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Development and Process Characterization of Low Cost Heat Pump Dehumidifier for Crackers Dryer

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***Abstract*— The aims of this reseach is developing low cost heat pump dehumidifier (HPD) for shrimp crackers dryer, and observe the process characteristic of HPD dryer. System of HPD dryer consist of evaporator, condensor, compressor, expansion valve, fan blower and drying chamber. Observed characteristic factor of the HPD dryer are drying chamber temperatur, fan blower speed, relative humidity and absolute humidity, drying time and energy consumtion. Result proved that development of HPD dryer can perform well for shrimp cracker drying. Based on statistical test, the fan blower speed factor has significant effect to drying time. the higher the fan blower speed, the shortest the drying time. Drying chamber temperatur factor and it's interaction with fan blower speed factor statisticaly has no significant effect to drying time. Statisticaly tested, the factor of drying chamber temperature, fan blower speed, and interaction factor of drying chamber temperature with fan blower speed has no significant effect to energy consumtion.**

Keywords*— *Heat Pump Dehumidifier, dryer, food drying, energy consumption

I. INTRODUCTION

Food drying technology is used to preserve food, reduce weight for ease of packaging and delivery[1][2][3]. The development of food drying technology starts from drying by using direct sunlight, then develops using solar collector to collect heat and dry food by convection[4][5][6][7].

Further technology uses microwave drying[8][9] infrared radiation[10], dehumidifier[11][12], and heat pump[13][14]. The use of heat pump technology provides the advantage of low energy consumption compared to infrared and microwave radiation technology.

II. OBJECTIVES AND RESEARCH METHODS

The targets of this research are: Developing low cost HPD dryers that are not weather dependent yet energy efficient, and characterize the drying process of shrimp crackers using this HPD drying machine. The HPD dryer system design consists of two main parts, that is a dryer and a drying chamber. Drying chamber is a space of material dried rack through wich the closed loop air dryer circulate. The drying machine components consist of evaporator, condenser, compressor, expansion valve, piping, refrigerant, and fan blower. This components are present in form a commercial split AC unit. The heat source of HPD dryer in this research uses the AC indor unit, including evaporator, expansion valve, fan blower, and control board. Indor AC units in the HPD dryer work to condense water vapor in air circulated in closed loop. The latent condensation heat vapor extracted by the evaporator is brought to the outdor AC unit for release as a source of the dryer air heater in the condenser. Outdor AC units used in this HPD drying machines consist of condenser, compressors, and fan blowers. Condenser serves to remove heat from the refrigerant, this heat is used to raise the dryer air temperature. Because the heat of the refrigerant is obtained from the evaporator unit located on a cooler area, from that condition the system is called the heat pump because it moves heat from low temperature to high temperature. The cycle diagram of the refrigerant and the cooling air cycle in the HPD drying system is shown in Fig.1. And the photograph of the built-in dryer is shown in Fig.2.

III. EXPERIMENT SETUP AND MEASUREMENT

The experiment conducted in this research is to study the effect of fan blower speed factor and evaporator temperature factor on drying time and drying energy consumption. The fan blower speed setting level is high, medium, low. The temperature setting level of the evaporator is 16oC, 19oC, 21oC. The drying process conditions, temperature, relative humidity and absolute humidity are monitored in real time from the dryer room using the BME280 sensor.

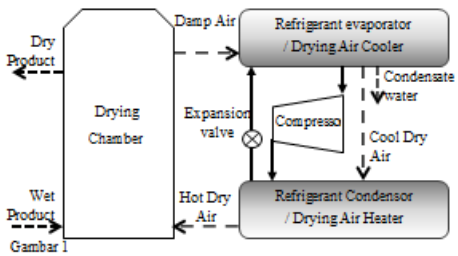
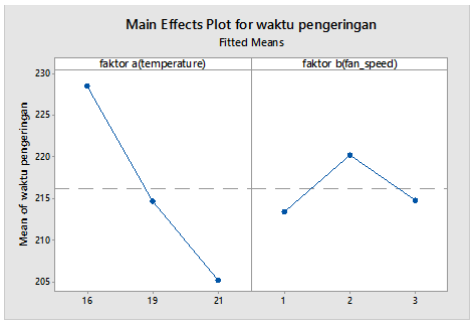


Fig. 1. Heat Pump Dehumidifier Drying system diagram.

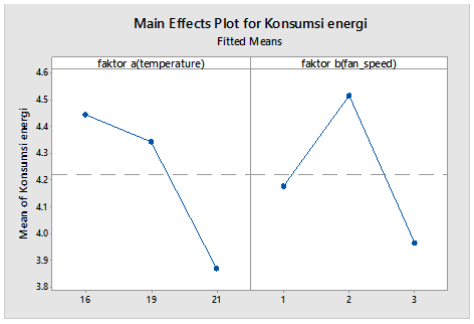
Fig. 2. The HPD dryer machine.

IV. RESULT AND DISCUSSION

Fig.3.a. and Table 1. show the main effect plot and anova test results of the dryer temperature factor, the fan blower speed factor over the drying time. The temperature factor of 16oC level requires an average drying time of 228 minutes, at 19°C average drying time is 214 minutes, while at 21°C the average drying time is 205 minutes. Fan speed factor, has 3 levels of high speed, medium speed and low speed. At the first level of high fan blower speed requires an average drying time of 213 minutes, for the second level of medium fan blower speed requires drying average time of 220 minutes, while for the third level low fan blower speed requires 215 minutes drying time average.



(a)



(b)

Fig. 3. Main effect plot of drying temperature factor and fan blower speed factor over, a). Drying time, b). Energy consumption.

Anova test for drying temperature factor, obtained P-value 0,004 <0,05 so statistically there is no significant influence of dryer temperature to drying time. P-value factor for fan blower speed is 0,505> 0,05 so there is significant influence of fan blower speed to drying time. For the combination of dryer temperature factor and fan blower speed, P-value value 0,000 <0,05 so statistically there is no significant influence of combination of drying temperature factor and fan blower speed to drying time. Anova test for effect of drying temperetur factor and fan blower speed factor over drying time

Table 1. Anova Test For Effect Of Drying Temperetur Factor And Fan Blower Speed Factor Over Energy Consumption

Source	DF	Adj SS	Adj MS	F-Value	P-Value
faktor a (temperatur)	2	2479,6	1239,8	7,58	0,004
faktor b (fan speed)	2	232,1	116,0	0,71	0,505
faktor a (temperatur) * faktor b (fan_speed)	4	5880,4	1470,1	8,99	0,000
Error	18	2943,3	163,5		
Total	26	11535,4			

Fig 3.b. and Table 2. show the main effect plot and anova test results of the dryer temperature factor, the fan blower speed factor over the energy consumption. The temperature factor at level 16ºC consume an average 4,45 kWh of energy, at 19°C average energy consumption is 4,34 kWh, while at 21°C the average energy consumption is 3,88 kWh. Fan speed factor, has 3 levels of high speed, medium speed and low speed. At the first level of high fan blower speed consumed average energy at 4,18 kWh, for the second level of medium fan blower speed the average energy consumption is 4,55 kWh, while for the third level low fan blower speed consume 3,95 kWh energy average.

Anova test for drying temperature factor, obtained P-value 0,019 <0,05 so statistically there is no significant influence of dryer temperature to energy consumption. P-value factor for fan blower speed is 0,034> 0,05 so there is no significant influence of fan blower speed to energy consumption. For the combination of dryer temperature factor and fan blower speed, P-value value 0,001 <0,05 so statistically there is no significant influence of combination of drying temperature factor and fan blower speed to energy consumption.

V. CONCLUSION

From the result of research proved that development of HPD dryer can perform well for shrimp cracker drying. Based on statistical test, the fan blower speed factor has significant effect to drying time. the higher the fan blower speed, the shortest the drying time. Drying chamber temperatur factor and it's interaction with fan blower speed factor statisticaly has no significant effect to drying time. Statisticaly tested, the factor of drying chamber temperature, fan blower speed, and interaction factor of drying chamber temperature with fan blower speed has no significant effect to energy consumtion

REFERENCES

[1] R. Winiczenko, A. Kaleta, K. Górnicki, and A. Choińska, "Impact of Drying Parameters and Methods on The Volume Increase of Dried Apples During Their Rehydration," *Agric. Eng.*, vol. 2, no. 150, pp. 219–228, 2014.

[2] S. S. Onimisi and A. N. Sule, "Investigation of DryingQuality of Yam (A Staple Food) From Developed Multipurpose Food Dryer," *Int. J. Eng. Technol.*, vol 6, no. 6, pp. 191–196, 2016.

[3] N. Toontom, M. Meenune, W. Posri, and S. Lertsiri, "Effect of drying method on physical and chemical quality , hotness and volatile flavour characteristics of dried chilli," *Int. Food*

Res. J. 19, vol. 19, no. 3, pp. 1023–1031, 2012.

[4] O. J. Alamu, C. N. Nwaokocha, and O. Adunola, "Design and Construction of a Domestic Passive Solar Food Dryer," *Leonardo J. Sci.*, no. 16, pp. 71–82, 2010.

[5] K. Bharadwaz, D. Barman, D. Bhowmik, and Z. Ahmed, "Design , Fabrication and Performance Evaluation of An Indirect Solar Dryer for Drying Agricultural Products," *Int. Res. J. Eng. Technol.*, vol. 4, no. 7, pp. 1684–1692, 2017.

[6] F. S. Alleyne and R. R. Milczarek, "Design of Solar Thermal Dryers for 24-Hour Food Drying," in *the Proceedings of the 2015 COMSOL Conference in Boston*, 2015, no. 1, pp. 2–5.

[7] M. Yahya, "Experimental and theoretical performances of a solar assisted dehumidification drying system for heat sensitive products," *J. Momentum*, vol. 14, no. 1, pp. 63–76, 2013.

[8] N. Izli, G. Izli, and O. Taskin, "Influence of different drying techniques on drying parameters of mango," *Food Sci. Technol.*, vol. 37, no. 4, pp. 604–612, 2017.

[9] G. V Barbosa-c, "Advances in dehydration of foods," *J. Food Eng.*, vol. 49, pp. 271–289, 2001.

[10] D. Maisnam, P. Rasane, A. Dey, S. Kaur, and C. Sarma, "Recent advances in conventional drying of foods .," *J. Food Technol.*, vol. 1, no. 1, 2016.

[11] J. C. Atuonwu, X. Jin, G. Van Straten, H. C. Van Deventer, and J. B. Van Boxtel, "Reducing energy consumption in food drying : opportunities in desiccant adsorption and other dehumidification strategies," *Ital. Oral Surg.*, vol. 1, pp. 1799–1805, 2011.

[12] L. Lecoq *et al.*, "Efficiency of air dehumidification on the drying process in a food plant," in *4th IIR Conference on Sustainability and the Cold Chain*, 2016.

[13] N. Poomsa-ad, K. Deejing, and L. Wiset, "Performance of Heat Pump Dryer for Kaffir Lime Leaves and Quality of Dried Products under Different Temperatures and Media," *Int. J. Nutr. Food Eng.*, vol. 5, no. 7, pp. 395–398, 2011.

[14] R. M. R. D. Abeyrathna and K. S. P. Amaratunga, "Use of heat pump dehumidifiers on industrial drying of chili," *Int. J. Sci. Res. Publ.*, vol. 7, no. 12, pp. 105–110, 2017.