Effect of blanching and solar energy-based drying models on the quality of dried shredded apples

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Abstract. This study aimed to find the best technology model to produce high-quality dried shredded apples as the resources of apple tea with the concept of green technology based on solar energy. Apple tea is a beverage product originated from Batu, Malang that is starting to be in high public demand because of its practical, sweet-scented nature and is believed to have a high content of apple antioxidants. This study determined the physical, nutritional, and bioactive changes resulting from the drying process of shredded apples, which were treated by blanching and non-blanching pre-treatment and dried using indirect convective solar drying and open sun drying. Blanched-shredded apples that were dried using an indirect convective solar dryer had the best vitamin C content and lowest mechanical damage, so it is prospective to be developed on a commercial scale as a raw material of apple tea.

1. Introduction
Drying is a preservation process widely used to extend and maintain the shelf life of food products, including apples. However, high temperatures applied during drying can cause fruit damage [1, 2, 3] and alter the bioactivity of heat-sensitive compounds like flavonoids. This degradation can be reduced by pretreatment before the dehydration process, such as blanching treatment or the addition of chemicals. The pretreatment is carried out to inhibit or reduce the thermal degradation of polyphenols. Several studies have reported increased antioxidant content resulting from structural changes in tissues that can release bound polyphenol antioxidants [4]. This process results in increased antioxidant activity [4, 5]. On the other hand, thermal processes can also induce chemical changes in polyphenols that result in the formation of degradation products, which can maintain or even have higher antioxidant activity [2, 4, 6, 7].

Understanding the effects of thermal processing on materials, including drying processes, is essential to obtain the maximum stability of the phytochemical constituents of foodstuffs. There are only a few reports regarding the effect of the drying process combined with multiple pre-treatments for dried apples. Apples subjected to osmotic pre-treatment and drying at 45 °C had a reduced polyphenol content by 55% [2]. These results indicate that dehydration of apples causes a significant change in the antioxidant content of dry products.
Effect of blanching and drying models on stability, physical properties, and antioxidant activity of polyphenols in pomace apples conducted by Heraz-ramirez [8], indicated that the blanching process causes color retention, total polyphenol content, and total flavonoid content of dried apples when compared to dried apples without blanching. It showed that blanching treatment has a positive impact on maintaining the quality of apples during drying. Standard methods of blanching treatment are rapid evaporation, instant boiling at a specific temperature, or treatment with chemicals. This study aimed to find the best technology model to produce high-quality dried shredded apples as the resources of apple tea with the concept of green technology based on solar energy.

2. Materials and Methods

2.1. Materials

The fresh apples (romebeauty) was bought at a local market in Malang, Indonesia. The ripe apples were chosen randomly in size. The weight was 50-100 g each with 85-90% moisture content. This study used a simple complete randomized design with a combination treatment of blanching and drying models. There were four treatment combinations: Drying unblanched shredded apple using convective solar drying (CSD) and open sun drying (OSD) and Drying blanched shredded apple using CSD and OSD drying models. Each treatment was repeated two times.

2.2. Experimental set up

Blanching was done by soaking the shredded apples in boiled water for 5 minutes, continued with the draining process. The CSD and OSD processes were carried out in Experiment Field of Agriculture Faculty, University of Islam Malang. The dryer used was a convective solar dryer designed by Mardiyani et al. [3]. The CSD is supported by a collector, a solar photovoltaic, a drying unit, and a blower. The blower has a maximum voltage: 24 volts and a maximum speed: 3 m/s. The drying implementation was done by 07.30-13.30 am (6 hours). The OSD was done by placing the treated shredded apples on open trays. The temperature in the CSD drying chamber was 40-60 °C due to the daytime; meanwhile, the ambient temperature was 25-36 °C. The CSD drying chamber's relative humidity was 24-50 %, while the ambient relative humidity is relatively stable at 16-20%. Solar intensity recorded were in between 450-900 W/m² regarding the day time and weather condition. The air drying rates in the CSD drying chamber were 2.6-3.2 m/s while the ambient air rates were 1-1.5 m/s.

2.3. Quality analysis

Quality analysis of dried shredded apples was done in the Agricultural Physiology Laboratory, University of Islam Malang. The analysis was done on ascorbic acid, total soluble solids, total phenol, rehydration ratio, and non-enzymatic browning index. The detail analyzes were as follows:

2.3.1. Ascorbic acid with modification.

About 5 grams of the sample was put in a flask (50 ml) and added with distilled water. It was homogenized and filtered using Whatman No.1 filter paper. The 0.01 N iodine solution was prepared by mixing 1,269 grams of I2 and 2 grams of KI and dissolved in 1 liter of distillate water overnight. The sample filtrate was added with a 1% soluble starch solution (4 ml) then titrated with 0.01 N iodine. The color-changing of the solution marked the titration endpoint into a blue tinge. 1 ml of 0.01 N iodine is equal to 0.88 mg ascorbic acid [9].

2.3.2. Non-enzymatic browning index

Dried shredded apples (0.1 ± 0.001 g) was dissolved in 50 ml of distilled water. The water-soluble pigment was extracted for 2 hours by axial shaker at 25 °C and 140 rpm. It was then centrifuged at 4000 rpm for 16 min. The supernatant was filtered with a paper Whatman no 1 (pore size 0.45 mm) to remove suspended particles. The spectrophotometer (Shimidzsu UV 160U, Kyoto, Japan) wavelength used to
measure the absorbance of the filtrate was 420 nm. The Browning index value unit in this method is the Abs / 0.1 gr sample).

2.3.3. Rehydration ratio ([10])
About 2 g of dried sample was placed in a 100 ml beaker glass and added by 50 ml distillate water, then covered with aluminum foil. It was then heated to boil within 3 minutes and then cooled until 50°C. The rehydrated sample was drained using filter paper and weighed.

2.4. Statistical analysis
The data resulted from this research were analyzed using ANOVA. It was continued with the Least Significance Difference (LSD) 5% test if there was a significant influence to know the difference level among the treatments.

3. Results and Discussion
The value of Ascorbic Acid ranges from 2.29-10.21 mg/100 g, total phenol 0.11-0.16 mg/100 g, total soluble solid 3.5-4.9 °Brix, rehydration ratio from 0.09-0.24.0 and non-enzymatic browning index from 0.09-0.48 Abs/0.1 mg). The statistical analysis shows that the combination of the treatments significantly affected vitamin C content and browning index. The combination of these treatments had no significant effect on the total phenol, total dissolved solids and rehydration ratio.

Blanched shredded apples dried using the CSD drying model had the highest vitamin C content, which was significantly different from other treatments, while the non-blanched dried shredded apples dried under the open sun drying had the lowest ascorbic acid content (Figure 1). It shows that the solar blanching and drying process used in this study can prevent vitamin C degradation during the drying process. Santos and Silva [11] stated that ascorbic acid degradation depends on moisture and temperature during the drying process. Ascorbic acid is exposed to the sun or dehydrated in a forced air dryer heated by solar energy. According to Behera and Rayaguru [12] sun drying could not preserve much ascorbic acid, may be due to the longer drying period. This result is in line with the research of Kadam et al. [13] who blanched cauliflower in hot water followed by immersion in different concentrations of potassium metabisulfite solution. After drying, the highest ascorbic acid content was found in samples blanched in hot water for 3 min.

**Figure 1.** The effect of various blanching-non blanching treatment and two drying models (CSD and OSD) on ascorbic acid and total phenol.
Meanwhile, in this study, the unblanched dried shredded apples tended to have a higher total phenol, both on CSD and OSD drying (Figure 1). It is not in line with the results of previous studies [9] which stated that the polyphenolic components of unblanched apple pomace were significantly reduced by drying temperatures. According to Devic et al., [2] apples with osmotic pretreatment and drying at 45°C had reduced polyphenol content by 55%.

![Figure 1](image.png)

**Figure 1.** The effect of various blanching-non blanching treatment and two drying models (CSD and OSD) on non-enzymatic browning index and rehydration ratio of dried shredded apples.

Figure 2 shows that the browning index values for blanching and non-blanching dried shredded apples on the CSD system were relatively higher than those dried using the OSD system. The browning index is mainly influenced by drying temperature. This study indicated that the temperature of the appliance dryer was relatively higher (40-60°C) than the temperature of the ambient air (25-36°C) so that the browning process in apples ran faster. Meanwhile, there is no significant difference in the rehydration ratio among the treatment combination. It shows that the tissue damage of shredded apples was similar among the treatments.

### 4. Conclusions

The combination of blanching-non blanching treatment and solar energy drying models (CSD and OSD) had a significant effect on vitamin C content, total phenol, and browning index. Blanched shredded apples dried using the CSD drying system had the highest vitamin C, which was significantly different from other treatments. The non-blanched dried shredded apples dried under the open sun drying had the lowest vitamin C content. Meanwhile, in this study, the unblanched dried shredded apples tended to have a higher total phenol, both on CSD and OSD drying. This study indicates that the CSD dryer's temperature was relatively higher than the temperature of the outside air so that the browning process in apples ran faster. Overall, the use of the indirect convective solar dryer is prospective to be developed on a commercial scale of shredded apples drying as the raw material of apple tea.

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