Effect of Pre-Treatment on The Physicochemical Characteristics of Potato Powder Dried by Drum Dryer

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Abstract. In the industrial processing of fruits and vegetables, such as potato, the peeling and blanching processes are considered as pre-treatment. The choice of the most appropriate treatment depends on the raw material and the necessary attributes for the final product. This study aimed to determine the effect of pre-treatment (peeling and blanching method) on the physicochemical characteristics of potato powder dried by drum dryer. In this study, Margahayu variety was used. Potatoes were sorted, peeled (no peeling, abrasive, lye, and hand peeling method), soaked in clean water, cut into four parts, drained, and then blanched for 10, 15, and 20 minutes. Blanched potatoes were subsequently mashed into a paste and then dried by drum dryer. The physicochemical character of potato powder was analyzed, i.e. yield and colour, water, ash, fat, protein, and carbohydrate content. The results showed that peeling and blanching treatment had a significant effect on yield, colour, water and protein content, and had no significant effect on ash, fat, and carbohydrate content. Treatment of lye peeling with blanching for 10 minutes resulted in the best of yield (17.8%) and powder physicochemical characteristics such as colour (L=95.30; a=0.36; b=28.83), water content 7.18%, ash 3.25%, fat 0.36%, protein 10.14 %, and carbohydrate 80.80%.

1. Introduction
Potato (Solanum tuberosum L.) is one of the important horticultural products for fulfilling food demands and supporting food diversification. Potato production in Indonesia has annually increased with the total production of 1,347,815 tons in 2014 [1]. Potato tubers have high nutritional value due to a high content of carbohydrates and vitamins, pleasant taste and high digestibility. On a dry weight basis, the protein content of potato is similar to that of cereals and is very high in comparison with other roots and tubers. The potato is a moderate source of iron, and its high vitamin C content promotes iron absorption. It is a good source of vitamins B₁, B₃ and B₆ and minerals such as potassium, phosphorus and magnesium, and contains folate, pantothenic acid and riboflavin [2].

Fresh potato tubers are bulky and highly perishable, and difficult to store. Under the existing circumstances, processing of the bulky perishable potatoes into various processed products is a viable option which can help extend the storage life, solve the storage problem, and serve as a means to increase the supply in off seasons thus maximizing potato utilization. These considerations make clear that dehydrated potato in the form of a powder can be a very interesting product for the food industry. Potato powder can be sold as either an ingredient, a semi-finished or a finished product, for industrial reworking
(production of vegetable soups, minestrones, etc.), for catering, and for retail in particular fields as dietic and baby foods or foods for elderly.

Basically, potato tubers are transformed into powder by a series of processes which include pre-treatments like peeling and blanching, which is followed by drying and grinding to obtain a stable powder. Peeling is a unit operation that is employed during the processing of tubers to remove unwanted or inedible material and to enhance the appearance of the final product [3]. Peeling must be done to achieve low product losses, minimized energy and chemical usage, minimized pollution load, and minimized heat ring formation [4]. Methods of peeling reported in the literature include abrasive, lye, steam, and knife (hand peeling), each of which has its own benefit and limitations. Hand peeling is traditional peeling and is a tedious process, time-consuming, and may require several workers to carry out an operation which ultimately increases operating cost [5]. Lye peeling which involves the use of sodium hydroxide at different concentration is commonly used in the peeling of fruits and vegetables [6]. Generally, lye peeling removed skins with less loss than abrasive peeling. Peeling losses varied from 5 to 28 per cent with lye and 14 to 18 per cent using abrasive peeling techniques. However, in lye peeling process the heat ring is formed below the surface of the potato due to tissue damage that can affect the quality of potato powder.

Blanching is an important unit operation for processing of fruits and vegetables. Blanching is a short and mild heat treatment prior to the main process for the purpose of enzymes inactivation, modifying texture, preserving colour, flavour and nutritional value and removing trapped air [7]. Hot air and steam are the most commonly used heating media for blanching in the industry. Discolouration phenomenon on fresh tuber has long been known to be associated with the enzymatic activity, e.g. due to the action of polyphenol oxidase and peroxidases. These enzymes are inactivated by blanching. However, blanching reduces the nutritional value of food due to nutrition leach out or degrades by heating [8]. Starch properties may also be altered by heating. These conditions must be adjusted according to the characteristics of the raw material in order to optimize the quality of the final product. This study aimed to determine the effect of pre-treatment (peeling and blanching method) on the physicochemical characteristics of potato powder dried by drum dryer.

2. Method

Fresh potatoes tubers (Margahayu variety) from farmer’s farm at Pangalengan, West Java were selected. The stages of processing potato powder include washing, peeling, cutting, dipping in sodium metabisulphite solution, blanching, pasting, drying, and grinding (Figure 1).

Tubers were manually washed and then peeled by four methods, namely unpeeling, abrasive, lye, and hand peeling. In the lye method, the potatoes were immersed in sodium hydroxide solution (commonly called lye or solution of caustic soda) long enough for the chemical to soften the surface of the potato. The lye solution was maintained under optimum conditions at 9% concentration and a temperature of 90°C. In the abrasive method, peeling of potatoes using an abrasion type peeler, whereas in the hand peeling method, peeling of potatoes using a knife.

Peeled potatoes were cut into four-part and dipped in water containing sodium metabisulphite (1,500 ppm) for 15 minutes. The potatoes were softened by blanching them on hot steam (± 97°C) for 10, 15, and 20 minutes before drying. The food processor was used to smash the blanched potatoes and convert them into pasta. Potatoes pasta was poured on the drum of the heated double drum dryer at 0.5 mm drum gap size. The drum drying was run until the potatoes pasta was fully dried at a rotation speed of 5 rpm. The drum dryer temperature on the outside is 80°C and the temperature at the inside is 140°C. The flake was ground by a hammer mill, packed and sealed in polyethylene 0.08 mm and stored at 20 ± 2°C prior to analysis. The experiment uses a completely randomized design of factorial pattern with two replication.

The physicochemical character of potato powder was analyzed, i.e. yield and colour, water, ash, fat, protein, and carbohydrate content. The colours of powder were measured using a Minolta portable chromameter. The hunter lab colour coordinates system L, a, and b values were recorded. Water, ash, fat, protein, and carbohydrate fibre contents were analyzed according to the standard methods of AOAC
Microstructure of potato powder was determined using a Scanning Electron Microscope (Carl. Zeiss/EVO MA 10).

3. Result and Discussion

The results showed that the peeling and blanching method had a significant effect on the yield of potato powder (Table 1). Treatment without peeling resulted in the highest of potato powder yield (average 17.42%), and significantly different from lye (average 15.84%), abrasive (average 14.31%), and hand peeling (average 13.90%). Among the peeling methods tested, lye peeling was the most effective method because it produces high yields for each treatment of blanching time, which means the peel loss in the peeling process was quite low. According to Caceres et al. [10], in the lye peeling process (caustic soda) temperature and concentration of the solution, as well as the treatment time varies according to the raw material and were an important aspect for peeling efficiency. Graham and Denys [11] reported that lye peeling of Yacon gave about 14% peel loss, while Barringer et al. [12] reported peeling losses varying between 21.8 and 29.5% during lye peeling of tomato. In the abrasive and hand peeling, the loss of flesh was very high so the yield was lower. However, blanching tended to decrease the yield of potato powder. The longer of blanching time, the yield of potato powder decrease in all peeling methods (Table 1). Leeratanarak [13] reported that blanching help to increase the dehydration ratio of the product which represents the decrease in the yield of the dehydrated product. The increase in dehydration ratio of the powder in blanching treatment might be attributed to leaching losses of the nutrients and solids.

[Table 1]

Figure 1. The stages of potato powder processing

The peeling and blanching method also had a significant effect on the colour of potato powder. The colour is the most significant physical property for consumer acceptance of the product. Potato powder produced by no peeling method was less bright and dark brown in colour, which was shown by the lower value of $L^*$ (lightness), and higher value of $a^*$ (Table 1). The phenolic compounds of potato are present in peel and flesh, but the peel was reported to have the highest amounts (90%). Phenolic
compounds that could oxidize to form brownish compounds. This reaction is catalyzed by polyphenolase enzyme [14] and inactivation of this enzyme could prevent phenol oxidation that resulted in brighter colour. Table 1, showed that three peeling methods (lye, abrasive and hand peeling) obtained bright potato powder, but lye peeling is the most effective method, especially at short blanching times. This was because lye peeling can facilitate the stripping of potato skin and also had the ability to inhibit enzymatic browning. According to Caceres et al. [10], lye peeling solution can be reduced enzyme activity up to 92.6%. This result in accordance to the result of Caceres et al. [10], that lye peeling method with NaOH solution and heating for just 5 minutes was enough for the peeling cubic fruit and to prevent the enzymatic browning. Blanching for more than 10 minutes seems to be less effective in increasing the brightness of potato powder for all peeling methods, and even reduces yield due to increased losses of the solid and nutrient.

Table 1. Effect of peeling and blanching method on the yield and colour of the potato powder

| Treatments   | Yield (%)  | Colour |  |  |
|--------------|------------|--------|---|---|
|              |            | L*     | a* | b* |
| No peeling   |            |        |    |    |
| Blanching 10 min | 18.27±1.28 | 88.60±1.35 | 1.92±0.28 | 23.72±1.21 |
| Blanching 15 min | 18.15±1.14 | 87.36±1.61 | 1.54±0.07 | 25.09±0.76 |
| Blanching 20 min | 15.85±1.05 | 87.42±0.71 | 1.29±0.23 | 24.75±1.36 |
| Abrasive peeling |            |        |    |    |
| Blanching 10 min | 15.79±1.04 | 92.19±0.93 | 1.13±0.14 | 26.98±1.05 |
| Blanching 15 min | 14.07±0.86 | 91.98±1.46 | 1.27±0.21 | 25.65±1.12 |
| Blanching 20 min | 13.05±0.23 | 91.11±1.37 | 1.71±0.04 | 27.03±1.19 |
| Lye peeling |            |        |    |    |
| Blanching 10 min | 17.18±0.62 | 95.30±0.93 | 0.36±0.03 | 28.83±1.23 |
| Blanching 15 min | 14.55±0.37 | 91.04±1.20 | 1.69±0.08 | 26.98±0.99 |
| Blanching 20 min | 15.80±0.81 | 91.09±0.95 | 1.38±0.06 | 26.98±0.92 |
| Hand peeling |            |        |    |    |
| Blanching 10 min | 12.73±0.68 | 92.16±0.98 | 1.03±0.18 | 24.98±1.15 |
| Blanching 15 min | 13.03±1.12 | 90.53±1.24 | 1.09±0.01 | 25.64±1.06 |
| Blanching 20 min | 12.94±0.95 | 91.04±1.22 | 1.69±0.08 | 26.98±1.18 |

The peeling and blanching method had a significant effect on the water content of potato powder. Potato powder produced by no peeling method had a higher moisture content compared to another peeling method. However, the water content of potato powder produced from all peeling method is lower with the longer blanching time (Table 2). This condition was related to the difference in drying rate of potato powder at each blanching time, where the drying rate was expected to be higher with longer blanching times. According to Vaccarezza and Chirife [15], during the blanching process, there was a change in physical properties of the potato tissue, such as destruction of the cell membranes by heat, and loss of soluble solids. This condition affects the drying rate of potato powder. Biekman et al. [16] observed that shrinkage in blanched tissues which was due to the contraction of bio-polymers during blanching. It opens up plant cells which exude fluids with simultaneous loss of solutes. Blanching affects the distribution of soluble components within the tissues during drying. This also results in the leakage of soluble components to the surrounding environment (water) and loss of these solutes affects the rate of drying.

The protein content of potato is similar to that of cereals and is higher in comparison with other roots and tubers. In addition, the potato is low in fat [2]. Table 1 showed that all potato powder had low-fat content and powder was not a good source of fat. Ash content of potato powder was 3.17 - 4.31%, potato powder with higher ash content was less acceptable. Table 2 showed that the peeling and blanching method had a significant effect only on the protein content of potato powder, while the ash, fat, and carbohydrate content had no significant effect. Potato powder produced by no peeling method had a higher protein content compared to another peeling method. The protein content decreases with increasing blanching time, especially during blanching for 20 minutes for all peeling methods. This could be due to leaching out of nutrient during blanching. The nutrients were affected by the temperature and time of blanching. Guerrant et al [17] found that blanching had advantage in many ways having detrimental effects particularly on the water-soluble nutrients. Prolonged blanching time resulted in considerable loss of carbohydrate; protein and minerals.
Table 2. Effect of peeling and blanching method on the chemical characteristics of potato powder

| Treatments          | Water content (%) | Ash (%)   | Fat (%)   | Protein (%) | Carbohydrate (%) |
|---------------------|-------------------|-----------|-----------|-------------|------------------|
| No peeling          |                   |           |           |             |                  |
| Blanching 10 min    | 7.84±0.78         | 3.81±0.16 | 0.30±0.06 | 11.31±0.44  | 80.03±1.97       |
| Blanching 15 min    | 7.15±0.41         | 3.54±0.44 | 0.46±0.08 | 11.16±0.42  | 79.62±2.79       |
| Blanching 20 min    | 5.85±1.03         | 4.31±0.12 | 0.34±0.04 | 10.47±0.35  | 81.03±0.32       |
| Abrasive peeling    |                   |           |           |             |                  |
| Blanching 10 min    | 5.79±0.33         | 3.64±0.27 | 0.32±0.06 | 10.78±0.38  | 80.00±1.74       |
| Blanching 15 min    | 5.07±0.32         | 3.38±0.10 | 0.27±0.04 | 10.13±0.21  | 79.35±0.92       |
| Blanching 20 min    | 4.05±0.24         | 3.85±0.21 | 0.25±0.09 | 6.11±0.13   | 80.68±1.30       |
| Lye peeling         |                   |           |           |             |                  |
| Blanching 10 min    | 7.18±0.51         | 3.25±0.35 | 0.36±0.03 | 10.14±0.20  | 80.80±1.58       |
| Blanching 15 min    | 4.55±0.34         | 3.17±0.10 | 0.32±0.08 | 10.27±0.24  | 80.40±1.13       |
| Blanching 20 min    | 5.80±0.45         | 4.31±0.38 | 0.34±0.03 | 9.47±0.61   | 82.03±1.32       |
| Hand peeling        |                   |           |           |             |                  |
| Blanching 10 min    | 6.73±0.76         | 3.55±0.58 | 0.32±0.04 | 10.16±0.11  | 81.41±1.91       |
| Blanching 15 min    | 5.03±0.04         | 3.53±0.27 | 0.29±0.05 | 10.27±0.38  | 79.95±1.87       |
| Blanching 20 min    | 4.94±0.20         | 3.45±0.35 | 0.42±0.07 | 6.90±0.57   | 82.17±0.81       |

Scanning electron microscope (SEM) image of potato powder produced by lye peeling and blanching 10 minutes showed clustered granules and formed aggregates mass (Figure 2). The shape of the granules is different from the granules of native powder. According to Avula and Singh [18], the native powder had oval, spherical and irregularly shaped starch granules of 6-60 µm size. However, the granular appearance in native powder disappeared by heat treated from drum drying. Avula and Singh [18] found that agglomeration of granules in heat treated powder the size of such agglomerations to be more than 100 µm. These change would have improved hydration of drum dried powder that determines pasting viscosities.

![Figure 2. Microstructure of potato powder](image)

4. Conclusion
Lye peeling treatment with blanching for 10 minutes produced the highest yield of potato powder (17.18%). The physicochemical characteristics of powder from the treatment were as follows: colour (L=95.30; a=0.36; b=28.83), moisture content 7.18%, ash 3.25%, fat 0.36%, protein 10.14%, and carbohydrates 80.80%.

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