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Effect of Blanching and Drying Process on Physicochemical and Microbiological Characteristics of Dried Chili

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***Abstract*—Fresh red chili has a short shelf life, so it is processed into dry chili. However, the quality of dry chili may not meet the requirement of consumers. Pre-treatment (blanching) and drying can be used to maintain the quality of dried chilies. This research aims to determine the physical, chemical, and microbiological characteristics of the dried red chili with blanching and drying treatments. In this study, we compared three blanching treatments of chili (water; 0.2 % vitamin C (w/v); and 0.2% Sodium metabisulfite solution (w/v)) for 10 minutes at 90 °C, with three drying methods (sun-drying, sun-drying with plastic shade, and cabinet drying at 50-60 °C). Chili was obtained from the Panjatan sub-district, Kulon Progo district, Yogyakarta Special Region Province, Indonesia, with a 90% maturity level. We found that the yield of dried chilies was 20% in all treatments. The moisture content of all blanching and drying treatments requires the Indonesian National Standard (INS No. 01-3389-1994) for dried chili (<11%). In all blanching treatments, sun-drying with plastic shade treatment produced the highest levels of vitamin C. The highest beta-carotene content was produced by blanching with 0.2% sodium metabisulfite solution and plastic shaded sun-drying (2.24%), and the lowest Total Plate Count (TPC) was produced by cabinet drying at all blanching treatments (<10 – 4.10^1 CFU/g). The dried chili processing is expected to increase the shelf life and value-added of chili.**

***Keywords*— Dried red chili; physicochemical characteristic; microbiological characteristic; blanching; drying.**

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I. INTRODUCTION

Chili (*Capsicum annuum* L.) is an important horticultural commodity because it is widely needed in food processing (household and industrial) and non-food industries. According to the Ministry of Agriculture of the Republic of Indonesia, this commodity's management has two problems: fluctuations in supply and price [1]. Seasonal change and chili production problems (availability of land, pests/diseases, and non-optimal production facilities) cause fluctuations in supply [1]. Price fluctuations usually occur during the dry season because demand exceeds supply [2]. On feast day (religious holidays), demand for chili can increase by 10-20% from normal need, which results in the price of chilies above IDR 50,000/kg.

Meanwhile, during the harvest season, the price drops to IDR 7,000 - IDR 10,000/kg due to this commodity's abundant availability. This very significant price fluctuation can ultimately affect the inflation rate. Besides, the shelf life of fresh red chilies is relatively short (five days at room temperature) due to their high moisture content (70-80%). If stored at room temperature, it can only last for about seven days. The solution can be made to stabilize prices and extend the shelf life of fresh chilies by processing them into dried chilies. Pre-treatment (blanching) and proper drying can maintain and improve the quality of agricultural products [3], [4]. Blanching has an essential role in food processing by stopping food enzymes (polyphenols, peroxidase), accelerating drying, increasing or maintaining the quality of its derivative products, and suppressing the microbial population [3], [5].. Blanching in sodium metabisulfite solution can maintain the quality of dried chilies [6]. The variation of sodium metabisulfite and vitamin C solutions can affect the drying speed and quality of the dried chilies [7]–[9]. The drying process aims to extend the shelf life of the material by reducing the material's moisture content to a specific limit so that the microorganisms cannot grow and enzyme activity causes rotting stops [10]. The method and drying conditions will determine the quality of dried chili in maintaining carotenoids and antioxidants [11]. The controlled drying technique of fresh chilies will maintain the physicochemical and functional properties of chili derivatives [12]. This study aims to determine the physical, chemical, and microbiological characteristics of the Koi dried red chili with blanching and drying treatments.

II. MATERIALS AND METHOD

A. Materials

The main material in this study was Koi variety fresh chili (*Capsicum annul* L.). Fresh red chili was harvested at 90% maturity (ripening) level, and requiring to minimal the third grade in the Indonesian National Standard of fresh chili (INS Number 4480:2016). This chili had a minimum length and diameter 14.10 cm and 0.77 cm respectively. The chili was harvested from Panjatan sub-district, Kulon Progo district, Yogyakarta Special Region Province, Indonesia. The supporting materials used are water, sodium metabisulfite, vitamin C, and other materials for physical and chemical analysis. The equipment used was a digital scale, stainless steel pan, stirrer, drainer, cabinet dryer, tray, drying rack, grinding machine, and other physical and chemical analysis equipment.

B. Methods

The study was conducted at Melati farmer women's group (FWG), Panjatan sub-district, Kulon Progo district, Yogyakarta Special Region Province, Indonesia; Postharvest Laboratory of Yogyakarta Assessment Institute for Agricultural Technology (AIAT), Indonesia and Chemical Laboratory, Faculty of Agricultural Technology, Gadjah Mada University (UGM), Yogyakarta, Indonesia. The research utilized a Completely Randomized Design (CRD) with two factors and three replications. The first factor is the blanching method (A), namely A1 = blanching with water, A2 = blanching with 2% vitamin C solution (w/v), and A3 = blanching with 0.2% sodium metabisulfite ($Na_2S_2O_5$) (w/v). The second factor is the drying method (B), i.e., B1 = sun-drying, B2 = sun-drying with plastic shade, and B3 = cabinet drying at 50-60 ºC as shown in Figures 1, 2, and 3.

Fig. 1 Sun-drying

Fig. 2 Sun-drying with plastic shade

Fig. 3 Cabinet drying at 50-60 ºC

C. Dried Chilies Processing

The dried chili preparation was modified from the previous method [13]. The chilies were carefully selected before the drying process. The chilies were sorted, washed, blanched, and dried under the previous modified method [14]. The sorting of chilies was done to choose quality chilies based on fresh chili Indonesian National Standard (INS Number 4480:2016), which is at least in the third grade. The bruised, discolored, decayed, wilted, or damaged chilies were excluded. The washing and blanching were carried out using drinking water standards (safe drinking water). Safe drinking water is water that does not exhibit any significant risk to health over lifetime consumption, including also the consideration of different sensitivities that may occur between life stages [15]. The washing process aims to remove impurities (dust and dirt particles) and pesticide remnants present on the chilies. After that, the chilies (5 kg/treatment) were drained and blanched. The blanching process used the previous modified method [7]. Blanching was done by boiling 5 kg of fresh chilies in a stainless-steel pan with water at 90°C for 10 minutes and based on treatments. Blanched chili was cooled immediately in water for 1 minute and drained based on the treatments until the moisture content was approximately 11%.

D. Analysis

1) Determination of Yield: Yield was the ratio of the dried chili's weight to that of the fresh chili, expressed as a percentage. The determination of yield was modified from the previous method [9]. The yield was calculated with the following formula:

$$Y = \frac{dried\ chili\ weight}{fresh\ chili\ weight} X\ 100\% \qquad (1)$$

Y is the yield of dried chili produced, compared with the initial weight (fresh chilies) and presented in percentages. The dried chili weight is the weight of dried chili produced by each treatment (blanching and drying) in weight units. Fresh chili weight was the weight of fresh chilies before pre-treatment and drying.

2) Determination of Moisture Content: The Thermogravimetric method was used to determine the moisture content [16]. The moisture content was determined using an oven dryer at 150°C±1°C for 48 hours and calculated with the following equation:

$$\text{Moisture content} = \frac{Mw-Md}{Mw} x\ 100\% \qquad (2)$$

Mw is fresh chili masses before pre-treatment and drying. Md is dried chili masses after pre-treatment and drying treatments. All masses were measured with an analytical balance (±0.0001 gram).

3) Determination of Vitamin C Content: The vitamin C content in chili was measured using the UV-Vis Spectrophotometry method at about 200-300 nm wavelengths, using distilled water as blanks and ascorbic acid as standard solutions [17].

4) Determination of Beta-carotene Content: The beta-carotene content was measured by spectrophotometric method at 430-470 nm wavelength [9], [18], [19].

E. Statistical Analysis

All tests were performed in triplicate and analyzed by one-way analysis of variance (Anova). When a significant difference was found, a Duncan analysis was performed at a significance level of $p \leq 0.05$.

III. RESULTS AND DISCUSSION

A. Yield

The six treatments had almost the same dried chili yield, which was around 20%. The yield can be used as a quantitative indicator of the food processing quality [20]. Processing is more effective if the yield is greater [21]. This is because the yield affects the value-added (profits) being obtained. If the yield is higher, the added value obtained will be higher [22]. 20% of dry chili yield can provide an added value ratio of around 60%, and therefore it is profitable [23].

B. Moisture content

Moisture content is one of the factors that affect the shelf life of food. The shelf life of food will be higher if the moisture content is lower [20]. The moisture content must be optimized to limit the development of pathogenic microorganisms, which will be inhibited or stopped if the moisture content is reduced so that the food can acquire a relatively long shelf life [10]. The fresh chili moisture content of Koi variety was 76.64%, while the dried chilies' moisture content is presented in Table 1.

TABLE I
THE MOISTURE CONTENT OF CHILI AFTER BLANCHING AND DRYING TREATMENT

Treatments		Moisture
Blanching treatments	**Drying treatments**	**content (%)**
Water	Sun-drying	10.13^{g*}
	Sun-drying with plastic shade	9.80^{f}
	Cabinet drying at 50-60ºC	7.91^{c}
Water with 0.2% vitamin C solution (w/v)	Sun-drying	11.00^{h}
	Sun-drying with plastic shade	8.42^{d}
	Cabinet drying at 50-60ºC	7.50^{c}
Water with 0.2% sodium metabisulfite solution (w/v)	Sun-drying	10.09^{g}
	Sun-drying with plastic shade	8.60^{e}
	Cabinet drying at 50-60ºC	7.20^{a}

Source: processed primary data. *
*) Similar letter in the same column shows no significant difference at 95% confidence level with Duncan's test

The dried chilies had 7.20 – 11.00% moisture content, which fulfilled the Indonesian National Standard 01-3389-1994 (maximum 11%). Blanching and drying treatments can reduce the microbial population and increase consumer acceptance of dried chilies [10], [24]. The drying of red chili with a cabinet dryer exhibits the lowest moisture content than sun-drying with plastic shade and sun-drying without shade.

Statistical analysis with multiple correlation test shows that the correlation coefficient between blanching and drying treatment and the moisture content was 0.965. This shows that the blanching and drying treatments greatly influence the moisture content of the dried chili. The simultaneous effect of blanching and drying treatment on the moisture content of 93.2% and 6.8% were influenced by other factors such as surface area expanse of dried chili and chili thickness on the drying rack. The decrease of moisture content can also be influenced by several factors, including temperature, drying speed, humidity, and the type of material being dried [21].

Based on the Duncan test at 95% confidence level, dried chili's moisture content was partially significantly different between treatments, except the blanching with water or addition of a 0.2% sodium sulfite solution with sun-drying. A solar-assisted heat pump dryer (SAHPD) [25] utilized sun-drying as a comparison showed that the performance of sun-drying as follows

- Average of drying temperature for four days was lower (30ºC)
- Average of relative humidity was higher (52 %).
- The final air content of dried chilies produced was the same, i.e., 10-11%.
- Average of solar radiation was the same (750W/m^2).
- The average of wind speed was 3.2 m/s, drying time was longer (32 hours).
- The average of drying rate was 15.50%.

The chilies with cabinet drying produce lower moisture content because the drying temperature can be controlled, and the heat spread evenly in all parts so that the drying rate was constant in all trays. The sun-drying is very depending on weather, temperature, and drying speed cannot be controlled, and the distribution is uneven. Besides, sun-drying can also cause microbial contamination from the environment.

C. Vitamin C Content

Vitamin C is a type of vitamin that is very susceptible to heat. Its sensitivity to heat is an indicator in maintaining the nutrition of dehydrated products [9]. The fresh curly red chili contains vitamin C of around 4,463 ppm or 0,4463% [17]. In this study, the vitamin C content of fresh chili was 1.67%. However, after drying, there is a decrease of vitamin C level to about 0.48% to 0.95% (Table 2). This decrease in vitamin C content is due to pre-treatment (blanching) and drying. Some studies [4], [5], [9], [10], [26]explained that several factors caused the decrease of vitamin C content, i.e., 1) vitamin C is water-soluble, therefore the washing and blanching process can decrease the vitamin C content, and 2) vitamin C is easy to be damaged due to heat. During blanching, the heating process causes oxidation of vitamin C. Heating the chilies twice, i.e., when blanching for 10 minutes at 90°C using metal heaters and drying, it causes an oxidation process. The high temperatures cause the vitamin C to be oxidized to dehydroascorbic acid because heating the ascorbic enzyme oxides becomes active. If the enzyme ascorbate oxidase is active, then an oxidation process can reduce the levels of vitamin C. The ascorbic oxides enzymes can damage vitamin C by accelerating the change in vitamin C to dehydroascorbic acid. The vitamin C content of dried chili after blanching and drying treatment is presented in Table 2.

TABLE II
THE VITAMIN C CONTENT OF DRIED CHILI AFTER BLANCHING AND DRYING TREATMENT

Blanching treatments	Drying treatments	Vitamin C content (%)
Water	Sun-drying	0.69b*
	Sun-drying with plastic shade	0.84d
	Cabinet drying at 50-60ºC	0.69b
Water with 0.2% vitamin C solution (w/v)	Sun-drying	0.66b
	Sun dryer with plastic shade	0.95e
	Cabinet drying at 50-60ºC	0.70b
Water with 0.2% sodium metabisulfite solution (w/v)	Sun-drying	0.77c
	Sun-drying with plastic shade	0.94e
	Cabinet drying at 50-60ºC	0.48a

Source: processed primary data.
* The same letter in the same column shows no significant difference at the 95% confidence level.

In this study, dried chili produced vitamin C levels at 0.48 – 0.95%. The two highest vitamin C levels were obtained from sun-drying with plastic shade in two blanching treatments, namely, 0.2% sodium sulfite ($Na_2S_2O_5$), 0.2% vitamin C solution, respectively 0.94 and 0.95%. This study applied the blanching process with the immersion of sodium metabisulfite ($Na_2S_2O_5$) and citric acid solution for 30 minutes, followed by drying at 65ºC showed higher vitamin C levels and brighter color of dried chili as compared to soaking using water [14]. Moreover, the addition of sodium metabisulfite and vitamin C to the immersion water results in the availability of vitamin C in the immersion water, which can cause an increase in the vitamin C content of the immersed material. Based on statistical analysis by Duncan test at a 95% confidence level, most of the vitamin C content from the nine treatments were significantly different, except the treatment of blanching with water by cabinet drying, blanching with 0.2% vitamin C solution which was either sun-drying or cabinet drying. From the nine treatments, the vitamin C content was 0.66 to 0.69%.

D. Beta-carotene Content

Red chili contains several nutrients; one of them is beta-carotene. Beta-carotene is one of the antioxidants compounds, and a precursor of vitamin A formation. In this study, the beta-carotene content of fresh chili was 2.27%. The drying treatments with sun-drying and at 50-60°C in the cabinet dryer aim to prevent carotenoid content loss. According to [27] the drying process on specific South Mexican chilies shows that at 60ºC with 0.5 cm thickness or at 50ºC with 1 cm thickness, the carotenoid content has not been damaged. The dried chili's beta-carotene content was decreased after the blanching and drying, as presented in Table 3.

TABLE III
THE BETA-CAROTENE CONTENT OF DRIED CHILI AFTER BLANCHING AND DRYING TREATMENTS.

Blanching treatments	Drying treatments	Beta carotene content (%)	Changes in beta carotene content (%)
Water	Sun-drying	1.39	0.88
	Sun-drying with plastic shade	1.85	0.42
	Cabinet drying at 50-60ºC	1.47	0.80
Water with 0.2% vitamin C solution (w/v)	Sun-drying	1.50	0.77
	Sun-drying with plastic shade	1.18	1.09
	Cabinet drying at 50-60ºC	2.04	0.23
Water with 0.2% sodium metabisulfite solution (w/v)	Sun-drying	2.09	0.18
	Sun-drying with plastic shade	2.24	0.03
	Cabinet drying at 50-60ºC	1.43	0.84

Source: processed primary data

Blanching and drying treatment affect the beta-carotene levels of dried chili (Table 3). Blanching can reduce the antioxidant content [28], while pre-treatment and drying treatment affect the flavonoid content, total carotene, and beta-carotene content [29]. The lowest beta-carotene content was 1.18%, and the highest was 2.09%. The blanching treatment in 0.2% vitamin C solution and sun-drying with plastic shade had the highest decrease in beta carotene content (1.09%). In this treatment, the content of beta-carotene was 1.18%.

Meanwhile, the blanching treatment in 0.2% sodium metabisulfite solution and sun-drying with plastic shade had the least decrease of beta-carotene content (0.03%). In this treatment, the beta-carotene content was 2.24%. The blanching treatment in a 0.2% sodium metabisulfite ($Na_2S_2O_5$) solution and sun-drying with plastic shade has a beta-carotene above 2% and the blanching treatment in 0.2% vitamin C solution and cabinet drying.

The chili's red color comes from the content of carotene pigments, namely capsanthin, capsorubin, lutein, zeaxanthin, carotene, and cryptoxanthin. Carotenoids contained in chili are sensitive to heat. Therefore, it is easy to experience oxidation due to cooking, drying, and grinding (if processed into chili powder). The decrease in carotenoid content depends on the temperature and the duration of the processing, cutting, or destruction [30].

E. Total Plate Count (TPC)

The Total Plate Count (TPC) testing in this study was used to determine the product's quality in microbiological terms. This method is used to determine the number of microbes in foodstuff as a whole, i.e., mold, yeast, and bacteria. The microbial content in a food is limited in accordance with established standards. The maximum TPC content in a food is

10^5 CFU/g [31]. The TPC content of dried chili with blanching and drying treatments are presented in Table 4.

TABLE IV
THE TOTAL PLATE COUNT (CFU/G) CONTENT OF DRIED CHILIES BY BLANCHING AND DRYING TREATMENT

Blanching treatments	**Drying treatments**	**TPC contents (CFU/g)**
Water	Sun-drying	2.8 x 10^4
	Sun-drying with plastic shade	2.5 x 10^4
	Cabinet drying at 50-60ºC	< 10
Water with 0.2% vitamin C solution (w/v)	Sun-drying	3.0 x 10^3
	Sun-drying with plastic shade	1.4 x 10^5
	Cabinet drying at 50- 60ºC	< 10
Water with 0.2% sodium metabisulfite solution (w/v)	Sun-drying	2.0 x 10^4
	Sun-drying with plastic shade	1.3 x 10^5
	Cabinet drying at 50-60ºC	4.0 x 10^1

Source: processed primary data

The TPC content of dried chilies <10 to 1.4 x 10^5 CFU/g (Table 4). The TPC content in dried chili was in the form of fungi, bacteria, or yeast. Cabinet drying at 50-60ºC in all blanching treatments resulted in the lowest TPC content, followed by sun-drying and sun-drying with plastic shaded. This shows that the use of cabinet drying can reduce microbial contamination from the environment. In line with research by [9], which reported that the drying treatment using a cabinet dryer produces the lowest TPC content because of the minimum contamination during the drying process, hot air can be distributed evenly in the entire surface of the chili, so that the drying process is possible to run evenly and can be controlled according to the physical properties of the material.

Sun-drying with plastic shade can minimize contamination to dust and other impurities. However, on the other hand, the drying house's situation becomes humid because the distribution of hot air and steam is not optimal, and the high humidity is optimum for mold growth. In this study, the blanching in 0.2% metabisulfite ($Na_2S_2O_5$) and 0.2% vitamin C solution by sun-drying with plastic shade have maximum TPC content for food. Therefore, this dried chili product is not safe for consumption.

IV. CONCLUSIONS

Blanching and drying treatment influenced the chemical and microbiological properties of dried chili with a yield of around 20%. All pre-treatment and drying treatments produce moisture content that require Indonesian National Standards (max. 11%). Heating process caused the loss of beta-carotene and vitamin C content. Pre-treatment with 0.2% sodium metabisulfite and 0.2% vitamin C solution by sun-drying with plastic shade results in TPC levels higher than the maximum value for food (10^5 CFU/g). Dried chili produced from cabinet drying has a good quality, indicated by a smaller total plate count (±10 CFU/g). Therefore, chili preservation recommendation treatment is blanching in 0.2% vitamin C as pre-treatment and drying using cabinet dryer at 50-60°C.

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