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THE EFFECT OF DRYING CONDITIONS USING A FOOD DEHYDRATOR ON THE PHYSICAL AND CHEMICAL CHARACTERISTICS OF RED CAYENNE PEPPER POWDER (*Capsicum frutescent* L.)

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ABSTRACT

Red cayenne pepper (*Capsicum frutescens* L.) is an important horticultural commodity in Indonesia with high demand; however, its high moisture content makes it highly perishable. One way to extend its shelf life is to process it into powder through drying. Drying using a *food dehydrator* is considered more effective because it allows precise control of temperature and time, which affects the final product quality, including moisture content, color, and vitamin C, β-carotene, and capsaicin levels. This study aimed to determine the effects of different drying temperatures and durations using a *food dehydrator* on the physicochemical characteristics of red cayenne pepper powder. A Completely Randomized Factorial Design was used with two factors: drying temperature (50, 60, and 70°C) and drying time (16, 20, and 24 h), resulting in nine treatment combinations with three replicates. The parameters observed included moisture content, yield, color (L*, a*, and b*), vitamin C, β-carotene, and capsaicin content. The results showed that increasing temperature and drying time significantly decreased the moisture content, yield, and vitamin C content, while increasing the brightness and redness of the pepper powder. β-carotene content increased at moderate temperatures and decreased at higher temperatures, while the highest capsaicin content was found at 60 °C for 20 h (998.96 ppm or 16,083.33 SHU) and decreased at 70 °C. Overall, drying at 60 °C for 20 h produced red cayenne pepper powder with optimal physicochemical quality.

Keywords: red cayenne pepper, drying, food dehydrator, physicochemical characteristics

INTRODUCTION

People in Indonesia are known to be very fond of foods with strong flavors, especially spicy foods. Spicy flavors are commonly associated with chili peppers. In Indonesia, there are various types of chili peppers, including large, curly, bell, katokkon, and cayenne peppers (Fadhilatunnur et al., 2022).

Cayenne pepper (*Capsicum frutescens* L.) is an important commodity in Indonesia's agricultural sector because of its high demand. Cayenne pepper thrives in various regions of Indonesia. According to data from the Central Statistics Agency (BPS) in 2023, cayenne pepper production in Indonesia increased significantly. Bird's eye chili production reached 1,544,441 tons (Central Statistics Agency, 2024), with household consumption reaching 610,800 tons.

Red cayenne pepper has a high water content, causing it to rot or spoil easily, making it difficult to maintain freshness. Damage to red cayenne pepper can be influenced by internal and external factors originating from outside the pepper (Setyawibawa et al. 2018). This is exacerbated by the lack of post-harvest handling by farmers. Therefore, measures must be taken to maintain the quality of chili peppers. One such measure is drying the grain.

Drying is a process of simultaneous water vapor transfer that requires energy to evaporate the water contained in the material and transfer it from the surface of the material to the drying medium. Several drying methods can be applied to extend the shelf life of chili peppers, such as drying with sunlight, hot air, ovens, and food dehydrators. The use of a food dehydrator in the drying process has the advantage of being able to control the temperature and drying time precisely, allowing for a more uniform and consistent drying process. Drying can be applied to cayenne pepper to produce a product in the form of chili powder.

Chili powder processing minimizes damage to the cayenne peppers. Cayenne pepper powder is more practical to store and has a longer shelf life than fresh chilies. Chili powder has a very fine particle size and low moisture content

This study aimed to determine the effects of temperature and drying time using a food dehydrator on the physicochemical characteristics of red chili powder. This study also provides information on optimal drying temperature and time.

MATERIALS AND METHODS

Materials

The material used in this study was red cayenne pepper obtained from the Segiri Samarinda traditional market in Indonesia. The chemicals used were absolute ethanol, distilled water, capsaicin standard, ascorbic acid, and β-carotene.

Experimental Design and Data Analysis

This study was conducted using a completely randomized factorial design with two factors. The first factor was drying temperature variation at 50, 60, and 70 °C, and the second factor was drying time at 16, 20, and 24 h. Based on these two factors, nine treatment combinations were obtained and repeated thrice.

The parameters analyzed in this chili powder were its physical and chemical properties. The physical properties parameters were water content, yield and color. The chemical properties parameters were vitamin C, β-carotene and capsaicin. The data obtained were analyzed using ANOVA, followed by Duncan's Multiple Range Test.

Research Procedures

The red cayenne peppers were separated from their stems, washed thoroughly, and weighed to make 100 g. The clean red cayenne peppers were dried using a food dehydrator according to the treatment, then blended and filtered using an 80-mesh sieve.

Preparation of Materials

The time used for drying red cayenne pepper was 16, 20, and 24 h, while the temperatures used were 50, 60, and 70 °C. A total of 100 g of sample was used for each treatment. The chemicals used for chemical analysis were absolute ethanol, distilled water, ascorbic acid, and capsaicin standard.

Analysis Procedure

The analysis procedure used in this study was the recommended moisture content (Murti, 2017), yield (Setyawibawa et al., 2018) and color (Rizquna et al., 2024). Vitamin C (Sihotang and Meilani, 2024), β-carotene (Hagos et al., 2022), and capsaicin (Amaliah, 2018).

RESULTS AND DISCUSSION

The drying conditions significantly affected (p<0.05) the yield and moisture content of red cayenne pepper powder, but not the color (Table 1).

Yield

Yield is an important parameter in the drying process that describes the efficiency of converting fresh materials into dry products. The yield value was obtained by comparing the final weight of the product after drying to the initial weight before drying (Mar'atuzzahwa et al., 2022).

In this study, the yield of red cayenne pepper powder showed significant differences between temperature treatments and drying times. The highest yield was obtained from the treatment at a temperature of 50 °C for 16 h, which was 49.44±0.39%, while the lowest yield was obtained at a temperature of 70 °C for 24 h, which was 14.63±0.24%.

The decrease in yield that occurs with increasing temperature and drying duration indicates that overly intensive drying processes can cause a significant reduction in the dry matter weight. This is due to excessive water evaporation and the loss of volatile components, such as essential oils and aromatic compounds that usually evaporate at high temperatures. This study is in line with the results of a study by Fadhilatunnur et al. (2022), who stated that drying at high temperatures or for too long can reduce the final yield of the material due to excessive

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evaporation and damage to volatile compounds.

Moisture Content

Moisture content is one of the main parameters for determining the quality of cayenne pepper powder. Moisture remaining in cayenne pepper powder can affect physical characteristics such as texture and color, as well as determine the product shelf life. High moisture content can increase the risk of microbial growth, such as bacteria, mold, and yeast, which accelerate the spoilage. The low moisture content in red chili powder indicates that the drying process is effective in reducing the water content and extending the shelf life of chili powder (Saputri et al., 2022).

Based on the results of the study, the highest moisture content was found in the 50 °C drying treatment for 16 h at 40.05%, and the lowest moisture content was found in the 70 °C drying treatment for 24 h at 1.75%. These results are consistent with those of Saputri et al. (2022). The decrease in water content occurs because some of the water contained in the cayenne pepper evaporates during the drying process, which utilizes heat energy (Jamilah et al., 2019). The higher the temperature used for drying, the greater the heat energy transferred, which accelerates and increases water evaporation. Accordingly, a longer drying duration correlates with greater water loss from the material. As a result, the moisture content in the cayenne pepper powder will be low (Citra et al., 2023)

Table 1. Effect of drying conditions on yield and physical characteristics of red cayenne pepper powder

Sample	Yield	Moisture Content	L	a	b	ΔE	Color Representation
Control	100±0,00	60,93±1,24	39.32	63.51	87.14		
50 ˚C, 16 h	49,44±0,39^{a}	40,05±1,73^{a}	47.08	23.76	39.62	61.59	
50 ˚C, 20 h	37,01±0,05^{b}	14,57±0,21^{b}	54.04	22.66	43.03	20.11	
50 ˚C, 24 h	22,59±0,45^{c}	12,92±0,60^{c}	51.99	21.72	42.93	59.66	
60 ˚C, 16 h	21,68±0,19^{d}	7,40±0,34^{d}	55.03	27.24	53.35	55.61	
60 ˚C, 20 h	20,23±0,24^{e}	5,40±0,39^{e}	58.20	25.38	52.64	52.54	
60 ˚C, 24 h	19,67±0,11^{f}	4,70±0,18^{e}	59.22	24.10	52.32	54.28	
70 ˚C, 16 h	17,72±0.14^{g}	3,54±0,20^{f}	58.20	25.38	52.64	52.44	
70 ˚C, 20 h	15,74±0.04^{h}	2,44±0,09^{fg}	59.60	26.05	52.73	54.66	
70 ˚C, 24 h	14,63±0.24^{i}	1,74±0,06^{g}	59.23	25.19	53.38	51.84	

Note: Data (mean ± standard deviation) were obtained from three replicates. Data were analyzed using analysis of variance (ANOVA). Data in the same column (excluding control) followed by different letters indicate significant differences (DMRT, $p<0.05$).

Color

Color analysis is an important parameter for determining the visual quality of a product, as it can affect the consumer perception of red chili powder. In this study, color measurements were performed using the CIE Lab* color system, which consists of three main components: L* (brightness level), a* (red-green), and b* (yellow-blue).

Based on the measurement results of L*, a*, and b* values at various combinations of temperature and drying time, there was a significant difference influenced by temperature variations. The L* value, which indicates the level of brightness, tended to increase with increasing temperatures from 50 to 70 °C. The highest value was obtained at 70 °C (59.60 ± 0.48), whereas the lowest value was found at 50 °C (47.08 ± 2.14). The a* value, which represents the intensity of red color, also increased from 22.60±1.55 at 50°C to 25.53±1.20 at 70 °C, indicating a stronger red color at higher temperatures. Similarly, the b* value, which indicates the tendency of yellow color, increased from 41.76±2.34 at 50 °C to 48.64±5.98 at 70 °C, indicating a stronger dominance of yellow color at higher drying temperatures.

This study is in line with the research conducted by (Murti, 2017) which shows that drying at high temperatures has a significant effect on the color change of Lado F1 curly chili peppers. The results of this study show that the L* a* b* color values tended to increase as the temperature increased from 50 to 80 °C. The L* value increased from 30.20 to 31.17, the a* value from 17.77 to 27.93, and the b* value from 8.53 to 11.80, respectively. This increase in color values indicates that the dried chili products have a brighter and more attractive color appearance. This phenomenon is due to faster water evaporation and the inactivation of color-degrading enzymes, which allows natural pigments such as carotenoids to remain stable. In addition, the increase in L*, a*, and b* values was caused by the formation of a surface that was more reflective of light due to the decrease in water content, as well as better color pigment stability at high temperatures during the optimal drying duration (Murti, 2017).

Chemical Characteristics

The drying conditions significantly affected (p<0.05) all chemical components studied (vitamin C, β-carotene, and capsaicin) (Table 2).

Table 2. Effect of drying conditions on chemical characteristics of red chili powder

Sample	Vitamin C	β- Carotene	PPM	Scoville Heat Unit (SHU)
Control	1293.06±63.63	15.83±10.52	790.87±98.36	12,732.95±1,583.56
50 ˚C, 16 h	931.84±7.20^{a}	47.89±9.53^{b}	760.73±2.82^{de}	12,247.82±45.49^{de}
50 ˚C, 20 h	893.29±4.53^{ab}	108.29±11.77^{b}	683.52±18.16^{e}	11,004.70±292.40^{e}
50 ˚C, 24 h	867.21±13.24^{bc}	128.92±44.48^{b}	735.31±12.95^{e}	11,838.50±208.42^{e}
60 ˚C, 16 h	841.59±14.78^{c}	193.48±47.63^{a}	960.36±76.86^{ab}	15,461.76±1,237.47^{ab}
60 ˚C, 20 h	795.56±11.02^{d}	219.91±19.88^{a}	998.96±77.17^{a}	16,083.33±1,242.48^{a}
60 ˚C, 24 h	766.53±0.00^{de}	225.19±21.57^{a}	885.97±21.58^{bc}	14,246.12±347.36^{bc}
70 ˚C, 16 h	745.22±14.37^{ef}	236.58±46.97^{a}	844.54±43.54^{cd}	13,597.07±705.06^{cd}
70 ˚C, 20 h	708.71±20.44^{f}	230.90±40.67^{a}	736.56±64.60^{de}	12,293.30±1,040.10^{de}
70 ˚C, 24 h	595.56±67.45^{g}	215.94±43.34^{a}	698.59±56.28^{e}	11,247.26±906.19^{e}

Note: Data (mean ± standard deviation) were obtained from three replicates. Data were analyzed using analysis of variance (ANOVA). Data in the same column (excluding control) followed by different letters indicate significant differences (DMRT, p<0.05).

Vitamin C

Analysis of vitamin C content in dried red chili powder using a combination of temperature and time showed that vitamin C levels decreased significantly as the temperature increased and the drying time lengthened.

The highest vitamin C content was obtained at a temperature of 50 °C for 16 h (931.84 µg/g), and then gradually decreased to 867.21 µg/g at 24 h. This decline continued at a temperature of 60 °C and a drying time of 16 h, where the vitamin C content decreased to 841.59 µg/g, and further decreased to 766.53 µg/g at 24 h. The most significant decline occurred at 70 ˚C, where the lowest vitamin C content of 595.56 µg/g was observed.

These results indicate that vitamin C is easily degraded and highly sensitive to temperature and drying time. An increase in drying temperature accelerates the oxidation and decomposition of vitamin C, thereby reducing its content.

In addition, a longer drying time provides a greater opportunity for vitamin C

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degradation (Paramita, 2023). This study is in line with (Putranto, 2021) which states that high temperatures and drying time significantly reduce vitamin C levels in carrots because of the nature of vitamin C, which is easily damaged by heat.

β-Carotene

β-Carotene is a type of carotenoid compound commonly found in red, yellow, and orange vegetables and fruits. Based on the results of this study, the β-carotene content in red cayenne pepper powder decreased as the temperature and drying time increased.

At a temperature of 50 ˚C, the lowest β-carotene content recorded was 47.89 µg/g with a drying time of 16 h, and it increased to 128.92 µg/g at 24 h. When the temperature was increased to 60 °C, the β-carotene content increased further, from 193.48 µg/g (16 h) to 225.19 µg/g (24 h). The most significant decrease occurred at 70 ˚C, with a β-carotene content of 236.58 µg/g at 16 h and reaching a low point of 190.02 µg/g at 24 h of drying.

The significant increase in β-carotene content during the drying process is closely related to the decrease in moisture content and the change in the basis of calculation from a wet to a dry basis. Under control conditions, where the moisture content is still high, β-carotene is measured on a wet basis, causing the pigment to be dispersed or diluted in a large mass of water, resulting in low concentrations.

As the drying process progresses, the water content decreases significantly, such that the calculation of nutrient content proportionally better reflects the dry basis conditions. Under these conditions, the lost water mass did not contribute to the total mass of the material. Consequently, although the absolute amount of β-carotene did not increase, its relative concentration increased because the total mass of the material decreased. This decrease in water mass reduces the divisor value in the calculation, that is, dry mass + water mass. The lower the water content, the smaller the divisor value, so that the ratio of β-carotene per unit mass of material increases, resulting in a much higher concentration (Prastikasari et al., 2023).

This phenomenon creates a clear negative relationship between water content and β-carotene, where progressive water evaporation reduces the divisor, causing the pigment concentration to surge. The exponential decrease in water content increases the specific dry weight proportion, causing the ratio of β-carotene per gram of dry weight to increase significantly because the measurement divider remains relatively stable while the diluting water is removed. This explains the sharp increase in β-carotene content during the early to middle stages of drying, where the increase in dry weight is directly correlated with pigment concentration (Histifarina et al., 2004).

At temperatures above 70 ˚C, the decrease in β-carotene content with increasing temperature and drying time is caused by higher heat energy triggering a faster degradation process through oxidation and isomerization, which damages the polyene chain of β-carotene and changes its form from trans to the less stable cis. This process causes a significant decrease in β-carotene content, especially after prolonged heating, because chemical damage to the pigment is more dominant than tissue release. As a result, volatile compounds such as aldehydes and ketones are formed, which affect the reduction in red color intensity, nutritional value, and product stability (Pratita et al., 2023).

The degradation of β-carotene can occur due to the presence of lipoxygenase enzymes, which are inactivated by heating. The results of this study are in line with those of Halimah et al. (2021), who showed that the β-carotene content in pineapple juice decreased significantly as the pasteurization temperature increased. At 70 °C, the β-carotene content was recorded as the highest, whereas at 90 °C, there was a fairly drastic decrease in content.

β-Carotene is a carotenoid pigment that gives foodstuffs an orange to reddish color. Degradation caused by β-carotene content results in a decrease in the color intensity of chili powder, making it paler or faded in color. This can be observed from the color analysis results (L* a* and b* values), where the higher the temperature and drying time, the more the red color intensity decreases (Meriska, 2022).

Capsaicin

The capsaicin content in cayenne pepper powder is greatly influenced by temperature and drying time, which also directly affect the Scoville Heat Unit (SHU) value as an indicator of spiciness. Based on the results of this study, temperature and drying time affect the capsaicin content in red cayenne pepper powder.

The data obtained showed that at a temperature of 50 °C with a drying time of 16 h, the capsaicin content was 760.73±2.82 ppm with an SHU of 12,247.82±45.49. Then, it decreased at 20 h to 683.52±18.16 with an SHU value of 11,004.70±292.40 and increased again at 24 h to 735.31±12.95 with an SHU value of 11,838.50±208.42. At 60 °C, the capsaicin content increased further to 960.36±76.86 ppm, with an SHU value of 15,461.76±1,237.47. The highest capsaicin content was obtained at 20 h with a value of 998.96±77.17 ppm and an SHU value of 16, whereas at 70 °C, the capsaicin content tended to decrease with values of 844.54±43.54 ppm and 13,597.12±347.36 SHU. At 70 ˚C, the capsaicin content tended to decrease with successive values of 844.54±43.54 ppm and an SHU value of 13,597.07±705.06, 736.56±64.60 ppm and an SHU value of 12,293.30±1,040.10, 698.59±56.28 ppm and an SHU value of 11,247.26±906.19.

The capsaicin content in fresh red chili peppers tends to be low compared to 50 ˚C and 60 ˚C. This is because lower temperatures are not optimal for the maximal release of capsaicin from the chili tissue. At these temperatures, the drying process occurs more slowly; therefore, the moisture content in the material does not decrease significantly, causing capsaicin to remain trapped in the cell matrix and not be measured to its fullest extent. This is consistent with the findings of Khairani et al. (2024), who stated that a decrease in water content plays an important role in increasing capsaicin yield because the lower the water content, the more concentrated the active compounds are in the dry material. Conversely, a temperature of 60 °C provides greater heat energy to accelerate water evaporation and help release capsaicin from the tissue, but is still within the safe limits for capsaicin thermal degradation. Similar research was also described by Rachmat et al. (2023), who showed that the decrease in water content during the drying process plays an important role in increasing the spiciness level of chili powder. High water content causes a lower capsaicin concentration, resulting in a final product with suboptimal spiciness. However, at 70 °C, the capsaicin content decreased compared to that at 60 °C. This decrease indicates that 70 °C exceeds the thermal stability limit of capsaicin, triggering its degradation of the capsaicin compound. Increasing the temperature and drying time will cause a decreases the spiciness of chili peppers, as capsaicin is highly sensitive to heat. This degradation is caused by damage to the chemical structure of capsaicin due to excessive heat, which ultimately reduces the concentration of active compounds in the final product (Hayati et al., 2023).

CONCLUSION

The combination of drying temperature and time significantly affects the physicochemical characteristics of red cayenne pepper powder. The best treatment was obtained at a temperature of 60°C for 20 h, with a moisture content of 5.40%, yield of 20.23%, color ΔE of 52.54, vitamin C of 795.56 μg/g, β-carotene of 219.91 μg/g, and the highest capsaicin content of 998.96 ppm (16,083.33 SHU). A temperature of 60°C is optimal because it provides balanced heat energy to effectively reduce moisture content, maintain moderate yield without excessive loss of volatile compounds, produce attractive bright colors, and maintain the stability of vitamin C and β-carotene through adequate water evaporation without excessive oxidation as at 70°C. while the 20-hour duration achieves peak capsaicin concentration with the release of active compounds from the cell matrix before thermal degradation occurs at longer durations, thereby producing the best physicochemical quality overall.

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