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Development of Shelf-Rise Freeze Vacuum Drying with Capacity 250 gr of Dryied Product

Awaludin Martin,[a,*] Iwan Kurniawan[a], and Mintarto[a]

[a)]*Conversion Energy Laboratory, Mechanical Engineering, Universitas Riau, Indonesia*

*Corresponding author: awaludinmartin01@gmail.com

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ABSTRACT

Drying is a method or process to remove or eliminate some of the water of a substance by evaporating using thermal energy and can be done by various methods such as sun-drying or drying using solar, artificial drying such as oven, spray drying, vacuum drying, etc., and also drying by freezing. Drying by using solar and artificial drying such as with oven and others can be changing the structure, color and nutrients of the dryied material. Freeze vacuum drying method is an optimum process to dry the product without changing the physical and chemical properties of materials, even drying with freeze vacuum drying are can be maintain the structures, nutrient, and colors of original substances. The aim of this research is to develop and analyze a shelf-rise freeze vacuum drying system where the capacity of freeze vacuum drying is 250 gr of dryied product with pressure and temperatures ranging from -70 to -75 mmHg and -5 to -7°C, respectively. Yam bean is used as the product to be dryied by the time variation of freeze vacuum drying process up to 5 hours. This research was result the water content losses in yam bean are up to 80%.

KEY WORDS: *Freeze vacuum drying, shelf- rise, Dryied product.*

NOMENCLATURE

CFM Cubic Feet per Minute

1.0 INTRODUCTION

Drying is a method or process to remove or eliminate some of the water of a substance by evaporating using thermal energy and can be done by various methods such as sun-drying or drying using solar, artificial drying such as oven, spray drying, vacuum drying, etc., and also drying by freezing. Drying by using solar and artificial drying such as with oven and others can be changing the structure, color and nutrients of the Dryied material.

Freeze vacuum drying method is an optimum process to dry the product without changing the physical and chemical properties of materials, even drying with freeze vacuum drying are can be maintain the structures, nutrient, and colors of original substances [1,2,3, and 4].

A weakness of freeze vacuum drying is its high consumption of energy due to the long drying time required especially in the process of sublimation below triple point condition [5]. Drying time can be reduced by increasing temperature or decreasing pressure in the chamber (drying room).

Currently there are two problems in developing of freeze vacuum dryer; maintaining the quality of product and reducing energy consumption during vacuum freeze drying process.

Acceleration of the sublimation process by utilizing waste heat of condenser is the one way to reducing energy consumption. Maintain drying products to keep them still dry by equipping the system with cool trap is one way to maintain product quality.

In the previous research freeze vacuum drying with utilize waste heat of condenser to reduce energy consumption was conducted and resulting and resulting, water losses at yam bean up to 78% at a freeze temperature -9^{o}C with drying time 4 hours where is the weight of yam bean is 50 gr [6].

The aim of this research is to develop and analyze a shelf-rise freeze vacuum drying system where the capacity of freeze vacuum drying is 250 gr of Dryied product with pressure and temperatures ranging from -70 to -75 mmHg and -5 to -7°C, respectively.

2.0 MATERIAL AND METHOD

2.1 Material

The material or fruit that used in this research is yam bean with water content of 85 to 90% [6]. The material weight was varied from 150 up to 250 gr.

2.2 Apparatus

Shelf-rise freeze vacuum drying with utilize waste heat of condenser and cool trap has been designed and manufactured in laboratory of conversion energy, Mechanical engineering, University of Riau. This shelf-rise freeze vacuum drying consists of a drying chamber with shelf-rise, refrigeration systems and heating systems (heat exchanger) from waste heat condenser and is also equipped with cool trap.

Temperature of drying chamber and the material was measured with thermocouple type K by using Advantech Adam 4018 as data acquisition. Initial and final weight of yam bean was measured by using digital weighing with accuracy of 0.1 gr. The capacity of shelf-rise freeze vacuum drying is 1 kg.

Freeze vacuum drying was use a vacuum pump 1 HP with a flow rate 9 cubic feet per minute (CFM). This vacuum pump is uses to decreasing drying chamber pressure, so that the sublimation process can be done, the schematic of freeze vacuum drying can be seen in Figure 1.

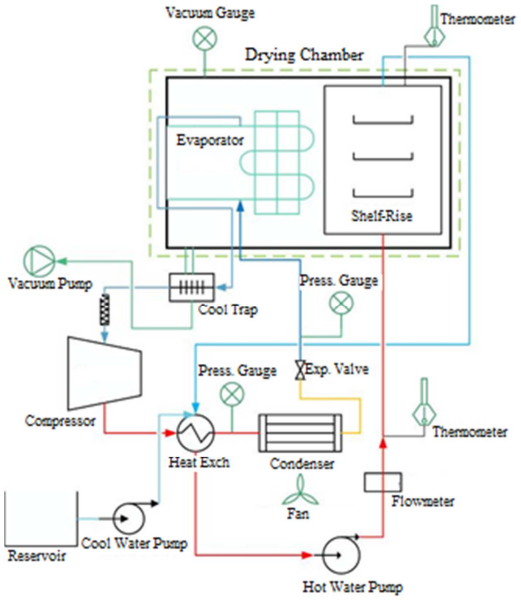

Figure 1: Schematic of experiment apparatus

2.3 Experiment Procedures

To start the process, 150, 200 and 250 gr of yam bean that wet powder condition was prepared and put to drying chamber and then refrigeration system was turned on when the temperature of drying chamber is ±25°C.

The characteristics of the freeze vacuum drying process as the procedure mentioned above can be seen in figure 2 [1].

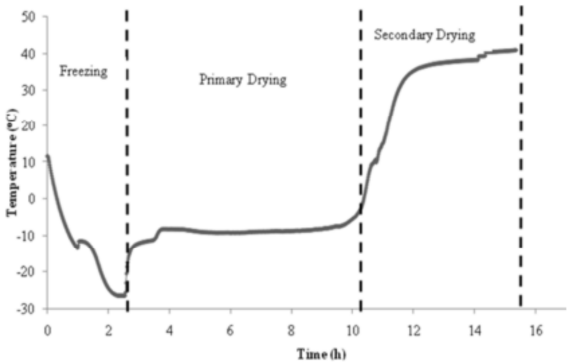

Figure 2: Characteristics of freeze vacuum drying process

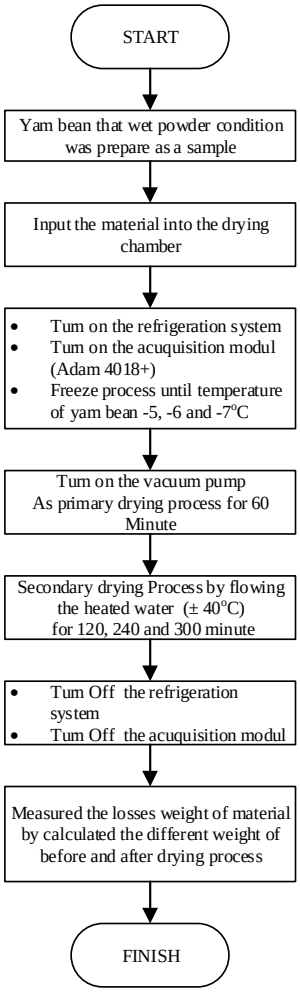

Figure 3: Flow chart of experiment procedure

The vacuum pump was then turned on when the material or yam bean temperatures reach to -5°C, -6°C and -7°C and appeared stable. And then, water that has been heated by using waste heat of condenser is flowed into the drying chamber for variation drying time is 2, 4 and 5 hours and the temperature of water was maintained in ±40°C.

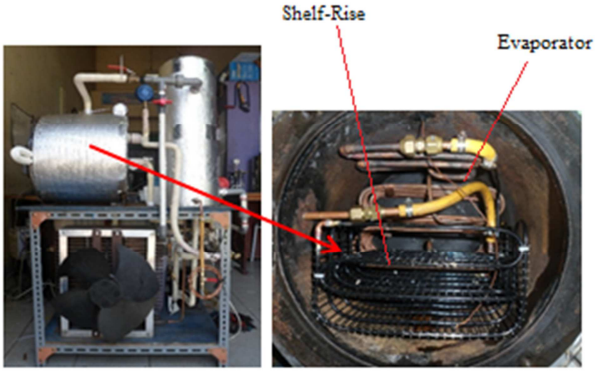

Figure 4: Shelf-Rise Freeze Vacuum Drying

Flow chart of experiment procedure was describe in figure 3 and the experiment apparatus can be seen in figure 4.

3.0 RESULT AND DISCUSSION

Research of shelf-rise freeze vacuum drying has been done. This research was conducted to investigate the characteristics of the shelf-rise freeze vacuum drying system that has been designed and manufactured. This research was conducted by varying the weight, temperature, and time of drying process.

From the testing with some variation resulting different water losses in the material. The material (yam bean) before and after dryied can be seen in figure 5.

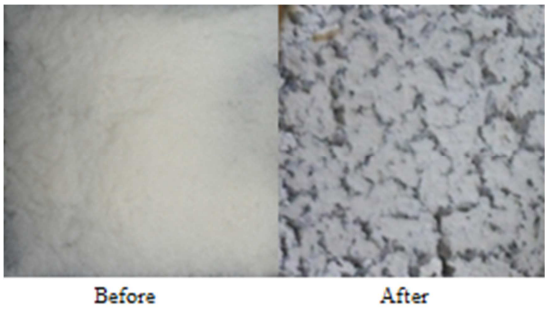

Figure 5: Material before and after dryied

3.1 Variation of Weight of Material

The material that will be dryied in freeze vacuum drying was prepared in 150, 200 and 250 gr. The processes of freeze vacuum drying are; firstly the water in yam bean in liquid phase was freeze to drying temperature -5°C and become solid phase. After the water in the yam bean was in solid phase, the vacuum pump is turned on for 1 hour to decreasing pressure in the drying chamber. The last process of freeze vacuum drying is, water that has been heated (at temperature ±40°C) by utilizing waste heat condenser is flowed into the drying chamber this process is secondary drying process.

Figure 6 describes the comparison of the result from shelf-rise vacuum freeze drying in variation of weight of the material, it can be seen the water losses will be decrease when the weight of material is increase. Because the water content of the material is greater so the percentage of the amount of water that sublimated will be smaller.

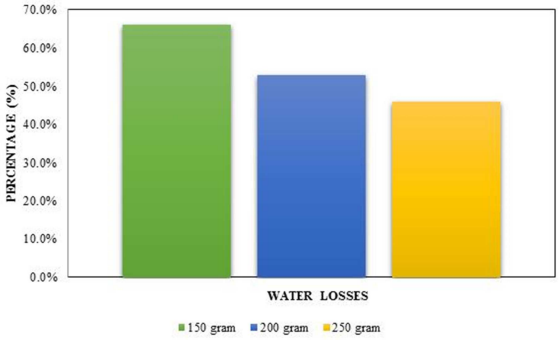

Figure 6: Comparison of water losses in different weight of material

3.2 Variation of Freezing Temperature

Testing with variation of freezing temperature of material is conducted on 250 gr yam bean. The freezing temperature of material are -5, -6 and -7°C where the procedure of testing is similar with previous testing.

Figure 7 describe the comparison of the result from shelf-rise vacuum freeze drying in variation of freezing temperature of the material, it can be seen the water losses will be decrease when the freezing temperature of material is decrease.

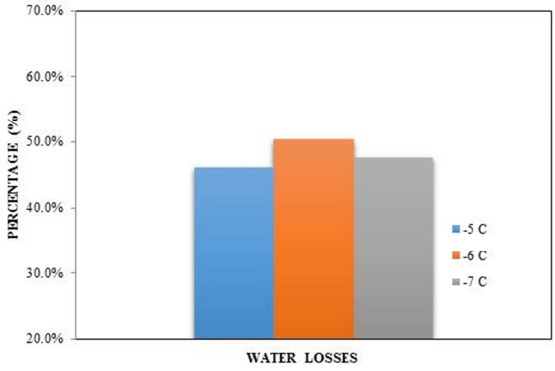

Figure 7: Comparison of water losses in different freezing temperature of material

But when the freezing temperatures of material is -7°C, the amount of water losses is less than when the freezing temperature of material is -6°C. This is caused, in the second drying process the temperature of the material has not been returned to the room temperature or the initial temperature in the process, so that the secondary drying process is not complete. The process of freeze vacuum drying can showed in figure 8 and this figure is match with figure 2 characteristic of freeze vacuum drying process.

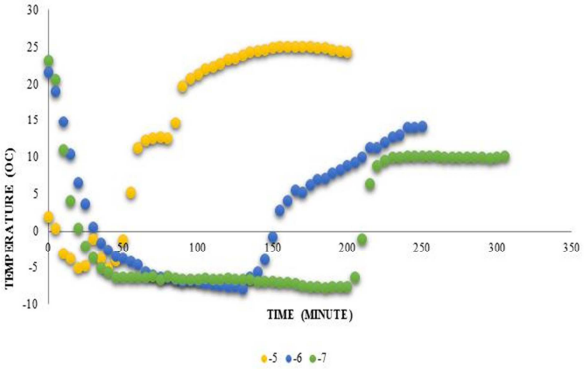

Figure 8: Process of freeze vacuum drying at different of freezing temperature

3.3 Variation of Time of Secondary Drying Process

In this research, the secondary drying process time will be varying namely 120, 240 and 300 minutes and the material is 250 gr. Figure 9 describe the comparison of the result from shelf-rise freeze vacuum drying in variation of secondary drying time, it can be seen the percentage of water losses in the material will be bigger when the secondary drying process is longer.

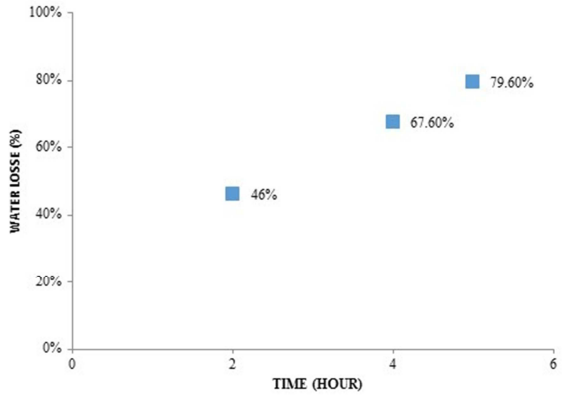

Figure 9: Comparison of water losses in different time of secondary drying process

This is caused in the second drying process the temperature of the material was returned to the room temperature or the initial temperature in the process, so that the secondary drying process was completed. Figure 10 describe the process of freeze vacuum drying with the process of secondary drying is 300 minute and this figure is match with figure 2 characteristic of freeze vacuum drying process and it is also can be concluded that the research is match with the reference of freeze vacuum drying process.

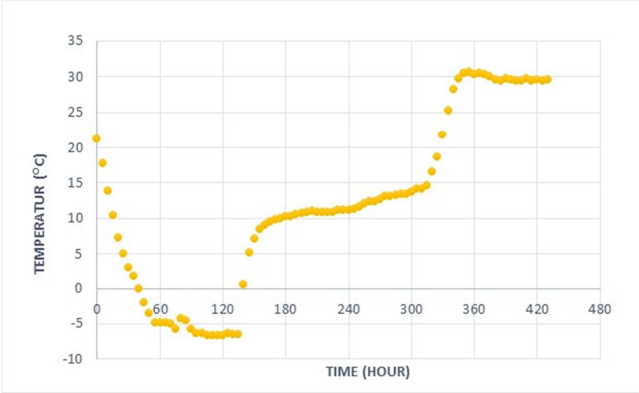

Figure 10: Process of freeze vacuum drying with the process of secondary drying 300 minute

4.0 CONCLUSION

Research of shelf-rise freeze vacuum drying with utilized waste heat of condenser and equipped with cool trap system was conducted with some of variation namely; weight of material (150, 200, and 250 gr), temperature of material (-5^{o}C, -6^{o}C and -7^{o}C) and time of drying process (2, 4 and 5 hour).

Hot water from utilized waste heat of condenser was maintained at ±40^{o}C and flowed to the drying chamber as a secondary drying process.

The water content losses maximum is 79.6% at material temperature -5^{o}C for 5 hour of secondary drying process.

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