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ORIGINAL ARTICLE

Parametric Investigations of Drying Roselle Calyces Flower

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ABSTRACT – In this research, a new dryer which use halogen lamp must be designed and the drying performance of Roselle is to be investigate. The power of lamp is varied (50, 75, 100, 125, 150, 175, 200, 225) W. The result shows that higher power of lamp produce high temperature and low humidity which shorten the drying time of Roselle. The drying rate of each parameter shows slightly different pattern as temperature does not constant since the power supply does not produce constant voltage or current. The heat of vaporization increase as the power of lamp is increase and quantity of heat energy to raise temperature of Roselle at certain mass also increase. The most suitable parameter is 200W since the colour of Roselle does not degrade very much with short drying time 240mins, heat, transfer coefficient 91.51 W/2K . Maximum has a sour taste and is ordinarily utilized in the readiness of cold and hot drinks and as energy needed to heat Roselle at 62ºC is 17.02 kJ and heat of vaporization are determined to be 2612.3 kJ/kg.

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INTRODUCTION

Human able to survive without food for about 3 weeks and without water for 3 to 4 days [1]. As population increases, the food demand is high and there are a lot of industry or manufacturing company working on to produce a mass production for foods and drinks. In UK, largest industry sector was dominated by the food industry as it contributes around £113 billion for economy [2]. Food and drink (F&D) producing in industrialized nations is an enormous segment by worth and volume, representing a huge extent of vitality utilization in the assembling area – 11% in the European Union (EU28), for instance (Eurostat,2018) – despite the fact that its vitality power is moderate [3]. There are various kind of food that can beharvest from the field [4], [5] so that it can processed as an example is Roselle. Hibiscus sabdariffa (Roselle) is a lasting herb forms by 3 leaves, stems and blossoms hat have a forceful portly calyx at the base. The calyces are dried and used to plan nourishments and drinks [6]. The most utilized piece of Roselle is the red, diligent calyx of its blossoms which has a sour taste and is ordinarily utilized in the readiness of cold and hot drinks and as a nourishment colorant. It is one of the most significant restorative plants and has been utilized as a wellspring of anthocyanins and acids. Therefore, with a lot of benefits that come from Roselle, it has tendency in market to produce a large scale, but the main drawbacks are to preserve the food due to the Roselle can be spoil when distributing to other place in a long time. In order to preserve the Roselle, dryer using Halogen lamp is to be designed and create.

METHODOLOGY

In this experiment, the power of lamp (50, 75, 100, 125, 150, 175, 200) W is varied in order to study the effect of temperature and humidity of dryer while distance between lamp and sample is fixed (5cm). Dryer has been designed using Catia software and electrical and electronic circuit design is done by proteus software. Drying conditions has been studied in every power of lamp which decide the most suitable parameters. In order to determine the performance of every power of lamp, thermodynamics/heat transfer analysis also has been studied.

Figure 1 shows the design of the dryer. It has three compartments namely A, B, and C in the figure. The 'A' part is the tray to put Roselle flower. The housing part at 'B' is installed with drying equipment such as fans and lamp for drying process The last part, 'C' is cover for electrical circuit panel in Figure 2.

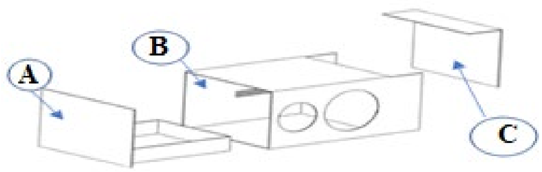

Figure 1. Design of dryer

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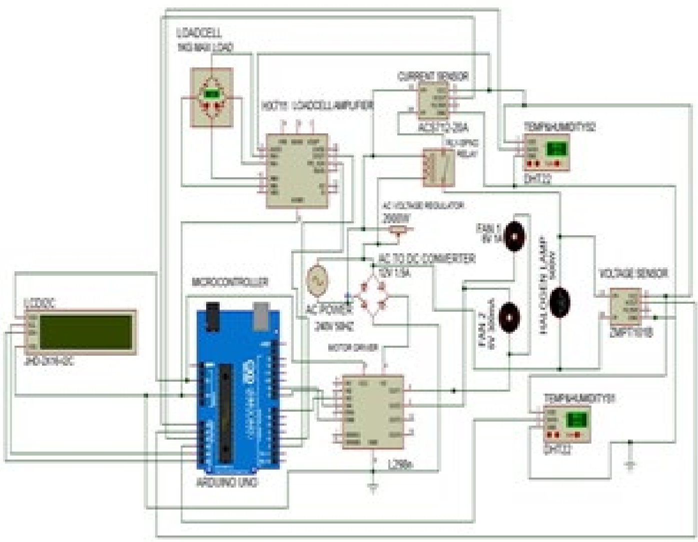

Figure 2. Schematic Circuit of dryer

Drying and Heat Transfer Analyis

Equation 1 until Equation 9 is parameters used in the analysis.

$$X = \frac{W_i W_{bd}}{W_i} \quad (1)$$

X = Moisture Content
W_i = Initial mass,g
W_{bd} = Drying mass,g

$$MR = \frac{X - X_{eq}}{X_0 - X_{eq}} \quad (2)$$

MR = Moisture ratio
X_{eq} = Moisture content during equilibrium
X_0 = Initial moisture

$$\dot{x}_1 = \frac{X_1 - X_0}{t_1 - t_0} \quad (3)$$

$\dot{x}_1$ = Drying rate at $t = t_0, \frac{g}{g.min}$

$$\dot{x}_n = \frac{X_{n+1} - X_{n-1}}{t_{1+1} - t_{n-1}} \quad (4)$$

$\dot{x}_1$ = Drying rate at $t = t_n\ ; n = 1, \ldots, N$

$$\dot{x}_f = \frac{X_f - X_{f-1}}{t_f - t_{f-1}} \quad (5)$$

$\dot{x}_n$ = Drying rate at $t = t_f$, final point

$$Q = mC_p \Delta T, J \quad (6)$$

m = Mass,kg
C_p = Specific heat capacity $, \frac{KJ}{kg}.K$
ΔT = Temperature, $^{\circ}C$

$$\dot{Q}_{total} = \dot{Q}_{conv} + \dot{Q}_{rad}\ , J \quad (7)$$

$$\dot{Q} = h_{combine} A_s (T_s - T_{\infty}), J \quad (8)$$

A = Surface area, m^2
T_s = Tempearture surronding, $^{\circ}C$
T_{∞} = Room tempearture, $^{\circ}C$

$$Heat\ of\ Vaporization = h_v - h_c\ , KJ/kg \tag{9}$$

h_v = Specific Enthalphy of Saturated Steam, KJ/kg
h_c = Specific Enthalphy of Saturated, KJ/kg

RESULS AND DISCUSSION

Drying Results

The first 4 parameters have long drying time for the Roselle to become equilibrium moisture content and 90% mass reduction based on Figure 3 and Figure 4. This is due to low temperature generate by the first 4 parameters. For 50W of power it cannot be used for drying process even though the temperature is low. This is because the process of drying takes too much time which expose the Roselle to light for very long time. The drying rate for first 4 parameters decreasing as the moisture content become lesser. The reason why the result is spike is because the distortion in power supply which cause the temperature to changes over time thus sometimes increasing or decreasing the drying rate. Based on Figure 5 and Figure 6, the last 4 parameters have short drying time for the Roselle to become equilibrium moisture content or 90% mass reduction. For this last 4 parameters, 225W cannot be used as the temperature gets too high which change and darken the colour of Roselle. The drying rate for the last 4 parameters is less spiky due to the temperature increasing constantly thus decreasing the drying rate constantly as the moisture content become lesser based on Figure 7.

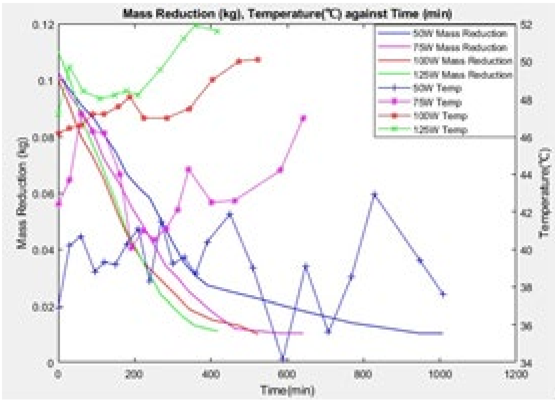

Figure 3. The first 4 parameters graph Mass Reduction (kg), Temperature against Time (min)

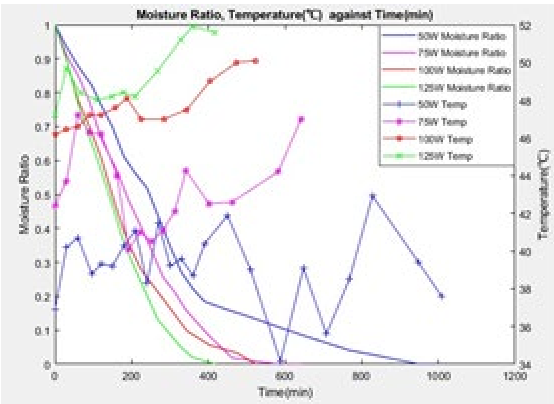

Figure 4. The first 4 parameters graph Moisture Ratio, Temperature against Time (min)

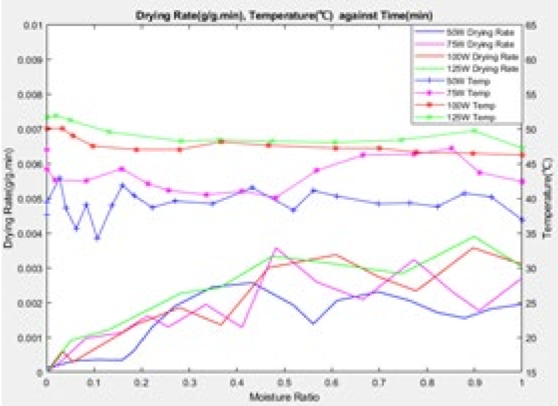

Figure 5. The first 4 parameters graph Drying Rate (g/g.min), Temperature against Time (min)

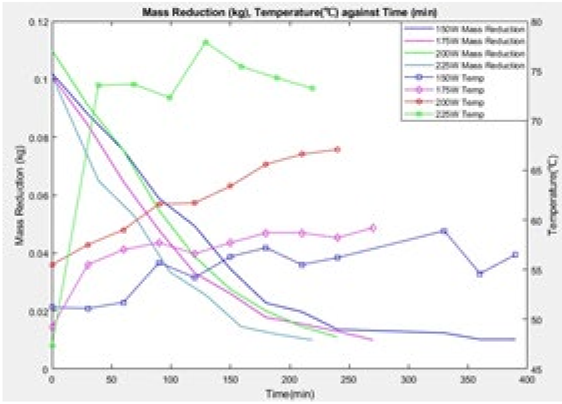

Figure 6. The last 4 parameters graph Mass Reduction (kg), Temperature against Time (min)

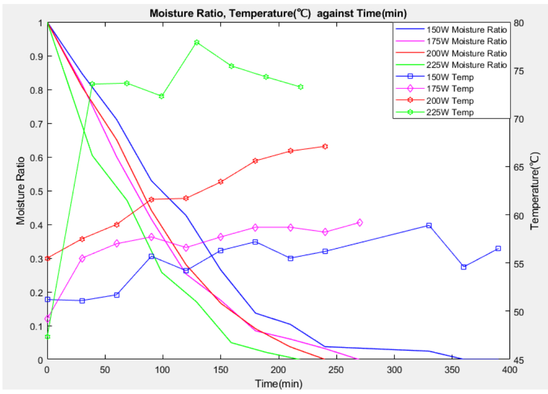

Figure 7. The last 4 parameters graph Moisture Ratio, Temperature against Time (min)

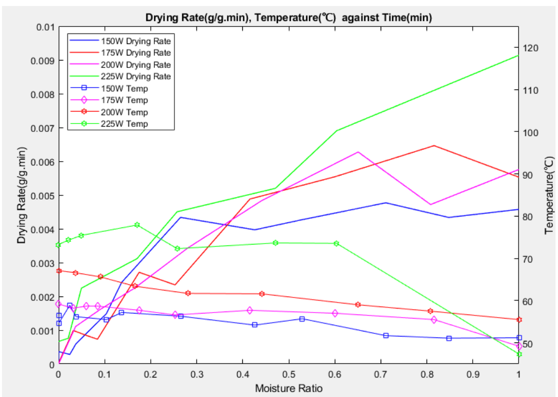

Figure 8. The last 4 parameters graph Drying Rate (g/g.min), Temperature against Time (min)

Heat Transfer Results

The first 4 parameters show increasing heat transfer coefficient as the power of lamp increase (Table 1). 50W have the lowest temperature change and lowest heat transfer coefficient. This contributes to low maximum energy (Table 4) required by the Roselle to heat from certain temperature thus lowering the heat of vaporization (Table 5). This situation also suggest why 50W cannot be used for drying. For the last4 parameters, heat transfer coefficient (Table 3) increases from 150W to 175W before it starts to decrease from 200W to 225W. The reason why heat transfer coefficient starting to decrease from 200W to 225W is because the temperature difference is very high. For this last 4 parameters, 225W cannot be use for drying. This is because, the Roselle change its colour and its become dark due to heat transfer coefficient is low relatively to the temperature difference and heat of vaporization is too high (Table 6).

Table 1. The first 4 parameters Heat Transfer Coefficient

Heat				
Power of lamp (W)	50	75	100	125
96.5% of power in halogen lamp is convert to heat (W)	48.25	72.38	96.50	120.63
Area (m^2)	0.057	0.057	0.057	0.057
Temperature, T_d (°C)	39.23	43.45	47.69	49.31
Temperature, T_s (°C)	25	25	25	25
Temperature, T_d - T_s (°C)	14.23	18.45	22.69	24.31
Coefficient, h_combined $\left(\frac{W}{m^2K}\right)$	59.49	70.05	74.61	85.99

Table 2. The last 4 parameters Heat Transfer Coefficient

Heat				
Power of lamp (W)	150	175	200	225
96.5% of power in halogen lamp is convert to heat (W)	144.75	168.88	193.00	217.13
Area (m^2)	0.057	0.057	0.057	0.057
Temperature, T_d (°C)	54.93	56.85	62.00	72.52
Temperature, T_s (°C)	25	25	25	25
Temperature, T_d - T_s (°C)	29.93	31.85	37.00	47.52
Coefficient, h_combined $\left(\frac{W}{m^2K}\right)$	84.85	93.02	91.51	81.59

Table 3. The first 4 parameters Quantity of heat

Heat				
Power of lamp (W)	50	75	100	125
Mass of Roselle collected (kg)	0.102	0.103	0.100	0.110
Specific heat capacity of Roselle, C_p $\left(\frac{kJ}{kg°C}\right)$	4.182	4.182	4.182	4.182
Temperature, T_d - T_s (°C)	14.23	18.45	22.69	24.31
Amount of heat required (kJ)	6.07	7.95	9.49	11.18

Table 4. The last 4 parameters Quantity of heat

Heat				
Power of lamp (W)	150	175	200	225
Mass of Roselle collected (kg)	0.102	0.101	0.110	0.101
Specific heat capacity of Roselle, C_p $\left(\frac{kJ}{kg°C}\right)$	4.182	4.182	4.182	4.182
Temperature, T_d - T_s (°C)	29.93	31.85	37.00	47.52
Amount of heat required (kJ)	12.76	13.45	17.02	20.07

Table 5. The first 4 parameters Latent heat of vaporization

Heat				
Power of lamp (W)	50	75	100	125
Mass of Roselle collected (kg)	0.102	0.103	0.100	0.110
Temperature in the dryer, (°C)	39.23	43.45	47.69	49.31
Heat of vaporization for 1kg, $\left(\frac{kJ}{kg}\right)$	2572.1	2579.6	2587.1	2589.5
Heat of vaporization for sample of Roselle mass, (kJ)	262.35	265.70	258.71	284.85

Table 6. The last 4 parameters Latent heat of vaporization

Heat				
Power of lamp (W)	150	175	200	225
Mass of Roselle collected (kg)	0.102	0.101	0.110	0.101
Temperature in the dryer, (°C)	54.93	56.85	62.00	72.52
Heat of vaporization for 1kg, $\left(\frac{kJ}{kg}\right)$	2600.1	2603.3	2612.3	2630.4
Heat of vaporization for sample of Roselle mass, (kJ)	265.21	262.93	287.4	265.7

CONCLUSION

The most optimum parameter is 200W as it has short drying time which is 240 min. This is because the temperature is high and the humidity inside the dryer is low when this parameter is set. The colour of Roselle also did not change very much and it does not burn due to not constantly heated by the same temperature (increased slowly from 55 to 62) for a long time. The heat transfer coefficient during this power is 91.51 W/m^2.K, quite high which suggest heat to transfer very easily. This high heat transfer coefficient resulting to higher maximum energy and increase the heat of vaporization for Roselle which in turn improve the drying performance a lot.

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