Optimal Energy of Glutinous Rice Drying via Infrared Irradiation

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Abstract. *This work aims to study the energy consumption of glutinous rice drying via infrared irradiation. An experimentation was used an infrared heater, with the power adjusted at 300, 400 and 500 W. Parameters were studied on layer's thickness of glutinous rice, moisture ratios and energy. An experimental result revealed that a drying energy consumption of 0.75 kWh with glutinous rice at 5 mm of layer's thickness which was optimal. The power was selected at 300 W using a drying time of 150 min.*

1. Introduction

Khao Tan (Rice Crackers) are traditional Thai snacks that is full of nutrients. Production processing is as result by steaming and then dried glutinous rice. After that, it is fried and added its with sugar [1]. The drying technique of glutinous rice is used heat energy form of natural solar, which is used for a long time by drying and the temperature is unstable. This could affect the quality and quantity of the products.

Recently, a study of food drying techniques which included agricultural products that could be taken from anyplace, for example, sea cucumber and anchovy were dried via infrared radiation and air drying. The energy's result was found to be dependent on drying temperature. Moreover, the heat's sensitivity of infrared radiation was higher than the air drying. Infrared radiation technique increased the efficiency of moisture's evaporation over a short duration when it compared with air drying [2, 3]. Likewise, amid the drying of apple and kiwi fruit, infrared radiation technique was applied [4-6]. For the drying of Cavendish banana slices was used Infrared radiation technique to verify the vacuum pressure, temperature and thickness. These parameters had significant effects on the drying kinetics and various qualities of drying banana as color, hardness and shrinkage [7]. An employing infrared drying was studied the parameters of air temperature, velocity and infrared radiation as well as moisture diffusivity and energy consumption, which sour cherry was focused on. Artificial neural network (ANN) method was used to predict the relationships of parameters [8]. In addition, surface's response method was applied to consider shrinkage, energy consumption and total colour that change of almond kernel drying with infrared-vacuum dryer [9].

At present, heat-drying technique employing infrared radiation is more accepted than using hot air. This is due to the heat's sensitivity of infrared radiation being higher than drying air. Furthermore, the drying process utilizing infrared heat performs greater efficiency over a short time frame. This was established in preliminary literature reports. Nevertheless, the drying process of glutinous rice incorporating the model parameters of layer thicknesses, moisture ratios and energy consumption which using infrared irradiation technique is not to be investigated.

Therefore, the aim of this work is to study the energy consumption of glutinous rice drying via infrared irradiation. Parameters under consideration are the layer thickness, moisture ratios and energy on drying process.

2. Materials and Method
2.1 Moisture Content

Initially, steamed glutinous rice was left to cool at ambient temperature. After that, glutinous rice was formed in to square shapes of 10 x 10 cm with layer thicknesses of 5, 10 and 15 mm, as shown in Fig. 1.
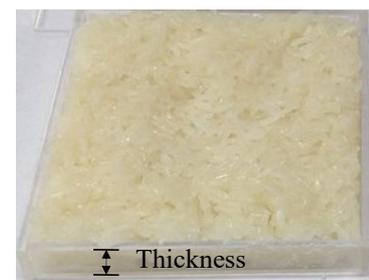

Fig. 1: Layer thickness of the glutinous rice which is one of the parameters under this research

Mass of the rice was measured by using an electronic balance meter incorporating accuracy of ± 0.1 g. The moisture content was presented the relationship as following,

$$M_i = \left(\frac{m_i - m_f}{m_i} \right) \times 100\% \qquad (1)$$

where M_i, m_i and m_f were the initial moisture content on a % wet-basis, initial mass and final mass, respectively [10]. Therefore, the initial moisture content of steamed glutinous rice after cool at ambient temperature was found about 81% of wet-basis to use a case study for this work.

The moisture ratio was accounted for the fraction as shown between the moisture content of wet glutinous rice at any time and initial moisture content. Moisture ratio can be expressed in equation,

$$M_r = \frac{M_t}{M_i} \qquad (2)$$

; where M_r and M_t were moisture ratio and moisture content at any moment respectively [11].

2.2 Energy Consumption of Glutinous Rice Drying

Drying energy was calculated in terms of the power and the time requirement for the drying process via the following equation:

$$D_e = Pt \qquad (3)$$

; where D_e, P and t were drying energy, power and drying time, respectively.

2.3 Experimental Test-Rig

Glutinous rice was dried by using the infrared irradiation technique. The dryer consisted of an infrared heater that could be set the operating power between 300-500 watts that having configuration diagram as shown in Fig. 2. A watt meter was used to measure the consuming power with high accuracy of ± 0.1 watts. Moisture ventilation was installed and carried out via a 50-watt electric power suction fan.
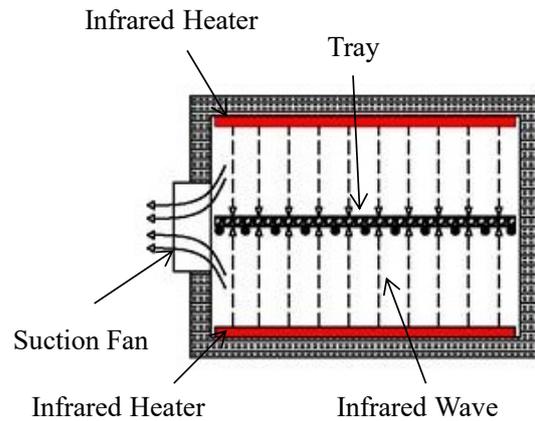

Fig. 2: Drying apparatus diagram

In general, the optimal moisture ratio of dried glutinous rice is in 30% part of initial moisture content. In which, the initial moisture content was defined at 81% of wet-basis in heading section 2.1. Thus, this work, the drying of glutinous rice, a two stages were utilised as follow detailed. Firstly, power at 300 W was applied to find the optimal value between layer's thicknesses and moisture ratios of glutinous rice. Secondly, power levels are define increase at 400 W and 500 W to find a drying energy that the optimal energy.

3. Results and Discussion
3.1 Drying Thickness

In the first stage, the experiment employed a power of 300 W along with drying time. Layer's thicknesses of glutinous rice were 5, 10 and 15 mm respectively. The experimental results were revealed by graph form in accordance with drying energy and the moisture ratios in Fig. 3.
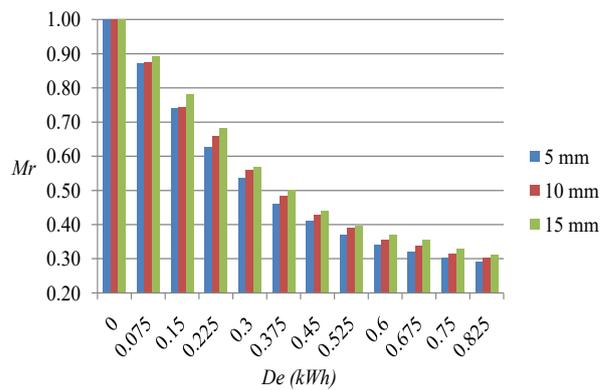

Fig. 3: Experimental results in accordance with drying energy and moisture ratio

Fig. 3 was shown that drying energy and moisture ratio which was using a power level of 300 W. The layer's thicknesses of glutinous rice had affect of decreasing moisture ratios. The drying energy was found to be 0.75

kWh using a drying time of 150 min, and moisture ratio of 0.302 or 30.2% at a layer thickness of 5 mm. Besides that, the layer's thicknesses of 10 mm and 15 mm gave moisture ratios of 0.315 and 0.331 respectively. Consequently, 5mm layer's thickness performed optimal moisture ratio when compared with 10 mm and15 mm. In addition, the drying time of 5 mm layer's thickness applied less time duration than 10 mm and 15 mm as shown in Fig. 4. Surface area of glutinous rice that all values of the thickness were revealed by indicating insignificant differences as shown in Fig. 5.
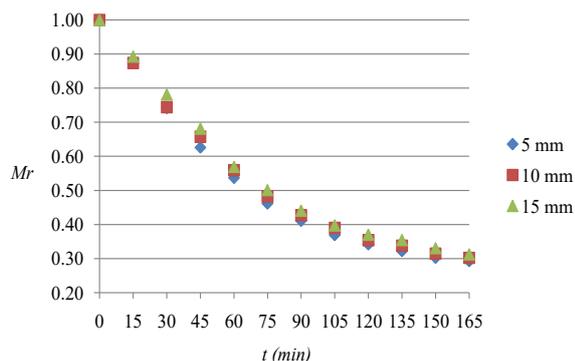

Fig. 4: Experimental results displaying drying duration and moisture ratio

Fig. 5: photographs of the surface areas of the glutinous rice under drying energy (0.75 kWh)

3.2 Drying Energy

As previous experiment, the optimal layer's thickness of glutinous rice was approximately 5 mm with utilizing drying energy of 0.75 kWh. The power of 300 W was used throughout 150 min of drying. The second experiment employing power incorporated the value of 400 W and 500 W with the glutinous rice layer's thickness at 5 mm. The results revealed that moisture ratios of 0.302 using power of 400 W and 0.3 for 500 W. Drying times application were 120 min and 90 min respectively. Furthermore, drying energy was about 0.8 kWh when using power of 400 W and 0.75 kWh of 500 W. The surface area of glutinous rice was observed as shown in Fig. 6.

According to Fig. 6, a moisture ratio of 0.3 using a drying time of 90 min for a power level of 500 W was applied the minimum time with drying energy as 0.75 kWh. However, the surface's area of glutinous rice was given burning. For a moisture ratio of 0.302 was applied drying time for 120 min with a power level of 400 W that using the drying energy of 0.8 kWh. As a result, the comparing with a

power of 300 W at drying time for 150 min, it was given moisture ratio as the same. The drying energy was used as 0.75 kWh, it is less than a power of 400 W. The surface's area of glutinous rice both 300 W and 400 W was different slightly. Thus, the optimal of drying energy was used at 0.75 kWh with a power level of 300 W.

Fig. 6: Power and surface area of the glutinous rice

4. Conclusions

Glutinous rice drying involving infrared irradiation technique is to study layer's thickness, moisture ratio and then energy was performed. The layer thickness of the glutinous rice has been significant to effect moisture ratios and drying energy. The experimental result was revealed that the glutinous rice drying utilised power level of 300 W with a drying time for 150 min which produce optimal energy of 0.75 kWh. A layer thickness of 5 mm gave an moisture ratio of 0.302. Moreover, a thickness layer of 5mm applied less drying time than both 10 mm and 15 mm.

Acknowledgements

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Biographies

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