Physical quality changes of dehydrated strawberry affected by different packaging in a tropical environment

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Abstract. Processed fruit strawberry such as dehydrated fruit was important as alternative ways to increase shelf-life and value of the fresh fruit. However, the unfavorable effects of the tropical environment can accelerate the deterioration quality of processed fruit. Applied packaging to protect the processed fruit was an important way to maintain the quality and increasing the shelf-life of the fruit. The objective of the study wants to know the effects of different packaging treatments for reducing unfavorable tropical environment conditions of dehydrated strawberry fruit. Dehydrated fruit strawberry was made using a combination of pretreatment by osmotic dehydration with hot air convective drying method. The combination for treatments of material and process for production dehydrated strawberry used is a drying temperature of 70°C, concentrate osmotic agents with 50°Brix, immersion time for 60 min, and drying time of 6 h until 9 h. The dehydrated strawberry fruit was packaging used Polyethylene plastic with Nylon that and stored in the ambient tropical temperature condition. Firstly, dehydrated strawberry fruit packaged conventionally using Polyethylene plastics with Nylon packaging with vacuum treatment and secondly, dehydrated fruit without packaging as a control. Physical parameters were analyzed using standard method texture and color of food. Based on the result, vacuum packaging treatments for the treatment of 70°C; 50°Brix; 60 min; 9 h; 36 h can be maintained the color changes and texture of dehydrated strawberry fruit compare with those of control. However, detailed changes in chemical quality and different thickness of vacuum bag packaging needed to be considered for future research.

1. Introduction
Strawberry (Fragaria x ananassa) is a subtropical horticulture fruit that is not only in demand by subtropical countries but also by Indonesia, which is a tropical country. Strawberry fruit is a useful source of bioactive food and contains polyphenol compounds and vitamin C [1]. However, the cultivation of strawberries in tropical environments has problems, especially in the post-harvest process. Strawberries have a short shelf life, so strawberries are subjected to various technological processes [1].

Processed strawberries such as dehydrated fruit are a great alternative for increasing the shelf life and value of fresh fruit. The dehydrated strawberry not only meets basic nutritional needs but also provide valuable bio-components for health. The dehydrated strawberry has many benefits such as making them a snack and can be used together with cereal for breakfast [2].

To maintain the quality of dried strawberries, proper handling is required after processing by applying the use of packaging. Packaging serves to slow down product deterioration, maintain the beneficial effects of processing, increase shelf life, and improve food quality and safety. The
packaging is expected to protect products, especially from external influences such as chemical, biological, and physical [3].

The objective of this study was to know the effect of different drying treatments and different packaging treatments for reducing unfavorable tropical environment conditions of dehydrated strawberry fruit.

2. Material and Methods
Sample of strawberry (F.ananassa var. California) had a maturity level of 100%, which was indicated by a fully strawberry fruit surface with red color. The fresh strawberry was obtained from Inggit Strawberry Farm, Ketep Magelang Jawa Tengah. Sample of fresh strawberry was carry on with packing bag to Faculty of Agricultural Technology, Universitas Gadjah Mada. Dehydrated fruit strawberry was made using a combination of pre-treatment by osmotic dehydration with hot air convective drying method.

2.1. Dehydrated fruit strawberry production with osmotic dehydration
The fresh strawberry fruit was clean up using running tap water thoroughly to make the surface of the fruit more hygienic and to disappear some dirty sand or dust, then strawberry fruit sample was put into a tray for several minutes for natural drying. Sample of the strawberry fruit was immersed in the juice of sucrose content with concentration 50°Brix, then shaking the solution that added fresh strawberry fruit using a magnetic stirrer (C-MAG HS7, IKA, Selangor, Malaysia) for 60 min with a temperature of concentrate sucrose solution around 27°C until 30°C. Fresh strawberry from the osmotic dehydration process was put on the tray for 2 min until 3 min before continuing the process using a dehydrator. Dehydrated strawberry process drying in this experiment using a dehydrator (MKS-FDH6, Maksindo, Malang, Indonesia) that using convective hot air drying principles. Hot air drying is one of the most widely used methods of preserving food [2][4]. Hot air drying is related to the convection process, in which hot air is in direct contact with the material. The advantages of this method are low cost, simple method, and control of operating conditions [2]. Fresh strawberry sample from osmotic dehydration process was inserted into a tray of the dehydrator with drying temperature 70°C for 6 h until 9 h, and then after finished the process, it was put into desiccator for 36 h until 48 h to stabilize their conditions.

2.2. Packaging treatment
The dehydrated strawberry fruit was packaging used Polyethylene plastic with Nylon that and stored in the ambient tropical temperature condition. Firstly, dehydrated fruit packaged conventionally using Polyethylene plastics with Nylon packaging with vacuum treatment. Secondly, dehydrated fruit without packaging as a control. Vacuum processing was using a vacuum sealer machine (Sayota Sinbo, DZ-280/2SD, China) which absorbs aerial inside packaging until the condition of oxygen concentration around 2% until 3%. All treatments and control were put in the room without controlled temperature and relative humidity.

2.3. Research Design
The experiment was carried out in a factorial completely randomized design (CRD). This study consisted of four treatments; P1T1 (control of dehydrated strawberry without packaging with drying treatment 70°C; 50°Brix; 60 min; 6 h; 24 h until 36 h), P1T2 (dehydrated strawberry was packaging used Polyethylene plastic with Nylon with drying treatment 70°C; 50°Brix; 60 min; 6 h; 24h until 36 h), P2T1 (control of dehydrated strawberry without packaging with drying treatment 70°C; 50°Brix; 60 min; 9 h; 36 h), P2T2 (dehydrated strawberry was packaging used Polyethylene plastic with Nylon with drying treatment 70°C; 50°Brix; 60 min; 9 h; 36 h). Data were averaged from 2 dehydrated strawberries with double replication measures.

2.4. Quality parameter for measurements
Physical parameters were analyzed using standard method texture and color of food. The color of dehydrated strawberry was measured using by Chroma Meter Konica Minolta CR-400 (CIELAB
Coordinate) and also visually using simple organoleptic. Then, the texture of dehydrated strawberry was measured using a texture analyzer (FHT-200 Extech, Taiwan).

The process for making dehydrated strawberry fruit, sampling preparation, and quality measurements were analyzed in the Laboratory under the Department of Agroindustrial Technology, Faculty of Agricultural Technology, Universitas Gadjah Mada.

2.5. Statistical Analysis
Data obtained from the experiment results were tabulated and calculated using Microsoft Excel 2010 (Microsoft Corporation) and then statistical analysis using SPSS version 22.0 (SPSS Incorporation).

3. Results and Discussions
The drying process not only reduces the moisture content of the product but drying process also causes changes in several physicals(soluble solid content), chemical properties (nutritional value), and sensory (texture, color, taste, flavor) [5][6][7]. Efforts have been made to reduce the impact of using high temperatures on the drying process by applying the osmotic dehydration method. Osmotic dehydration is a mass transfer process that is generally carried out by immersing food ingredients in a hypertonic solution to remove some of the water from the fruit tissue [8]. Application of osmotic dehydration as a pre-treatment in the process is effective at ambient temperatures with minimal detrimental effects on food quality, achieving product stability, nutrient retention, and improvement of food taste and texture [9][10]. Then compared to other drying processes, osmotic dehydration minimizes heat damage to color and taste and reduces enzymatic decolorization of fruit[10][11].

Based on the treatments which have been applied to the drying processing and packaging conditions, parameters of dehydrated strawberry quality can be shown as the effects on color and texture. Then, visually of the dehydrated strawberry also will be shown. Color or chromatic attribute is one of the most important quality parameters of dried fruit products for marketing value and consumer choice. The discoloration of dried fruit can be explained as a result of chemical, biological, and physical reactions that occur during thermal processing. Fresh fruit especially strawberries are susceptible to enzymatic browning due to their anthocyanin content. Besides, the color change can be caused by the brown pigment which is formed as a result of the Maillard reaction [5][12]. Figure 1 shows the color of the dehydrated strawberry under different packaging treatments. The lightness, redness, and yellowness value of dehydrated strawberry in the without packaging treatment for both drying methods tended to decrease during the storage period. Then, the vacuum-packaging treatment for both drying methods had relatively the same values and was stable during storage. This indicates that the vacuum-packaging treatment can maintain the lightness, redness, and yellowness value during storage. Based on the statistical test, there is a significant difference in the average lightness value in the treatment of the drying method used and the packaging treatment used. Then, there is a significant difference in the average redness value in the treatment packaging used, and there is a significant difference in the average yellowness value in the treatment of the drying method used and the packaging treatment used.

![Figure 1](image-url)
Figure 1. Color of dehydrated strawberry under different treatments for several days packaging treatments.

The surface hardness is one of the most influential quality parameters of dried fruit. This is related to the rheological and structural behavior of food which can be investigated through mechanical parameters [13]. The surface hardness of dehydrated strawberry under different treatments of packaging was shown in figure 2 below. The hardness of dehydrated strawberry at 6 h drying treatment for both without packaging and vacuum-packaging treatments tends to decrease during storage and will become mushy and juicy. In the 9 h drying treatment for both without packaging and vacuum-packaging treatments, the hardness of dried strawberries tends to be stable during storage. Based on the statistical test, there is a significant difference in the average hardness in the treatment of the drying method used, and there were no significant differences between the packaging treatments. Vacuum packaging using polyethylene plastic can protect dehydrated strawberries from the outside air environment, which directly affects surface hardness [3].

Figure 2. The surface hardness of dehydrated strawberry under different treatments for several days packaging treatments.

The dehydrated strawberry with different packaged treatments was visually observed on days 0, 2, 4, 6, 8, and 10 and can be seen in Table 1. The dehydrated strawberry in 6 h drying treatment and without packaging showed a color change on the 6th day, and at 6 hours drying treatment and vacuum packaging dehydrated strawberry showed a color change on the 4th day. Then the dehydrated strawberry with 9 h drying treatment, either without packaging or vacuum packaging did not change color until the 10th day. This shows that at 9 h drying the dehydrated strawberry color can visually be maintained until the 10th day.
Table 1. Visual organoleptic of dehydrated strawberry under different treatments

| Visual Day | P1T1                          | P1T2                          | P2T1                          | P2T2                          |
|------------|-------------------------------|-------------------------------|-------------------------------|-------------------------------|
| Day 0      | ![Red Color](#)               | ![Red Color](#)               | ![Red Color](#)               | ![Red Color](#)               |
| Day 2      | ![Red Color](#)               | ![Red Color](#)               | ![Red Color](#)               | ![Red Color](#)               |
| Day 4      | ![Red Color](#)               | ![Some of the samples of the dark red color](#) | ![Red Color](#)               | ![Red Color](#)               |
| Day 6      | ![Some of the samples of the dark red color](#) | ![Some of the samples of the dark red color](#) | ![Red Color](#)               | ![Red Color](#)               |
| Day 8      | ![Most of the samples of the red and brown-red colors](#) | ![Most of the samples of the dark red color](#) | ![Red Color](#)               | ![Red Color](#)               |
| Day 10     | ![Most of the samples of the brown-red color](#) | ![Some of the samples of the dark red color](#) | ![Red Color](#)               | ![Red Color](#)               |
4. Conclusion
Vacuum packaging treatments for the drying treatment of 70°C; 50°Brix; 60 min; 9 h; 36 h can be maintained the color changes and texture of dehydrated strawberry fruit compare with those of control.

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