Physical quality change of tempeh during freeze drying

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Abstract. Tempeh is one of the traditional foods from Indonesia, produced across generation. As the largest tempeh producer in the world, the average consumption per person per year is currently estimated at around 6.45 kg, supported by 81 thousand tempeh-making businesses with a production of 2.4 million tons of tempeh per year. Therefore, tempeh industry has a great opportunity to be developed. The main constraint of tempeh trading is due to its short shelf life. Freeze drying is one of the food drying techniques that can extend shelf life and maintain product quality. The purpose of this study was to determine the effect of freeze drying method drying on the physical quality of tempeh, also to compare the quality of the product from the freeze dryer and dryer cabinet methods. The material used is 1 cm thick tempeh. The freeze drying machine used has stainless steel plate material with a total length of 0.7 m, 0.5 m wide, and 1 m high. Drying was conducted at freezing temperature -18°C and heating 60°C at vacuum pressure -76 cmHg. The initial moisture content is 60.22% and after drying with freeze dryer decreased to 1.19% while in the dryer cabinet was 7.52%. The results of the study also showed physical changes namely color using three sample seeds. The average values of colors L, a *, and b * before drying are 73.39; 5.67 and 23.56. After drying, the tempeh color is darker at dryer cabinet.

1. Introduction
Tempe is a typical Indonesian food that has the opportunity to be appointed to large industries. This opportunity was opened by the approval of requesting a standard tempe submitted by Indonesia at the meeting of the Codex Alimentarius Commission (CAC) in Geneva in 2011. If Indonesia is able to develop tempe standards at the international level, it will open up huge opportunities to develop the modern tempe industry and make tempe "go international". At present, around 81 thousand tempeh-making businesses produce 2.4 million tons of tempeh per year. This shows that the tempe industry has a great opportunity to be developed [1].

The Minister of Trade announced that Indonesia was preparing for the time being constrained by a short shelf life of tempeh. Therefore, technology is needed that can make tempeh have a longer shelf life. Freeze drying is one of the drying techniques of food ingredients that can be extended shelf life. Some products are dried by freeze drying methods, namely fruit, vegetables [2], meat [3], eggs [4], and others. While tempe products have carried out research on related freeze drying on tempe yeast [5]. Until now, information related to drying for consumption with freeze drying is still very limited.

The purpose of this study was to study the drying characteristics of sliced tempeh by freeze drying method. Changes in physical properties such as weight loss, color and texture were discussed in this study.

2. Materials and Methods
The study was conducted at the Laboratory of Food Postharvest Engineering, Department of Agricultural and Biosystem Engineering, Faculty of Agricultural Technology, Universitas Gadjah Mada.
2.1. Equipment and materials
The tempeh used are "AREMA" branded tempeh produced by SMEs in Yogyakarta. The form of tempeh was a box then the tempeh was slice with a thickness of 1 cm before process in the freeze dryer.

The equipment used in this study was a small type of freeze dryer with a maximum drying capacity of 1.5 kg with dimensions of the drying tube chamber 40 cm in diameter and 60 cm in length. This freeze dryer was equipped with a vacuum pump that has the ability to vacuum up to -76 Pa. This freeze dryer was also equipped with a thermostat for cooling and heater. The cooling machine was able to cool the material to -20°C. Additional tools used include were Memmert brand oven for moisture content analysis, analytical ballance with accuracy of 0.0001, colour meter Colour-meter TES-135 brand, texture analyser (Brookfield) with diameter probe 4 mm with a speed of 0.5 mm/s.

2.2. Experimental design
The moisture content was measure by the gravimetric method, which was to oven the sample at 105°C for 24 hours. The tempeh dried in a freeze dryer for 12, 18, 24, 30 and 36 hours. During drying the material temperature data, ambient temperature and pressure were recorded in the freeze dryer with an interval of 1 hour. The parameters were determined during drying were moisture content, color and hardness. Color measurement was carried out with a color meter. Tempeh texture is measured using the texture analyzer Brookfield CT3 brand.

3. Results and Discussion

3.1. Moisture content
The initial moisture content of tempeh is 60.22% (w.b.). Final moisture content of drying with a length of time 12, 18, 24, 30 and 36 respectively is 55.44%; 54.16%; 46.43%; 5.67% and 1.19%. Figure 1 shows a decrease in the moisture content of tempeh during the freeze drying process. The drying rate of tempeh using freeze dryer is 1.64% / hour. In other hand, drying with a cabinet for 12 hours shows that the final moisture content of tempeh was 7.52%. In the previous study, drying using a freeze dryer was carried out on strawberry flavour which produced a final moisture content of 3.9-4.1% [6].

![Figure 1. Moisture the tempeh ingredients during the drying process in the freeze dryer.](image)

3.2. Texture
The texture of tempeh with drying times 18, 24, 30 and 36 each is 0.020 kg / mm²; 0.028 kg / mm²; 0.215 kg / mm²; 0.166 kg / mm². For drying with a cabinet dryer shows the texture of 0.178 kg / mm². Generally, the dried product have higher value of hardness. In the previous study, the freeze dryer method was used on bananas. The initial texture of bananas is 0.1 N / mm and after drying is 1.6 N / mm [7].
3.3. Colour

The color of fresh tempeh is white as shown in Figure 3.a while the color with freeze drying can be bound in Figure 3.b. Whereas the cabinet is shown in Figure 3.c. The value of L, a *, b * fresh tempe is 73,391; 5,665; and 23,563 while the value of L, a *, b * end of tempeh with freeze dryer for 36 hours is 69,526; 6,507; and 23,918. In the drying method with a dryer cabinet the values of L, a *, b * are 63,516; 7,518; and 25,716. When compared with the drying method with the dryer cabinet it is seen that it is darker than the freeze dryer method.

![Figure 2](image.png)

**Figure 2.** The texture of tempe during the drying process in the freeze dryer.

![Figure 3](image.png)

**Figure 3.** Photos of tempeh with different drying methods
4. Conclusion

From this study it was concluded that tempeh can be dried using the freeze drying method from the initial water content of 60.22% to 1.19%. Drying by freeze drying tends to show better results compared to the dryer cabinet.

Reference

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