# Experimental Study Of Drying Fruits And Vegetables Using The Freeze Drying Method With The Aim Of Maintaining The Nutrition And Effectiveness Of Processed Products

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*ABSTRACT*

*The potential of natural resources in tropical countries is very diverse. one of them is the abundant agricultural products. but there are some obstacles in the post-harvest cycle and the continuous availability when the harvest season ends. various methods of preserving agricultural products have been tested from conventional methods to advanced technology. one of the technologies for preserving agricultural products is freeze drying. various innovations continue to be tested until they get consistent results with good energy efficiency. This method was originally started in the pharmaceutical industry. Various treatments and flexible adaptations make this method penetrate the food industry to maintain the quality of food products. In the food industry, freeze drying is suitable for food products such as meat, fruits, grains, and vegetables. The advantage of freeze drying is that the food products produced do not change shape, form, texture, taste, and nutrition even though they have gone through the drying process. Of the various characteristics of fruits and vegetables have their own properties that can be changed with the temperature parameters applied in the freeze dryer method.*

***Keywords**: freeze drying, fruits and vegetables, quality of food products*

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## INTRODUCTION

In 2019, the research was conducted by Handayani and Dyah Titisari. The process of collecting data on this equipment uses a comparison system. The test is carried out by comparing the temperature read by the comparison thermometer with the temperature displayed on the LCD display. The test was carried out at temperature setting points of 35 °C, 36 °C, 37 °C, 38 °C, 39 °C, and 40 °C. Each test setting point was repeated 6 times with measurement data taken 5 times over a range of different times. The advantage of this equipment is that it has a comparison module that has been calibrated at a Health Facilities Service Center and a module that has been designed and tested/calibrated at a calibration laboratory. Meanwhile, the weakness of this equipment is that the heating produced by the equipment is still higher than the setting so that the data obtained has a correction value that is still quite far away (Bazzano et al., (2006); Barth et al., (2009).

The diversity of Indonesia's agricultural products is an abundant gift. Fruits and vegetables are one of the food ingredients that have an important role to fulfill nutritional needs and maintain human health. Various compositions of fruits and vegetables consist of vitamin B3 (niacin), vitamin B6 (pyridoxine), vitamin B1 (thiamin), vitamin C, folic acid, minerals and fiber. Some phytochemical components in the fruit, such as

flavonoids and vitamin C are considered to act as good antioxidants to kill carcinogenic substances that can activate tumor and cancer cells. In addition, the antioxidant content is considered capable of preventing metabolic syndrome diseases in humans.

However, fruit is one of the perishable foods that cannot be stored for a long time. This is related to the characteristics of fruit that are highly favored by bacteria. High water content, as well as several enzymatic reactions that can occur due to external factors, such as oxygen ($O_2$), light, and air humidity make fruit easy to damage (Rawat, 2015). Sensory damage to the fruit can be indicated by changes in color to brown (browning), mushy, and smells bad. In recent years, the development of food processing has shifted to the use of non-thermal techniques, namely food processing techniques using heat at relatively low temperatures with the aim of maintaining the quality of the food products produced (Moses et al., (2014). This type of processing is a development of the previous technique, namely thermal techniques, which are known to eliminate many nutrients in the fruit. Freeze drying or often called freeze drying is one example of food processing techniques with non-thermal principles (Liapis & Bruttini, 2020). This technique is carried out by removing the water content in food products through freezing, then sublimation is carried out to convert the solid phase (water) into gas by controlling the temperature and pressure in the processing. This type of drying is considered to have advantages in maintaining the quality of the product, both from sensory characteristics, nutritional value, physical and chemical compared to ordinary drying using thermal. Fruit chips are one of the foods that can be produced from freeze-drying processing techniques. This technique is able to produce chips that are better than chips with other techniques, such as vacuum deep frying, or ordinary frying when viewed from the sensory, chemical, physical, and microbiological characteristics therein (Hariyadi, 2013).

Freeze drying is one of the drying methods that has the advantage of maintaining the quality of the drying results (Habibi et al., 2019). Freeze drying has several advantages, including maintaining product stability (avoiding changes in aroma, color, and other organoleptic elements), maintaining material structure stability (shrinkage and shape changes after drying are very small), inhibiting microbial activity and preventing chemical reactions and enzyme activity that can damage the nutritional content of food ingredients.

Freeze drying is a non-thermal drying technology using low temperatures (Gaidhani et al., 2015). The tool used in this processing technology is called a freeze dryer (Shukla, 2011). The difference between freeze drying and other drying technologies is the mechanism in removing the water content in foodstuffs. The removal of water content in this technology occurs at low temperatures, through a sublimation mechanism.

In vegetable or fruit drying, the most important advantage of the freeze drying method is that it forms crunchy properties. All ingredients are initially frozen, then treated to a mild heating process in a vacuum cabinet. The ice crystals formed during the freezing stage, sublimate when heated at vacuum pressure i.e. change directly from ice to water vapor without passing through the thawing phase. The shock (socking) effect of frying frozen ingredients can cause a sudden change of ice grains into vapor. Thus, during frying, the chips produced are more crunchy. In addition, this method produces a porous product with very little change to the size and shape of the original ingredients. Since little heat is used, heat damage is also small compared to other drying methods.

## METHODS

The principle of freeze drying is to dry food by removing the water content in it through the process of sublimation of the water content in food that has become frozen and then converted into gas. Sublimation can occur when the pressure and temperature of the ice surface. This can be described in the Figure 1.

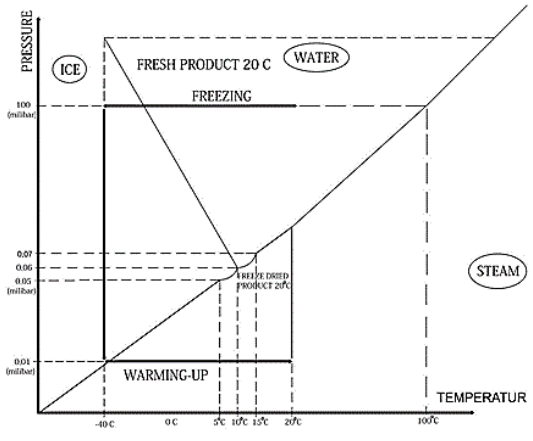


FIGURE 1. Freeze drying temperature rate

In the process, there are at least 4 stages in the freeze drying method, starting with food preparation, freezing, primary drying, and secondary drying. The first stage in freeze drying processing is food preparation. In fruit processing, identify fruits that will be dried with medium to low moisture content levels. Check the nutritional reactivity of the fruit to drying. If there is a case where the fruit has a large size or has a high water content such as melons, watermelons, mangoes, pineapples, or oranges, it is necessary to open the area to be dried by means of a thin slicing process. Meanwhile, fruits that are small in size and have medium to low water content such as star fruit, chili peppers, berries, grapes can be directly processed in freeze drying storage. Furthermore, the second stage is freezing. This stage is done by lowering the freeze dryer temperature to -40 °C. Freezing aims to change the water phase in the fruit into a solid phase (ice) (Shukla, 2011). Furthermore, after freezing, the third stage is the drying process. This process is carried out in two stages, namely primary drying and secondary drying. Primary drying aims to remove the water content in the fruit that has been frozen through the sublimation process by increasing the temperature to 0 °C and lowering the pressure in the tool below the triple point which is <4.58 mmHg, which aims to make the gas formed when increasing the temperature is wasted out. After the water content has come out around 95%, then secondary drying is carried out by increasing the pressure, and the temperature is at normal conditions of 35 °C, with the aim of conditioning that the fruit coming out of the tool is not in a frozen condition or can adapt to room temperature.

Products that have been produced from the freeze drying process generally do not lose their enzyme activity, but are temporarily inactive, due to the low water content in the product. This makes freeze drying products oxidizable, when exposed to oxygen ($O_2$). Therefore, in processing the product that has been produced must be immediately packaged using packaging that protects from $O_2$ such as using aluminum, or plastic materials. And it is better to use the vacuum packaging method.

## RESULT AND DISCUSSIONS

### *Testing For Vitamin C Content*

The vitamin C content decreases every week. During storage, especially at high storage temperatures, the ascorbic acid (vitamin C) content will decrease. The ascorbic acid content during storage is approximately 1/2 to 2/3 of that at harvest time. This is because the ascorbic acid found in plant tissue is easily oxidized, for example by the ascorbic acid oxidase enzyme found in the plant tissue.

### *Organoleptic Testing*

Each spice component contributes its own unique taste, color, aroma and appearance, so that their combination with each other will provide a new sensation that can increase the taste, acceptability and identity of each product produced. Naturally, spices contain various active components which play a very big role in creating the taste of a product. Spices contain antioxidant, anti-bacterial, anti-mold, anti-yeast, antiseptic, anti-cancer and antibiotic substances, all of which play a very big role in making spices last longer.

### *Taste and Texture*

Taste is the most important factor in determining consumers' decisions to accept or reject a food product. Even if the other parameters are good, if the taste is bad or you don't like it, the product will be rejected. There are four basic types of taste recognized by humans, namely salty, sour, sweet and bitter. While other flavors are a combination of these four flavors. Added salt also affects the taste because salt is a flavor enhancer and enhancer of pre-existing spices. Foods containing less than 0.3% salt will taste bland and undesirable.

The stability of the texture of a semi-wet product can be seen from changes in its viscosity. If there is a real change in viscosity, it is likely that the product has experienced a decline in quality. The viscosity parameter is one of the factors that can influence chili sauce, namely texture. This is because during storage, changes occur in the components contained in chili sauce, which has an influence on the viscosity of the product.

### *Changes in Microbiological Characteristics*

In processing fruit through freeze drying, there are changes in its microbiological characteristics.

Changes in microbiological characteristics include bacteria, molds and yeasts. The number of bacteria during processing has decreased, this is because the freezing process results in a decrease in water content in the fruit and water activity, this condition causes DNA and RNA damage, protein denaturation, changes in the cytoplasmic membrane and bacterial cell wall damage, which is related to an increase in acid concentration that can damage bacterial cells. However, on the other hand, there are compounds found in fruits and vegetables that can increase the survival ability of microorganisms during dehydration, such as sucrose and other sugars, polypeptides, polyalcohols, amino acids, glycerol, and carboxylic acids that have been shown to increase the survival ability of bacteria. A decrease in water activity is not the only factor that can affect the number of bacteria.

Other factors such as changes in atmospheric pressure, $CO_2$ or $N_2$ concentration or electromagnetic waves also have an influence on the number of bacteria in the product. During the freeze drying process, it is known that molds and yeasts cannot grow. However, the freeze drying process cannot kill the spores of molds and yeasts in the fruit. On the other hand, a decrease in water content and an increase in acid concentration, as well as antioxidants in the fruit can inhibit the growth of molds and yeasts.

## CONCLUSION

Freeze drying and regular drying are two common food preservation methods, each with distinct characteristics. One of the primary differences lies in the amount of moisture removed. Regular drying eliminates about 90–95% of water content, while freeze drying removes up to 98–99%, making freeze-dried foods more stable and less prone to spoilage. This significant reduction in moisture content gives freeze-dried foods a longer shelf life, typically between 25 to 30 years, compared to 15 to 20 years for products dried using conventional methods. Nutritionally, freeze drying retains more vitamins and minerals, especially those sensitive to heat, such as vitamin C, which tends to degrade rapidly in regular drying. While regular drying preserves fiber and iron, it can cause notable losses in essential nutrients like vitamins A, C, thiamine, riboflavin, and niacin due to the heat involved.

The appearance and texture of the final product also vary greatly. Regularly dried foods often look shriveled and feel firm, whereas freeze-dried foods appear dry, brittle, and are significantly lighter due to the more complete removal of water. This makes freeze-dried foods easier to transport and store, especially in emergency or long-term storage scenarios. However, the cost is another important consideration. Freeze drying involves more complex and energy-intensive technology, making it more expensive than regular drying. In contrast, regular drying, especially when done at home or with basic equipment, is far more economical, though it comes with shorter shelf life and reduced nutritional value. Ultimately, the choice between freeze drying and regular drying depends on the desired balance between cost, shelf life, nutritional retention, and storage convenience. Freeze drying is ideal for long-term storage with better nutrient preservation, while regular drying remains a practical option for everyday food preservation needs at a lower cost.

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