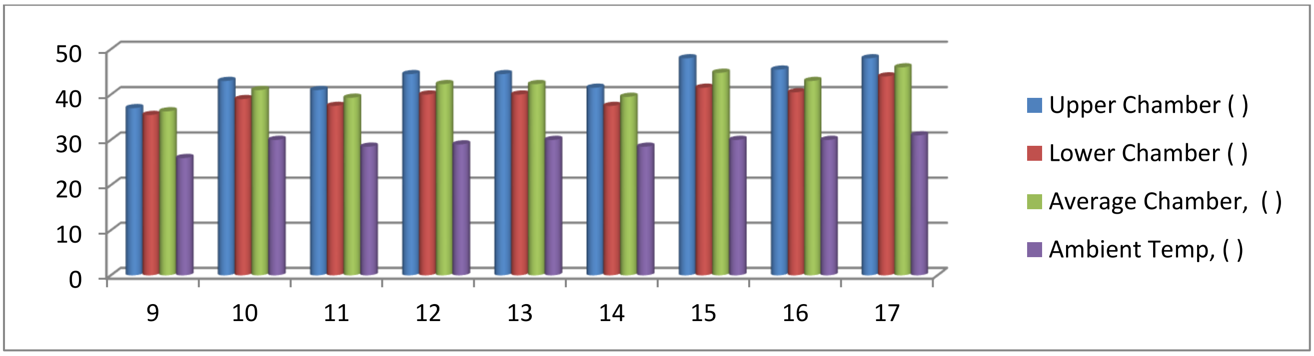

Figure 4:10: Temperature (°C) against Time (hrs) for Day 3 (PEPPER)

DAY – 4: SOLAR STORE MORNING-28°C ; EVENING-39 °C

Table 4.11: Data reading for PEPPER Day 4

TIME(hrs)	Solar collector, T_C(°C)	Upper Chamber (°C)	Lower Chamber (°C)	Average Chamber,T_d (°C)	Ambient Temp,T_a (°C)
0900	41.0	36.0	34.0	35.0	27.0
1000	43.0	38.5	36.0	37.3	27.0
1100	46.5	42.0	38.0	40.0	28.5
1200	57.0	50.5	43.0	46.8	30.0
1300	56.0	50.5	43.0	46.8	30.0
1400	52.0	49.0	42.0	45.5	33.0
1500	49.0	47.0	41.5	44.3	30.5
1600	47.0	45.5	41.0	43.3	30.5
1700	47.0	42.0	38.0	40.0	29.5

It is always observed that the solar store keep the temperature of the dryer minimally higher than the ambient temperature in the morning even when it has expended its whole heat over the night.

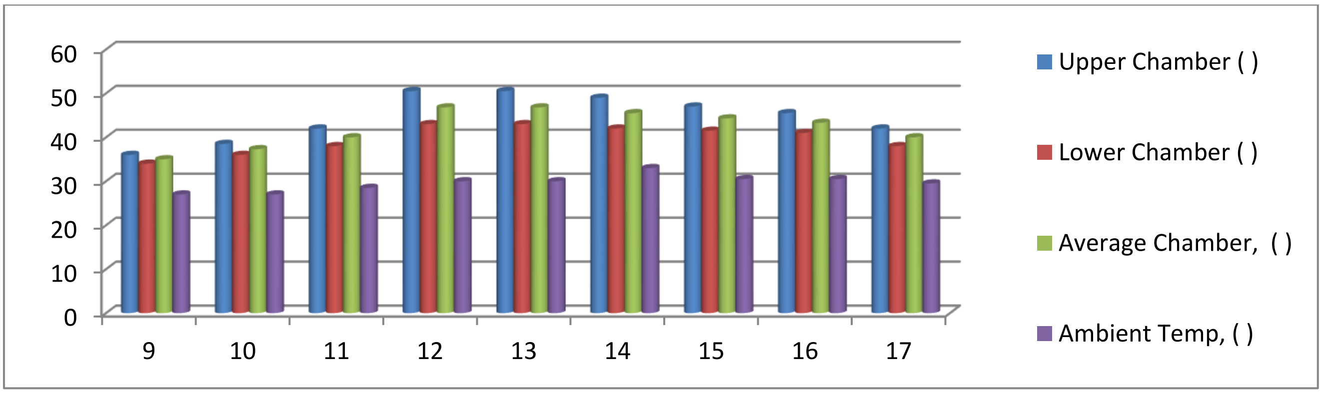

Figure 4:11: Temperature (°C) against Time (hrs) for Day 4 (PEPPER)

4.2 Mass of loaded cabinet and control moisture removed

The measurements are taken using digital weighing balance. The test also involves a comparison between the drying efficiency of solar dryer and direct radiation.

Initial moisture content of **YAM** = 80% and final moisture content= 10% (from Table 3.1)
Mass of Yam for dryer (before drying) = 1.0kg
Mass of control Yam (for direct radiation before drying) = 1.0kg
Mass of Yam for dryer (After drying for days) = 0.2915 kg
Mass of control Yam (after drying) = 0.2975 kg
Amount of moisture removed for dryer=$\frac{1.0-0.2915}{1.0} \times 100\%$=70.85 %
Amount of moisture removed for direct radiation (control) =$\frac{1.0-0.2975}{1.0} \times 100\%$= 70.25%

Table 4.12: Moisture Removed for Yam (WBD- Weight before Drying; WAD- Weight after Drying for the day)

	CONTROL			DRYER		
Day	WBD(kg)	WAD(kg)	Moist. Removed(%)	WBD(kg)	WAD(kg)	Moist. Removed(%)
1.	1.0000	0.8160	18.40	1.0000	0.6860	31.40
2.	0.7690	0.5535	44.70	0.6135	0.4430	55.70
3.	0.4950	0.3920	60.80	0.4135	0.3450	65.50
4.	0.3840	0.3715	62.85	0.3435	0.3280	67.2
5.	0.3610	0.3590	64.10	0.3355	0.3029	69.71
6.	0.3550	0.3105	68.95	0.3015	0.2915	70.85
7.	0.3100	0.2975	70.25	-	-	-

YAM Moisture Content (%) against DAY

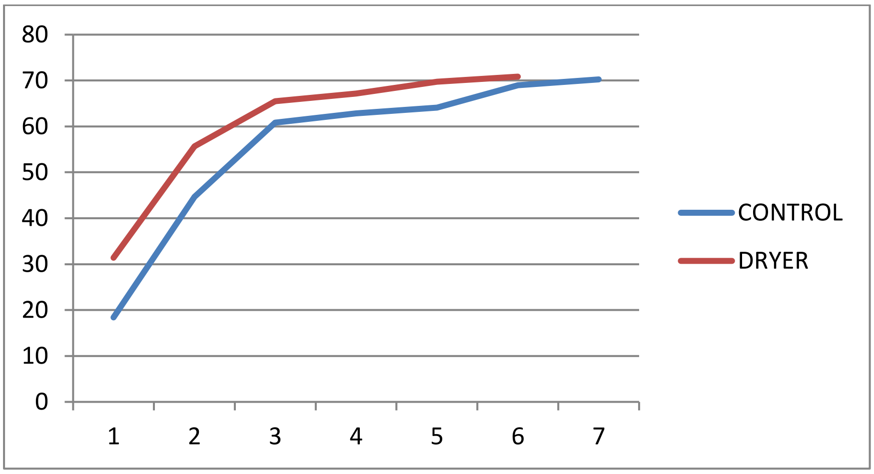

Figure 4.12: percentage of moisture removal against Day for YAM for 6 days

From the Tables 4.12 and Figure 4.12, it is noticed that the YAM in the dryer has dried up to the required dryness content on the sixth day while that of direct sun drying dried on the seventh day without even removing more moisture content than the dryer irrespective of the one day lagging.
Initial moisture content of **PEPPER** = 91% and final moisture content= 13% (Table 3.1)
Mass of pepper for dryer (before drying) = 0.5kg
Mass of control pepper (for direct radiation before drying) = 0.5kg
Mass of pepper for dryer (After drying for 4 days) = 0.0890kg
Mass of control pepper (after drying) = 0.0640kg

Amount of moisture removed for dryer=$\frac{0.5-0.0890}{0.5} \times 100\%$=82.2%

Amount of moisture removed for direct radiation (control) =$\frac{0.5-0.0640}{0.5} \times 100\%$= 87.2%

Table 4.13: Moisture Removed for Pepper (WBD- Weight before Drying; WAD- Weight after Drying for the day)

	CONTROL			DRYER		
Day	WBD(kg)	WAD(kg)	Moist. Removed(%)	WBD(kg)	WAD(kg)	Moist. Removed(%)
1.	0.5000	0.4510	9.8	0.5000	0.3780	24.4
2.	0.4330	0.3450	31.0	0.3420	0.1900	62.0
3.	0.3290	0.2760	44.8	0.1740	0.1210	75.8
4.	0.2620	0.2080	58.4	0.1140	0.0890	82.2
5.	0.1990	0.1270	74.6	-	-	-
6.	0.1100	0.0640	87.2	-	-	-

It is notice that the solar removes more moisture than the direct radiation drying. Also, the direct radiation is noticed to develop black colour as a result of the direct drying but the solar dryer does not give such reaction. Also, from the graph noticeable difference is seen between the performance of the Solar dryer and direct drying, the pepper in the solar dryer has dried about 3 days in advance compared to that of direct sun drying which dried in 6 full days.

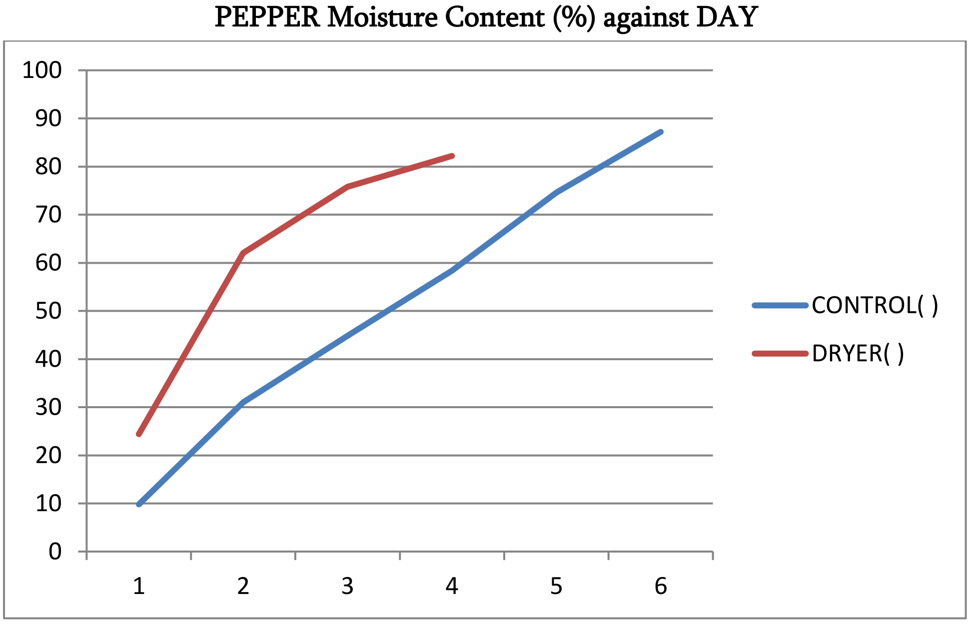

Figure 4.13: Solar dryer Moisture content against Day

4.3 Heat required

From Table 3.1, the highest initial moisture content for YAM is 80%. Using this value for the design, with final moisture content of 10%, and putting values into equation (3.2),

$$m_w = \frac{w\,(m_i - m_f)}{(100 - m_f)}$$

Then;

$m_w = (60\ (80-10))/\ ((100-10)) = 46.67$ kg

This value is rounded up to 47 kg. i.e., $m_w = 47$kg.

Substituting for m_w, in equation (3.1), highest collector temperature is 73°C and using an ambient temperature of 27°C, then;

$Q_w \quad = 4200 \times 47 \times (73-27) = 9080400$Wh

$Q_w \quad = 9080400/3600$Watts$=2522$W

From equation (3.1)

Heat gained by drying air; $Q_w = m_w C_p\ (t_d - t_a)$; since $m_w = 47$kg and $C_p = 4200$

t_d and t_a can be taken directly from Table 4.1 to 4.7 to complete the Required heat.

Table 4.14: Heat required by the YAM

TIME(hrs)	Heat (W) No-Load	Heat (W) Day - 1	Heat (W) Day - 2	Heat(W) Day - 3	Heat (W) Day – 4	Heat (W) Day - 5	Heat (W) Day - 6
0900	438.7	329.0	400.3	383.8	356.4	685.4	290.6
1000	603.2	548.3	466.1	493.5	438.7	767.7	685.4
1100	603.2	701.9	740.3	822.5	438.7	932.2	932.2
1200	849.9	1030.9	767.7	987.0	811.5	849.9	849.9
1300	822.5	1014.4	866.4	959.6	904.8	1178.9	1069.3
1400	712.8	1124.1	1178.9	1140.5	877.3	1030.9	987.0
1500	658.0	959.6	1151.5	740.3	712.8	1124.1	1398.3
1600	740.3	493.5	685.4	921.2	400.3	740.3	603.2
1700	466.1	274.2	466.1	493.5	290.6	510.0	400.3

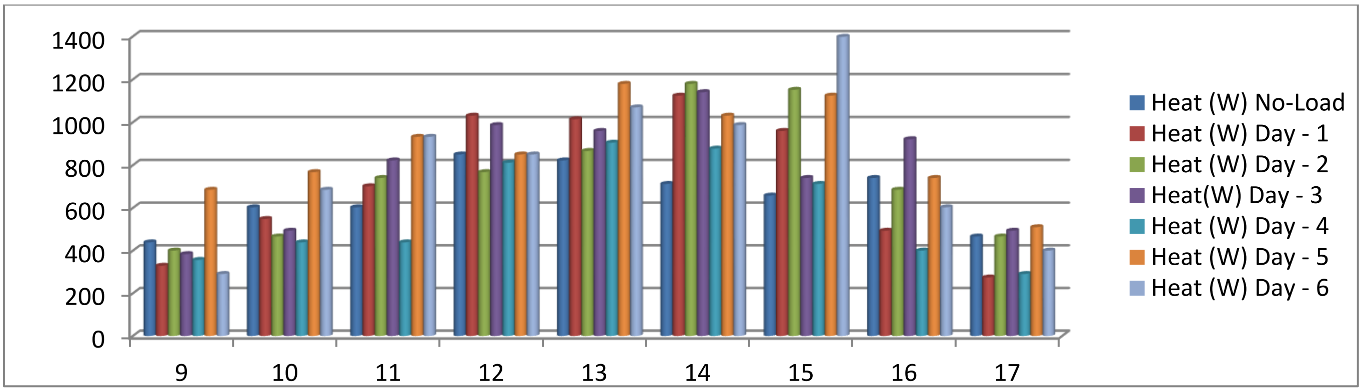

Figure 4.14: Histogram showing Heat (W) against Time (hrs) for YAM

From Table 3.2, the highest initial moisture content for PEPPER is 91%. Using this value for the design, with final moisture content of 13%, and putting values into equation (3.2),

$$m_w = \frac{w\,(m_i - m_f)}{(100 - m_f)}$$

Then; $m_w = (60\ (91-13))/\ ((100-13)) = 53.79$ kg

This value is rounded up to 54 kg. i.e., $m_w = 54$kg.

Substituting for m_w, in equation (3.1), highest collector temperature is 76.5°C and using an ambient temperature of 27°C, then;

Q_w = 4200 x 54 x (76.5-27) = 11226600Wh

Q_w = 9771300/3600Watts=3118.5W

From equation (3.1),

Heat gained by drying air; $Q_w=m_wC_p$ $(t_d–t_a)$; since m_w=54kg and C_p=4200

t_d and $t_a$can be taken directly from Table 4.1, 4.8 to 4.11 to complete the Required heat.

Table 4.15: Heat required by the PEPPER

TIME(hrs)	Heat (W) No-Load	Heat (W) Day - 1	Heat (W) Day - 2	Heat(W) Day - 3	Heat (W) Day - 4
0900	504.0	409.5	535.5	648.9	504.0
1000	693.0	567.0	630.0	693.0	648.9
1100	693.0	724.5	1071.0	680.4	724.5
1200	976.5	1165.5	1165.5	837.9	1058.4
1300	945.0	1152.9	1134.0	774.9	1058.4
1400	819.0	900.9	945.0	693.0	787.5
1500	756.0	1341.9	1197.0	932.4	869.4
1600	850.6	598.5	1089.9	819.0	806.4
1700	535.5	441.0	837.9	945.0	661.5

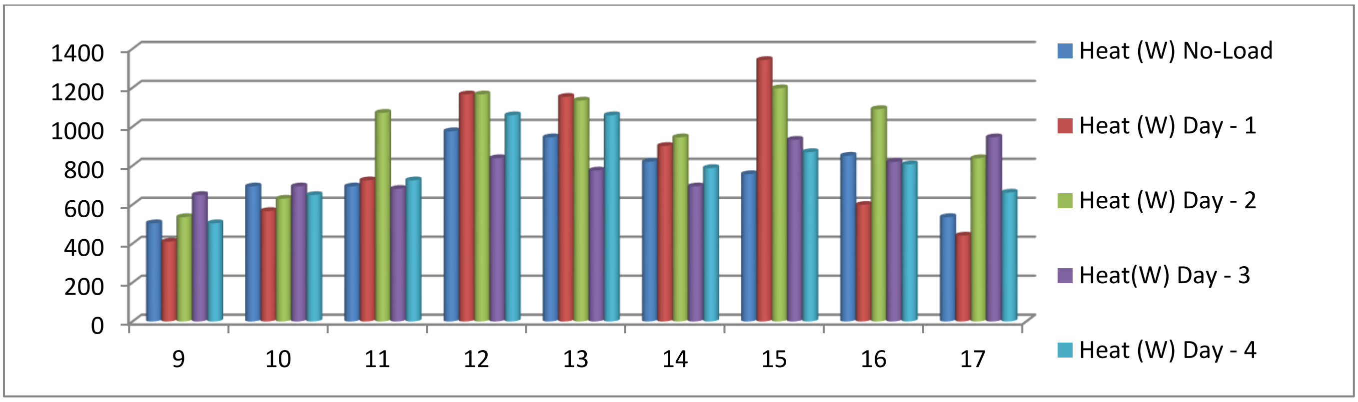

Figure 4:15: Heat required (W) against Time for PEPPER

4.4 Thermal Efficiency,

$ῃc = \frac{Q}{Q_w} \times \mathbf{100}$(From equation 2.4)

Table 4.16: Thermal efficiencies for YAM for 6days

TIME(HRS)	Thermal efficiency , ῃc No-load	Thermal efficiency, ῃc Day 1	Thermal efficiency , ῃc DAY 2	Thermal efficiency , ῃc DAY 3	Thermal efficiency , ῃc DAY 4	Thermal efficiency , ῃc DAY 5	Thermal efficiency , ῃc DAY 6

9	17.4	13.0	15.9	15.2	14.1	27.2	11.5
10	23.9	21.7	18.5	19.6	17.4	30.4	27.2
11	23.9	27.8	29.4	32.6	17.4	37.0	37.0
12	33.7	40.9	30.4	39.1	32.2	33.7	33.7
13	32.6	40.2	34.4	38.0	35.9	46.7	42.4
14	28.3	44.6	46.7	45.2	34.8	40.9	39.1
15	26.1	38.0	45.7	29.4	28.3	44.6	55.4
16	29.4	19.6	27.2	36.5	15.9	29.4	23.9
17	18.5	10.9	18.5	19.6	11.5	20.2	15.9

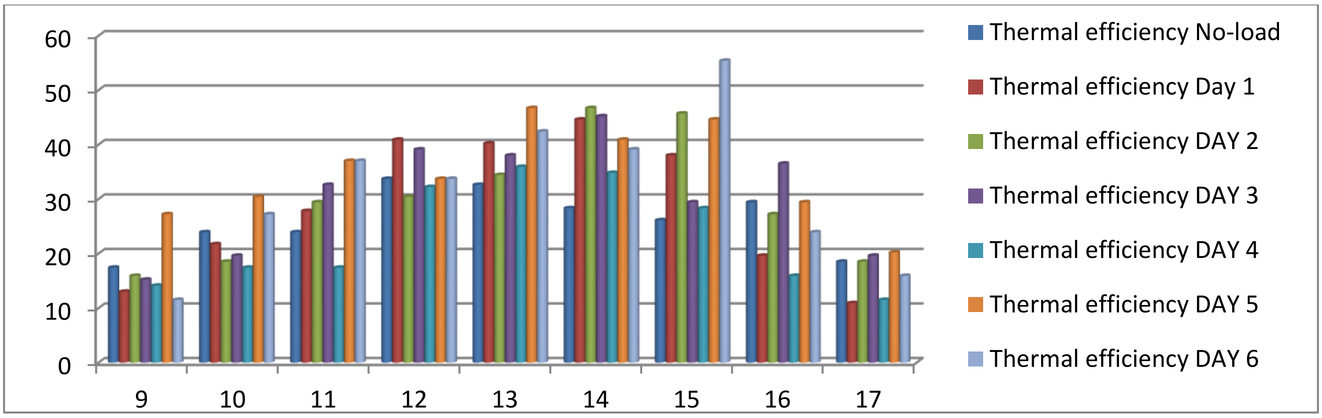

Figure 4.16: Thermal efficiencies against Time for YAM

Table 4.17: Thermal efficiencies for PEPPER for 4 days

TIME(HRS)	Thermal efficiency , ῆc No-load	Thermal efficiency, ῆc Day 1	Thermal efficiency , ῆc DAY 2	Thermal efficiency , ῆc DAY 3	Thermal efficiency , ῆc DAY 4
9	16.2	13.1	17.2	20.8	16.2
10	22.2	18.2	20.2	22.2	20.8
11	22.2	23.2	34.3	21.8	23.2
12	31.3	37.4	37.4	26.9	33.9
13	30.3	37.0	36.4	24.8	33.9
14	26.3	28.9	30.3	22.2	25.3
15	24.2	43.0	38.4	29.9	27.9
16	27.3	19.2	35.0	26.3	25.9
17	17.2	14.1	26.9	30.3	21.2

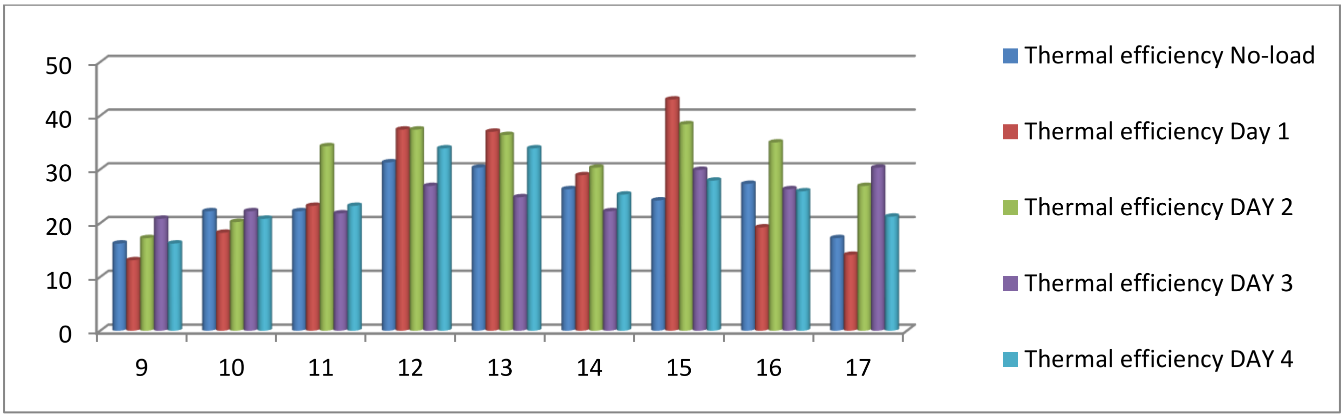

Figure 4:17: thermal efficiency against Time for PEPPER

4.5 Exergetic Efficiency

Heat Exergy, X (W)

The availability or Heat Exergy 'X' of a reservoir at temperature T providing a rate of heat transfer *q* in surroundings at temperature T_a is given by:

$$X = \left(\frac{T - T_a}{T}\right) q$$

Where;

X = Heat Exergy (W), T = Temperature at which heat is released (K), T_a= the prevailing environmental temperature (K), q= Rate of heat release (W)

Heat Anergy, Y (W)

Heat Anergy 'Y' is the remaining energy or unavailable energy. It is given as:

$$Y = \left(\frac{T_a}{T}\right) q$$

Where;

Y = Heat Anergy (W)

Therefore, Exergetic Efficiency 'η_x'= $\frac{X}{Y}$ x 100

Table 4.18: Exergetic Efficiency for YAM

TIME(hrs)	Exergetic Efficiency No-Load	Exergetic Efficiency DAY 1	Exergetic Efficiency DAY 2	Exergetic Efficiency DAY 3	Exergetic Efficiency DAY 4	Exergetic Efficiency DAY 5	Exergetic Efficiency DAY 6
0900	28.6	24.0	28.6	27.5	26.0	45.5	20.4
1000	39.3	38.5	30.3	33.3	30.8	46.7	46.3
1100	36.7	47.4	46.6	50.0	29.6	54.9	56.7
1200	53.4	62.7	46.7	61.0	51.0	49.2	50.8
1300	53.6	59.7	52.7	53.9	53.2	65.2	63.9
1400	46.4	62.1	67.2	64.0	52.5	55.3	58.1
1500	43.6	56.4	63.6	42.2	41.9	64.1	77.3
1600	48.2	37.5	42.4	54.2	31.7	43.6	36.7
1700	34.7	21.3	32.1	30.5	22.6	32.6	26.1

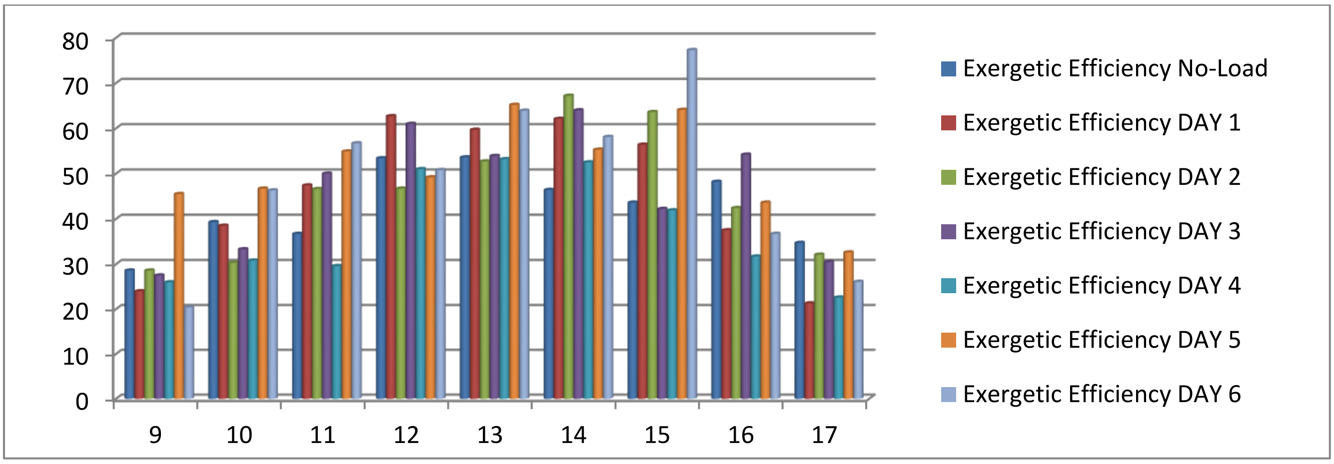

Figure 4.18: Exergetic Efficiency for YAM against Time up to 6 days

The highest usable energy that is, exergetic efficiency recorded during the drying of the YAM in the Dryer is 77.3% and the lowest 22.6%.

Table 4.19: Exergetic Efficiency for PEPPER

TIME(hrs)	Exergetic Efficiency No-Load	Exergetic Efficiency Day 1	Exergetic Efficiency Day - 2	Exergetic Efficiency Day - 3	Exergetic Efficiency Day - 4
0900	28.6	25.0	33.3	39.6	29.7
1000	39.3	32.1	35.1	36.7	38.2
1100	36.7	39.0	52.3	37.9	49.4
1200	53.4	61.7	56.9	45.9	56.0
1300	53.6	53.0	56.2	41.0	56.0
1400	46.4	45.4	46.1	48.6	37.9
1500	43.6	66.6	55.1	49.3	45.2
1600	48.2	30.6	50.9	43.3	42.0
1700	34.7	23.7	44.3	48.4	35.6

The highest usable energy that is, exergetic efficiency recorded during the drying of the PEPPER in the Dryer is 66.6% and the lowest 23.7%.

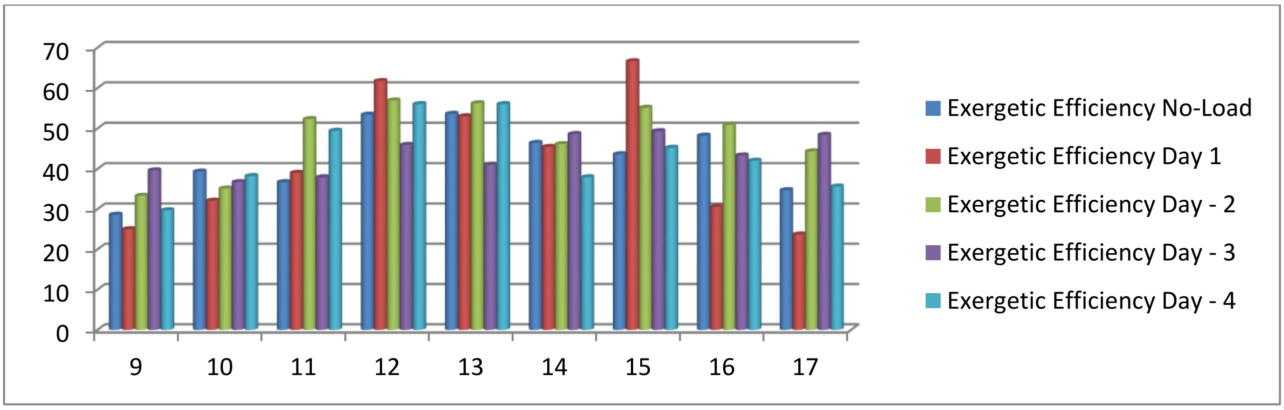

Figure 4.19: Exergetic Efficiency for PEPPER against Time up to 4 days

V. CONCLUSION

The solar dryer designed and developed for large storage of food items drying that need consistent drying so as not to allow growth of some microorganisms. The dryer is capable of producing the optimum temperature in the range of about 55℃ to 80℃ for drying of large amount of food. The solar dryer with total collector area of $1m^2$ is capable of drying about 5 kg of fresh pepper between 24 to 48 hours. The solar drying helped to reduce the drying time from 48 h to 24 h for the same level of moisture contents in comparison to the open sun drying of the food item because it is a mixed-mode dryer, working during the day and continuously in the night. The large-scale use of the solar dryer designed, fabricated, and evaluated would definitely help to prevent the deforestation in rural areas of Nigeria. The solar dryer has the ability to give good treat to food compared to that of direct radiation.

VI.RECOMMENDATION

The present Soar dryer design and fabrication is carried out based on the availability and cost of production since design was aimed at solving problem of basically rural problems. We hereby recommend that:

(i) More work should be done in the regulation of the effective and adequate performance of the solar dryer.

(ii) More work should be done in determining the rate at which heat moves from the collector to the drying cabinet with the velocity of the hot air entering the iron pipe for technical deductions.

VII. REFERENCES

[1]. S. A. Kalogirou. Progress in Energy and Combustion Science 30 (2004) 231–295.ASHRAE Handbook, chapter 32, pg. 3-5.

[2]. Mahler, E.D. P.L. Zervas, 2010, Determination of the optical tilt angle and orientation for solar photovoltaic arrays. Renewable Energy 35, 2468-2475.

[3]. Anderson B. Solar energy: fundamentals in building design. NewYork: McGraw-Hill; 1977.

[4]. Kreith F, Kreider J.F. Principles of solar engineering. New York: McGraw-Hill; 1978.

[5]. S.A. Kalogirou. Progress in Energy and Combustion Science 30 (2004) 231–295.ASHRAE Handbook, chapter 32, pg. 3-5.

[6]. James Stiling,Simon Li,Pieter Stroeve,Jim Thompson, Bertha Mjawa, Kurt Kornbluth, Diane M.Barrett. Performance evaluation of an enhanced fruit solar dryer using concentrating panels,Energy for Sustainable Development(2012),doi:10.1016/j.esd.2012.01.002

[7]. Bansal, N. K., Kleemann, M., Meliss, M., Kaul, R., & Ghosh, K. (1990). Renewable energy sources and conversion technology. New Delhi: Tata McGraw-Hill.

[8]. Stoecker W.F. and Jones W.J. Refrigeration and Air Conditioning, pp. 71-85.McGraw Hill, Tokyo (1982).

[9]. American Society of Heating, Refrigerating and Air-Conditioning Engineers. (1985). ASHRAE handbook.

[10].Derringh, E., & Halliday, D. (1981). Selected solutions for Fundamentals of physics second edition andsecond edition extended byDavid Halliday, Robert Resnick, Edward Derringh. Chichester: Wiley.

[11].Kurt Kornbluth, Diane M. Barrett. Performance evaluation of an enhanced fruit solar dryer using concentrating panels, Energy for Sustainable Development (2012), doi:10.1016/j.esd.2012.01.002

[12].Mahler, E.D. P.L. Zervas, 2010, Determination of the optical tilt angle and orientation for solar

photovoltaic arrays. Renewable energy 35, 2468-2475.
[13].Anderson B. Solar energy: fundamentals in building design. New York: McGraw-Hill; 1977.
[14].Akinola A.O. (1999). Development and Performance Evaluation of a Mixed-Mode Solar Food Dryer.M. Eng. Thesis, Federal University of Technology, Akure, Nigeria.
[15].Akinola A.O, Fapetu O.P. (2006). Exergetic Analysis of a Mixed-Mode Solar Dryer.J. Eng. Appl. Sci. 1: 205-210.
[16].Akinola, O.A, Akinyemi A.A, Bolaji B.O (2006). Evaluation of traditional and solar fish drying systems towards enhancing fish storage and preservation in Nigeria. J. Fish. Int. Pakistan 1(3-4): 44-49.
[17].Ikejiofor I.D. (1985). Passive Solar Cabinet Dryer For Drying Agricultural Products. In: O. Awe (Editor), African Union of Physics. Proc.

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