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Freeze Vacuum Drying With Utilized Waste Heat of Condenser by Quick Drying Method

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ABSTRACT

Freeze vacuum drying process is an optimum process to dry the product without changing the physical and chemical properties of materials. The advantages of drying with freeze vacuum drying are can be maintain the structures, nutrient, and colors of original substances. 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. The aim of this research are to optimizing freeze vacuum drying in order to reducing energy consumption by utilized waste heat of condenser to speed up the sublimation process and by using quick drying method. Thefreezing temperatures in this study were 6^{o}C and 9^{o}C with a variation of the drying time is 1, 2 and 4 hours. This research was result the water content losses in yam bean are 78% at a freeze temperature -9^{o}C with drying time 4 hours.

KEY WORDS: *Freeze Vacuum Drying; Drying Time; Yam Bean; Quick Drying.*

1.0 INTRODUCTION

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

Freeze-drying research has been done by previous researchers, among others; Drying aloe vera (aloevera) that contains a water content of 98.7% [1], tomatoes containing with water content of 93.4% [5], and pineapple with contains a water content of 85.30% [6].

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 [7]. Drying time can be reduced by increasing temperature or decreasing pressure in the chamber (drying room).

Cuurently there are two problem 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.

The aim of this research are to optimizing freeze vacuum drying in order to reducing energy consumption by utilized waste heat of condenser to speed up the sublimation process and by using quick drying method.

2.0 MATERIAL AND METHOD

2.1 Material

The material or fruit that used in this research is yam bean that has a water content of 85 to 90%.

2.2 Apparatus

Freeze vacuum drying with utilize waste heat of condenser has been designed and manufactured in the laboratory of conversion energy, Mechanical engineering, Universitas Riau. This freeze vacuum drying consists of a drying chamber with a capacity of 1 kg, refrigeration systems and heating systems from waste heat condenser. To measure the temperature, Thermocouple type K was used by using data acquisition Advantech Adam 4018. Initial and final mass of yam bean was measured by using digital weighing with accuracy of 0.1 gr.

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, schematic and freeze vacuum drying it can be seen in Figure 1 and 2.

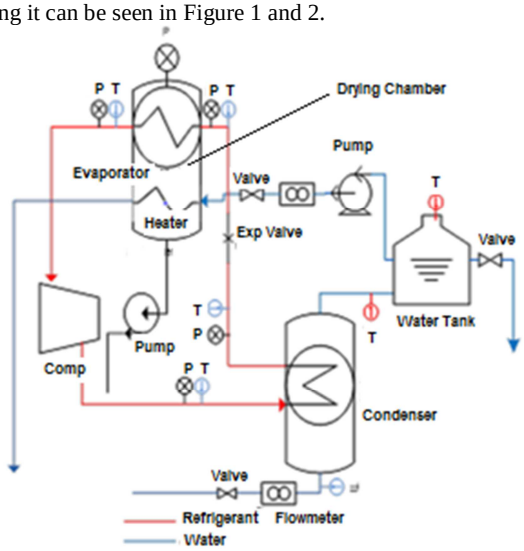

Figure 1: Scheme of freeze vacuum drying.

2.3 Experiment Procedures

To start the process, 50gr of yam bean that wet powder condition was input to drying chamber and then refrigeration system was turned on when the temperature of drying chamber is ±20^{o}C. The vacuum pump was then turned on when the material or yam bean temperatures reach to -6^{o}C and -9^{o}Cand 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 1, 2 and 4 hours and the temperature of water was maintained in ±40^{o}C. After drying process in 1, 2 and 4 hour drying process was completed, the refrigeration system, vacuum pump and the flow of hot water was turned off. The water or the moisture content that loss in this process will be found by calculated the different weight before and after of drying process.

Figure 2: Apparatus of freeze vacuum drying.

The characteristics of the freeze vacuum drying process as the procedure mentioned above can be seen in figure 3 [1].

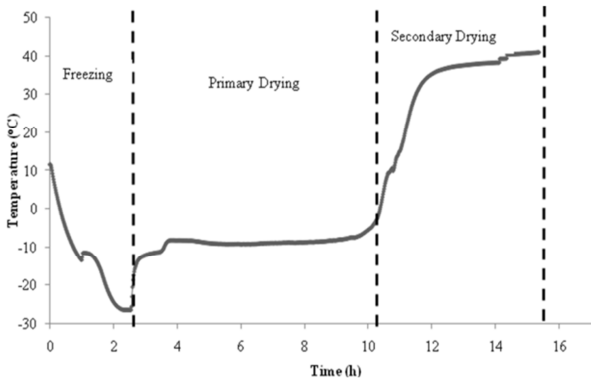

Figure 3: Characteristics of freeze vacuum drying process.

3.0 RESULT AND DISCUSSION

Freeze vacuum drying of yam bean has been done by quick drying method to determine the drying process characteristics on -6^{o}C and -9^{o}C by variation of drying time process is 1, 2 and 4 hour. From the testing with some variation, resulting different water losses in materials in different drying time. Wherethe largest water loss in the material is occurs in the process of drying for 4 hours at temperatures of 6^{o}C and 9^{o}C is 78 %.

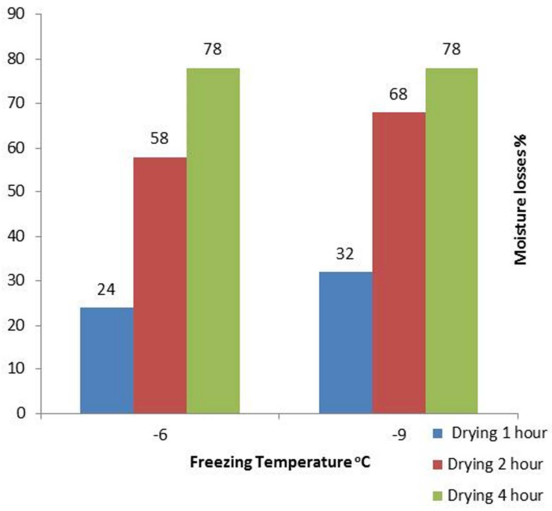

Figure 4: Comparison of water losses in different temperature and different drying time.

Figure 4 describes the comparison of the vacuum freeze drying yam bean in variation of drying time and drying temperature, its can be seen the water losses will be increase when the drying time is longer and the freeze temperature is lower. This is due to reach a lower freezing temperature takes a longer time, so that water that freezes in yam bean becomes more

and then the amount of freezed water will be more to sublimated.

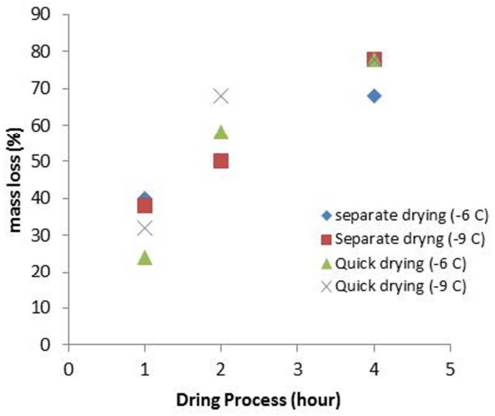

Figure 5: Comparison of Separate drying method and quick drying method.

In the previous research, vacuum freeze drying on yam bean has also been done by a separate drying method, and obtained the best drying results reached 84% within 6 hours of drying time [8]. Figure 5, shows a comparison the results of both drying methods and it can be seen in quick drying and separate drying method, the final result in 4 hour drying time is almost similar in drying temperature -6^{o}C and -9^{o}C. But in separate drying method where the drying temperature is -6^{o}C the water losses of yam bean is lower than the other temperature, This condition indicates that the quick method is better than the separate methods bases on drying time process.

The process of freeze vacuum drying was described in Figure 6.Firstly the water in yam bean in liquid phase was freeze to drying temperature -6^{o}C and -9^{o}C become solid phase (process 1 - 2) or freezing process, after the water in solid phase the vacuum pump is turned on to decreasing pressure in drying chamber (process 2 – 3) or primary drying process, together with vacuum pump is turned on, water that has been heated by utilizing waste heat condenser flowed into the drying chamber (process 3 – 4) or secondary drying process.

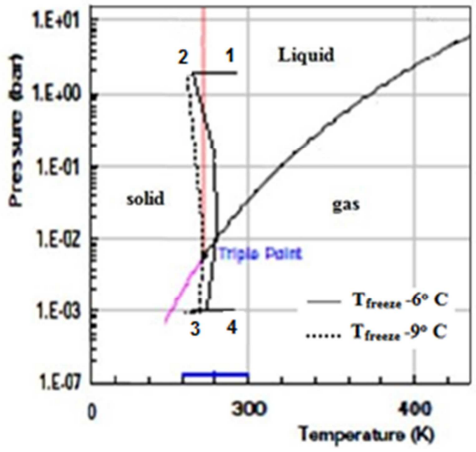

Figure 6: Temperature distribution of water in P-T diagram

Figure 6 show the trend line of distribution temperature in drying process at -6^{o}C and -9^{o}C with quick drying methods for4 hours. It can be seen in figure 6 that in temperature of material in -6^{o}C, water in liquid phase was change to solid phase on freezing process but when the vacuum pump was turned on, the solid water was back to liquid phase and at the next process when the hot water was flowed into drying chamber the liquid water was evaporated, so that it can be concluded in this process there are not sublimation in the secondary drying process.

It can be seen also in figure 6 that in temperature of material in -9^{o}C the process was complete. Water in liquid phase was change to solid phase on freezing process, when the vacuum pump was turned on, water in the solid phase is still on solid phase during primary drying process and when the hot water was flowed into drying chamber as a secondary drying process the water on solid phase was change to gas phase by sublimation.

The dried yam bean that dried by freeze vacuum drying in -9^{o}C for4 hour can be seen in figure 7.

Figure 7: Dried yam bean.

4.0 CONCLUSIONS

Research of freeze vacuum drying with utilized waste heat of condenser by quick drying method was conducted at material temperature of -6^{o}C and 9^{o}C for 1, 2 and 4 hour and hot water from utilized waste heat of condenser was maintained at ±40^{o}C.

Water or moisture content losses maximum is 78% both at material temperature -6^{o}C and 9^{o}C for 4 hour, but on material temperature -6^{o}C for 4 hour the freeze vacuum drying process is not complete because there are not the sublimation process at the secondary drying process.

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