Marygold Flower Drying Machine Performance with Cooling Dehumidification System Using a Refrigeration Machine

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Abstract: The purpose of this research is to make a drying machine for Marygold Flowers (Tagetes ercta L) which operates below 60 degrees Celsius. Serves so that the color, aroma and components contained in gemitir flowers are not damaged or greatly reduced due to high drying temperatures. The drying machine is made using a cooling dehumidification system using a refrigeration machine as the main component. This dryer operates at a temperature of 30-40 degrees Celsius with a humidity of 40-50%. This machine operates for 24 hours, producing dried flowers with a weight reduction of 90% and the smallest moisture content of 5%.

1 INTRODUCTION

Drying with a dehumidifier basically combines air conditioning with a dryer/heater. The air conditioner consists of a compressor, condenser, expansion valve, evaporator and fan to produce air flow. In a dehumidifier dryer the air coming out of the evaporator pumps up to a temperature of 30º to 57ºC (Minea, 2012) (Acar & Dincer, 2014). An increase in temperature will increase the rate of heat transfer to the material being dried and the rate of air diffusion in the material being dried. The low relative humidity of the air ultimately aids the movement of air from the dried material (Zamzami and Muhammad, 2017).

Here are some air dehumidification technologies, such as refrigeration dehumidification, membrane dehumidification, absorption dehumidification, and adsorption dehumidification (G. D. da Silva, at al, 2016) This dehumidification cooling technology is widely used in industrial and residential dehumidification fields because of its compactness and high safety (Caihang Liang, 2014). However, conventional dehumidification cooling systems are energy intensive. Energy costs will skyrocket if ventilation rates are high to control IAQ (Indoor Air Quality). As a result, a new dehumidification system was needed (Yu-Cheng Chu, et al, 2017). The advantage of dehumidifier drying compared to drying drying is that it is easy to control temperature and air drying so that it can be used over a wide temperature range (Chin, et al, 2018).

The process of removing moisture from agricultural materials is very energy-intensive. Process energy use is quite large about: 20-25% of the energy used by the food processing industry or 10-25% of the energy used in all industries in developed countries (Ziaforoughi and Esfahani, 2016). Therefore, energy along with time efficiency is one of the most significant design and operating parameters in food processing (Chong, et al, 2014). The low thermal conductivity and hardening of the material are the main factors responsible for slowing down the convective drying

There have been many advances in drying in recent years, including pretreatments, techniques, equipment and final product quality. Pretreatments, for example, are used with the aim of accelerating the drying process, improving quality and increasing food safety (G. D. da Silva, at al, 2016).

2 MATERIAL AND METHODS

2.1 Equipment

The drying machine is made with a scheme like Figure 1. Where the main equipment of the machine made consists of a compressor, condenser, expansion valve and evaporator. Additional equipment is a heater element that functions to heat the air coming out of the evaporator. The working scheme of this dehumification cooling drying machine at Fig 1.

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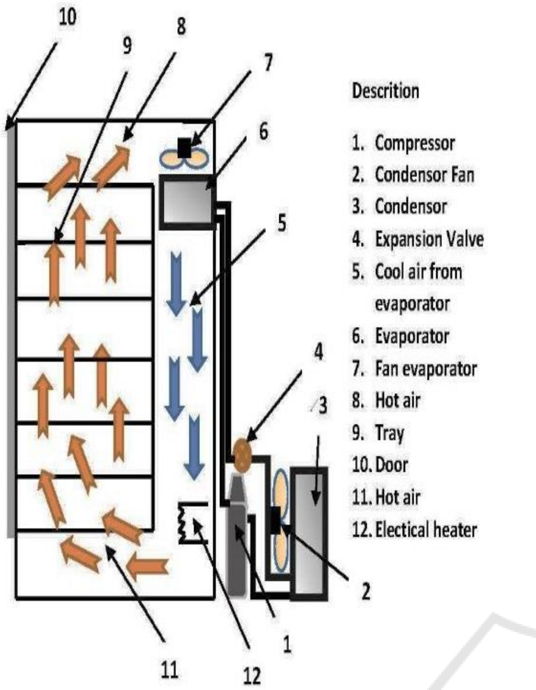

Figure 1: Schematic of the cooling dehumidification dryer.

2.2 Procedure Experiment

The Dryer that will be made uses a Refrigeration system component with a capacity of 1/2 Pk, with the evaporator and evaporator fan placed on the inside of the dryer, while the compressor, condenser and expansion valve are placed outside the dryer.

The Drying Machine is divided into 2 rooms, the first room has a shelf as a place for the bitter flowers to be dried, while the other room functions as a return air channel to the evaporator which will be cooled again by the evaporator. The air that is cooled by the evaporator will decrease in humidity, because in the evaporator there will be air condensation after passing through the gemitir flowers to be dried. The cold and dry air coming out of the evaporator is then heated by an electric heater. The hot, dry air then flows past the flowers on the drying racks. Bitter flowers placed on a drying rack will experience dehumidification, i.e. the moisture content contained in them will be taken up by dry and warm air that passes around them. The air that absorbs moisture from the bitter flower will be flowed back to the evaporator. And so on until the bitter flowers that are on the drying rack will become dry.

Control This Marygold flower dryer uses a thermostat to control the heater element at a temperature of 40 degrees Celsius and uses a humiditystat to control the compressor which will turn on at 50% relative humidity and turn off at 40% relative humidity.

Figure 2: Thermostat and humiditystat installed on the Smart control panel.

The gemitir flowers are to be dried, the Marygold flowers are removed from the stems first, then weighed, each shelf contains 500 grams of flowers. The drying chamber contains 7 shelves. The flowers that have been removed from the stems are placed on a shelf, then put into the drying chamber. The data logger is installed in the drying chamber and on the refrigeration system piping. Press the ON push button so that the dryer starts. Smart control is set at 40 degrees Celsius and humidity at 40%. And leave the dryer in the dryer for 24 hours.

Figure 3: Marigold flower dried in the drying chamber.

The temperature and humidity conditions of the dryer are monitored by data loggers and computers. Fresh flowers and dried flowers were weighed and the moisture content was measured using a moisture meter

Figure 4: Data logger and computer to get test data.

3 RESULTS AND DISCUSSION

The results of the marigold flower research that have been carried out are shown below.

3.1 Marigold Flower Drying Results

The results of the research that has been done where there are 7 shelves where dried flowers are made Table 1.

Table 1: Results of drying research of Marygold flower.

Shelf Number	Weigh Fresh Flower	Weight Dry Flower	Weiht Loss (Gram)	Weiht Loss (%)
1	150	25	125	83,33
2	150	25	125	83,33
3	150	25	125	83,33
4	150	25	125	83,33
5	150	25	125	83,33
6	150	20	130	86,67
7	150	15	135	90,00

Figure 5: Comparison graph of the weight loss of each shelf.

Flowers on shelf number 7 lost more weight (90%) than flowers placed on other shelves, because shelf number 7 was the first shelf to receive dry air coming out of the evaporator and heated by the heater. Following rack numbers 6, 5, 4 and so on.

Circulating air conditions in the dryer are depicted in Figures 6, 7 and 8.

On the condition of the second to 1750 seconds. Figure 6 shows the air coming out of the evaporator with a temperature of about 34 ºC and a humidity of 55%, after passing through the heater element the air temperature will increase to 50 ºC and the humidity is around 35% (Figure 7). After the drying air passes through the heater, it then passes through the flowers on the shelves, taking moisture from the marygold flowers. The air temperature increased by about 50ºC with the humidity also increasing to 43%. (Figure 8).

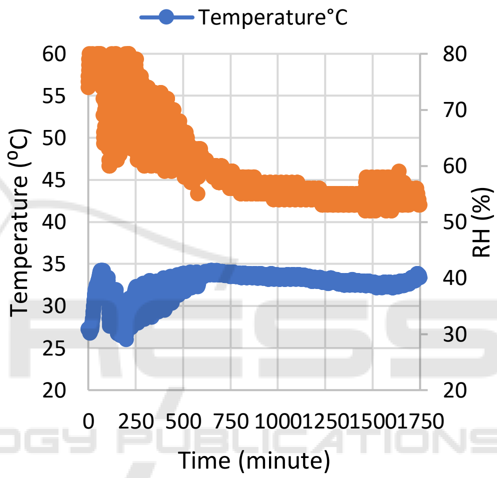

Figure 6: Graph of the condition of the air in the drying chamber coming out of the evaporator (point 5).

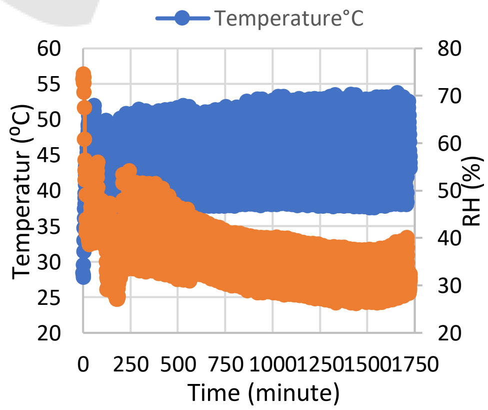

Figure 7: Graph of the air condition in the drying chamber after passing through the heater element (point 11).

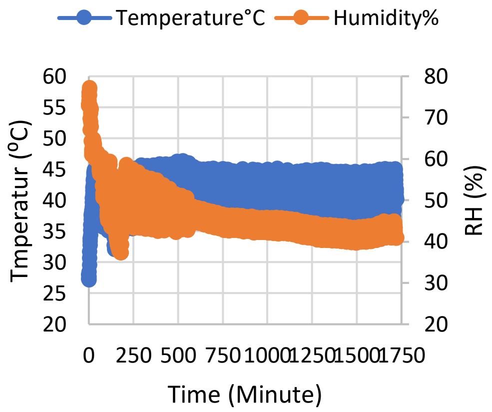

Figure 8: Graph of the air condition in the drying chamber after passing through rack number 1. (point 8).

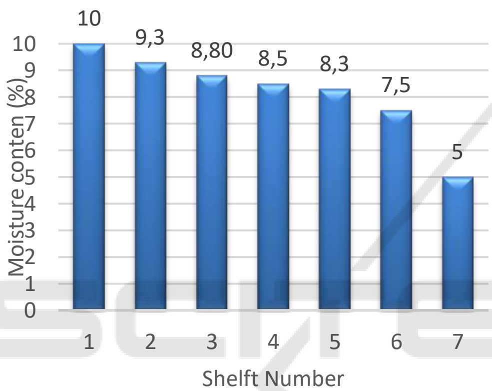

Figure 9: Moisture content of dried marigold flowers on each shelf.

The smallest moisture content is on the 7th shelf, because the flowers on that shelf are the first to receive the air heated by the heater element. Because in addition to the hot air that hits it causes the water vapor contained in the flowers to be easily released and also floats up towards the shelves above.

4 CONCLUSIONS

The results of drying marygold flowers are quite satisfactory, because the water content of dried flowers produced on average is below 10%, but not all of them show good results. Also the time it takes is still too long about 24 hours. It is necessary to make improvements to the machine, so that the results of the dried flowers are evenly distributed and the time required is under 24 hours.

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