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The Presence of Functional Compounds of Moringa Leaf Powder (Moringa Oleifera) Due to Technical Handling and Drying Temperature: How it Affects Humans

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Abstract

Moringa (Moringa oleifera) is a plant that contains many functional compounds that are useful for supporting human health, especially for prevention and overcoming degenerative diseases due to the influence of unfavorable conditions and environment. The purpose of this study is to obtain facts and information about the degradation pattern of functional values of the compounds contained therein, namely vitamin C, β-carotene, and antioxidant activity after the drying process. While the aim is to optimize the handling and processing of Moringa leaves into powder to be more useful in preventing and overcoming certain diseases, so as to maintain human health. The research methodology that has been carried out includes preliminary research, namely analyzing or testing the content of vitamin C, β-carotene, and antioxidant activity in fresh Moringa leaves. The main research used a randomized block design (RBD) which consisted of two factors, namely treatment before drying (TBD) and drying temperature. The variable response was a decrease in the content of vitamin C, β-carotene, and antioxidant activity of Moringa leaf powder after drying. The results of the study the factors of treatment before drying (TBD) and drying temperature showed a significant effect on decreasing the content of vitamin C, β-carotene, and antioxidant activity. The higher the drying temperature the content of vitamin C, β-carotene, and antioxidant activity decreases. Processing of Moringa leaves into powder using the lowest possible drying temperature can reduce the reduction in the content of functional compounds.

Keywords
moringa; drying; vitamin c; β-carotene; antioxidants

I. Introduction

Moringa (Moringa oleifera) is a plant that is widely found in the tropics and is well known in Indonesia, especially in rural areas, but has not been used optimally. Moringa leaves are very useful for the community as nutritious food and herbal medicines (phytopharmaceuticals). Moringa, which has been known to the public as a vegetable, is a multipurpose plant that has many advantages. Not only are all parts of the plant useful, Moringa has super nutritional content that far exceeds the nutritional content of food in general. Besides leaves, Moringa seeds are also processed into oil which is expensive and much sought after by consumers.

Many Indonesian people still do not know how to use Moringa, generally only known as a vegetable menu. The limited knowledge of the community regarding the benefits and ways of cultivating Moringa, causes the conservation action taken by the community towards Moringa is still low. According to Kusnadi (2015), this fast-growing tree is described by the world as one of the most nutritious plants. Moringa leaves contain beta carotene more than beta carotene in carrots, protein than protein in peas, vitamin C exceeds vitamin C in oranges, calcium exceeds calcium in milk, iron exceeds iron in spinach and potassium exceeds potassium in bananas.

Stunting illustrates the condition of failure to thrive in children due to malnutrition or chronic malnutrition during the period of growth and development that appears after children are 2 years old (Shinta, H. et al. 2020)

More recently, Moringa has been used successfully to combat malnutrition in children and efforts to boost the immune system in many developing countries. The world of traditional medicine has long used the Moringa plant to treat various diseases, including recovery from liver damage. Moringa plants are usually used as a supplement to modern medicine to treat chronic diseases, including AIDS and HIV-related diseases (Kusnadi, 2015).

The most functional content of this plant is its micro components including calcium, potassium, and antioxidants. Moringa leaf (Moringa oleifera) is a tropical plant that has long been used as a traditional medicine. This plant can be recognized by the shape of its small leaves. Moringa trees are also easy to grow and can live in less fertile soil. Moringa leaves are a good natural source of nutrients and energy. Based on the results of the proximate analysis revealed that Moringa leaves have high nutritional value such as phytochemicals, vitamins, minerals, proteins and amino acids. Moringa leaves can be used as natural antioxidant and antimicrobial agents that can be applied in pharmaceuticals and food (Sohaimy et al., 2015).

Moringa leaves can be processed into herbs, herbal teas, and supplements. Not a few people also use Moringa leaves as a cooking ingredient. In traditional medicine, Moringa leaves are believed to be efficacious to treat diabetes, joint pain, bacterial infections, to cancer.

Krisnadi (2013) in his book "Super Nutrient Moringa" states that: Information stored for thousands of years about the benefits and efficacy of Moringa, claims of traditional Indian Ayurvedic medicine that Moringa is capable of curing more than 300 diseases, and why Moringa oil has always been in the Egyptian pyramids, is now explained well by modern science. Furthermore, Krisnadi (2013) said: judging by its content, Moringa deserves the title "Miracle Tree" or "Trees of Life" and "Super Nutrition". Not without reason, the super nutritional content of Moringa has been verified by various scientific institutions and universities in various parts of the world. Moringa contains 539 compounds known in traditional African medicine (Krisnadi, 2015). The information is then used for humanitarian movements to tackle malnutrition (malnutrition) in poor African countries. Millions of people have been saved by consuming Moringa.

Moringa tree especially its leaves have been used to combat malnutrition, especially among infants and nursing mothers. One tablespoon (8 g) of Moringa leaf powder will meet about 14% protein, 40% calcium, 23% iron and almost all the needs of vitamin A for children aged 1-3 years (Mishra et al., 2012). Moringa leaves are also widely available and inexpensive, and can serve as a source of nutrients and can be grown in countries fighting micronutrient deficiencies. The dehydration technique is a way to concentrate nutrients and preserves in leafy vegetables. Nutrients contained in Moringa leaves, especially their bioactives, are relatively susceptible to degradation due to heat processing, so it is necessary to study to find out how far the level of nutrient sensitivity due to heat processing during postharvest and processing. Therefore, in this study the aim was to study the degradation patterns of functional compounds contained in Moringa leaves.

II. Research Method

The main ingredients used in this study were Moringa leaves along with the soft stalks. Besides the main ingredients, it also uses ingredients for the purposes of analyzing the levels of vitamin C, β-carotene, and antioxidant activity. Before conducting experiments with the designed methodology, firstly an analysis or testing of the nutrition of freshly harvested Moringa leaves was carried out on levels of vitamin C, β-carotene, and antioxidant activity.

The research method is an experiment using two factors, namely handling before Drying (HBD) with sub-factor d_1, d_2, d_3 and drying temperature with sub-factor t_1, t_2, t_3, t_4, t_5, dan t_6.

a. Handling Before Drying (HBD) first (d_1) Moringa leaves are first sorted, washed, dried with variations in temperature (25 °C with a vacuum; 30 °C; 35 °C, 40 °C, 45°C; and 50 °C), and floured.
b. Handling Before Drying (HBD) first (d_2) Moringa leaves are first sorted, washed, pulping with the addition of ice water 5 ºC, dried with variations in temperature (25 °C with a vacuum; 30 °C; 35 °C, 40 °C, 45°C; and 50 °C), and floured.
c. Handling Before Drying (HBD) first (d_3) Moringa leaves are first sorted, washed, pulping with the addition of ice water 25 ºC, dried with variations in temperature (25 °C with a vacuum; 30 °C; 35 °C, 40 °C, 45 °C; and 50 °C), and floured.

The experiment was carried out with two replications.

The dried Moringa leaf powder was then determined and analyzed for the response of variable levels of vitamin C by Iodometry method, -carotene by spectrophotometric method, and antioxidant activity by spectrophotometric method of 2,2-Diphenyl-1-Picrylhydrazyl (DPPH). Furthermore, to determine the significance of the response variables that have been analyzed or tested, analysis of variance is carried out using the equation.

$$Y_{ijk}= \mu + D_k + T_i + \delta_{ik} + Dj + (DT)_{ij} + €_{ijk}$$

The effect of the treatment can be proven between the average value of the interaction on all observed variable responses, then Duncan's further test is carried out at a 5% significance level.

III. Results and Discussion

Based on the experiments that have been carried out at the PT. Sibaweh Laboratories Indonesia (SLI), then the following results are obtained:

The results of the analysis or test of fresh Moringa leaves

Fresh Moringa leaves after analysis or quantitative tests show the following results:

a. Vitamin C = 232,5 mg/100 g
b. β-caroten = 35,64 mg/100 g
c. Antioxidant activity = 72,65 ppm

The experimental process of processing Moringa leaves into powder by applying variations in the technique and drying temperature obtained the results of the analysis as shown in the following table:

Table 1. Interaction of the effect of drying temperature and handling before drying (HBD) on vitamin C levels

Drying Temperature (°C)	Vitamin C Concentration (mg/100g)		
	d_1	d_2	d_3
25 (vacuum)	148,85 e A	212,45 f B	151,00 f A
30	96,56 d A	125,38 e B	98,05 e A
35	89,50 d A	92,25 d B	85,20 d A
40	45,40 c A	84,22 c B	47,42 c A
45	31,46 b A	65,60 b B	34,15 b A
50	20,70 a A	58,40 a B	23,85 a A

Description: Capital letters are compared horizontally, lowercase notation is compared vertically.

The response to vitamin C levels from the results of the analysis of variance (ANOVA) showed that there was a significant difference for each temperature treatment in the drying process and overall showed no significant difference for the first and third Handling Before Drying (PSP) treatments, while Handling Before Drying (HBD) the second showed a significant difference with the first and third Handling Before Drying (HBD). The response to vitamin C levels due to Handling Before Drying (HBD), that treatment of Moringa leaves with a pulping process with the addition of 5 ^oC cold water can inhibit the decrease in vitamin C content due to oxidation / hot conditions at the time of slurry, therefore it is significantly different with the response of vitamin C produced in the first and third Handling Before Drying (HBD), which at the time of slurry or drying can directly degrade the vitamin C content due to oxidation / hot conditions. However, due to the drying process, the higher the drying temperature, the higher the vitamin C degradation for all the first, second, and third HBD.

Vitamin C is a compound that is chemically sensitive to heat or oxidation, in other words it is a reducing agent, so it is reactive to the presence of oxygen or oxidizing agents or heat which will turn into dehydroascorbic acid (not vitamin C anymore). Therefore, food processing while using hot conditions will degrade the vitamin C content of the product. So as an effort to maintain the vitamin C content in Moringa leaf powder or processed food products, it is better to minimize the use of the heating process.

The response to β-carotene levels from the analysis of variance (ANOVA) showed that there were significant differences for each of the first, second, and third Handling Before Drying (HBD). Meanwhile, the response to β-carotene levels due to drying temperature factors in general showed that there were significant differences for each drying temperature. However, the response of β-carotene levels at drying temperatures of 40 ^oC, 45 ^oC, and 50 ^oC showed a significant difference with the drying temperatures of 25 ^oC (vacuum) and 30 ^oC. So in general, the response to β-carotene levels, both Handling before Drying (HBD) and drying temperature, either independently or interactively, shows that there is a significant difference.

Table 2. Interaction of the effect of drying temperature and handling before drying (HBD) on β-carotene levels

Drying Temperature (°C)	β-caroten Concentration (mg/100 g)		
	d_1	d_2	d_3
25 (vacuum)	33,45 d A	35,15 e B	33,30 e A
30	22,90 c A	25,04 d B	22,35 d A
35	22,55 bc A	24,85 d B	14,24 c A
40	21,83 b A	13,12 c B	11,91 b A
45	11,45 a A	10,45 b B	9,22 ab A
50	10,86 a A	8,25 a B	8,45 a A

Description: Capital letters are compared horizontally, lowercase notation is compared vertically

Based on the physico-chemical properties, β-carotene is a compound that is sensitive to oxidation and heat, so that β-carotene contained in Moringa leaves also occurs when drying using relatively high temperatures and in the presence of oxygen, degradation will occur, namely a change in β-carotene into retinol. So, with the degradation of -carotene into retinol due to oxidation, the content of β-carotene in Moringa leaf powder after going through the drying process decreases. Based on the results of this study, it was shown that the higher the drying temperature, the less β-carotene contained in Moringa leaf powder. Meanwhile, the content of β-carotene in Moringa leaf powder after drying is also influenced by Handling before Drying (HBD), namely that Moringa leaves that are dried in the form of slurry or fasta have a higher level of β-carotene degradation compared to dried Moringa leaves that are not pulverized destroyed. This happens because drying in the form of slurry / liquid -carotene is relatively more reactive with oxygen and heating compared to drying whole Moringa leaves.

So as an effort to maintain the β-carotene content in Moringa leaf powder or processed food products, it is better to minimize the use of the heating process and dry it completely or without the pulping process before drying.

The response to antioxidant activity from the analysis of variance on the interaction of Handling before Drying (HBD) with drying temperature showed that there were significant differences for all treatments, both Handling before Drying (HBD) and drying temperature. The higher the drying temperature, the lower the level of antioxidant activity significantly, this happens because almost all antioxidants (vitamin C, flavonoids, phenols, etc.) are reducing agents, so they are relatively easily degraded by oxidizing agents including heat. Including Handling before Drying (HBD) when it is dried at a hotter temperature, there is still a degradation of the level of antioxidant activity. The experimental results specifically showed that each Handling before Drying (HBD) and drying temperatures of 25°C (vacuum) and 30°C the level of antioxidant activity was still high in the "strong" category, almost close to the antioxidant activity of fresh Moringa leaves, namely 72.65 ppm.

Based on the research experiments that have been carried out, it shows that heat has a significant effect on decreasing the antioxidant activity of Moringa leaves which degrade both quality and quantity. So, it is recommended that if you want to dry Moringa leaves to be processed into powder, you should use a heat that is not too high and it is recommended to use a low temperature under vacuum conditions or it is better to use the "Freeze drying" method, so that the antioxidant activity of Moringa leaf powder can still be maintained in a vacuum. The strong category is the same as the fresh Moringa leaves.

Table 3. Interaction of the effect of drying temperature and handling before drying (HBD) on Antioxidant activity

Drying Temperature (°C)	**Antioxidant Activity (ppm)**		
	d_1	d_2	d_3
25 (vakum)	92,40 a B	81,25 a A	97,42 a B
30	124,34 b B	92,36 b A	172,35 b C
35	206,41 c B	112,50 c A	232,51 c C
40	268,94 d B	135,55 d A	324,22 d C
45	315,20 e B	170,80 e A	355,20 d C
50	360,60 f B	225,59 f A	392,63 f B

Description: Capital letters are compared horizontally,
lowercase notation is compared vertically

The overall study is based on the results of the experimental treatment of Moringa leaves with Handling Before Drying (HBD), namely, Moringa leaves are directly dried without being pulverized first (d_1), Moringa leaves are pulverized first with additional water at 5 ^oC then dried (d_2), and Moringa leaves Moringa is pulverized first with the addition of room temperature water (25 ^oC) and then dried (d_3), that the Moringa leaves are pulverized first with the addition of water at 5 ^oC then dried at 25 ^oC with a vacuum can maintain vitamin C levels, β-carotene, and the strength of antioxidant activity was relatively close to the levels of vitamin C, β-carotene, and the strength of antioxidant activity of fresh Moringa leaves.

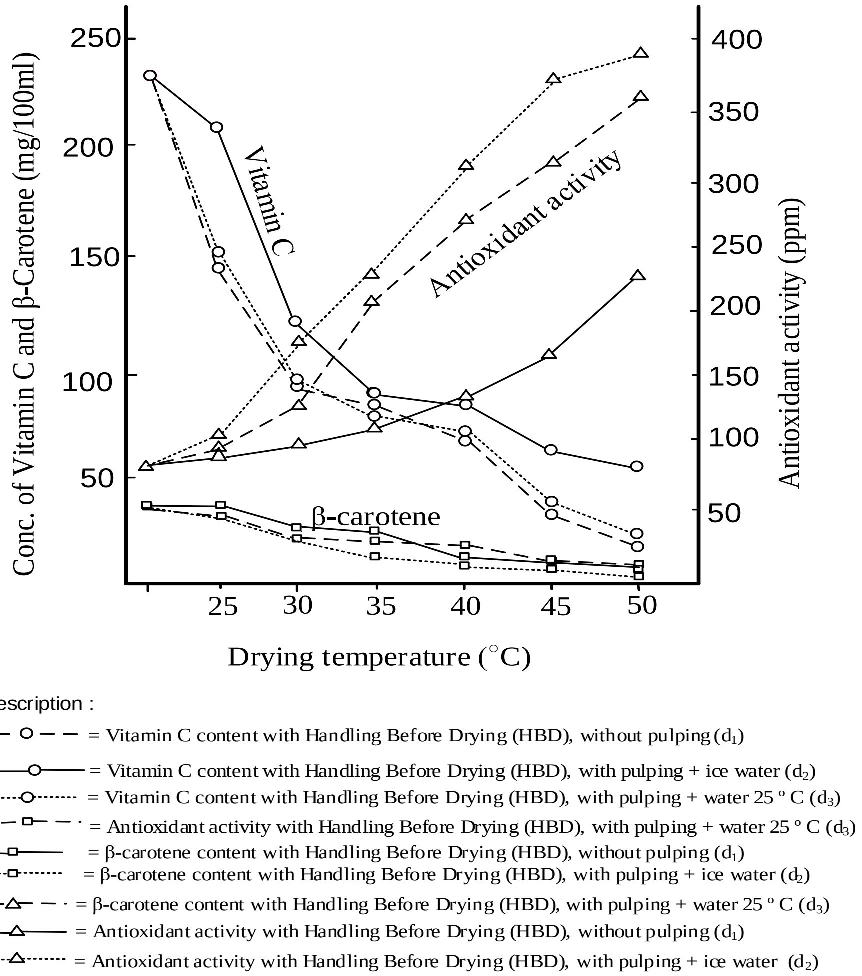

Figure 1. *The curve of decreasing Vitamin C, β-carotene, and antioxidant activity due to variations in temperature and handling before drying (HBD)*

Antioxidant can be defined as a substance that can inhibit or slow down the oxidation process. Oxidation is a type of chemical reaction that involves the gain of oxygen, the loss of hydrogen, or the loss of electrons. The oxidation process is a natural event that occurs in nature and can occur everywhere, including in our bodies. This antioxidant is significantly able to slow down or inhibit the oxidation of substances that are easily oxidized even in low concentrations. Antioxidants are also appropriately defined as compounds that protect cells from the harmful effects of reactive oxygen free radicals when associated with disease, these free radicals can come from the body's metabolism or other external factors. The analysis based on this study is vitamins (Vitamin C and vitamin E), flavonoids, phenols, saponins, terpenoids, alkaloids, tannins, and enzymes. These antioxidants can generally be obtained from two sources, namely natural and synthetic sources. Natural antioxidants are usually more in demand, because of their better safety and wider benefits in the fields of food, health and cosmetics. Natural antioxidants can be found in vegetables, fruits, and woody plants. Secondary metabolites in plants are derived from the group of alkaloids, flavonoids, saponins, quinones, tannins, steroids/triterpenoids.

Based on the mechanism of action, antioxidants are divided into primary antioxidants that can react with free radicals or convert them into stable products, and secondary antioxidants or preventive antioxidants that can reduce the initial rate of chain reactions and tertiary antioxidants. The mechanism of action of cellular antioxidants according to Ong et al. (1995) include antioxidants that interact directly with oxidants, free radicals, or single oxygen; prevent the formation of reactive oxygen species; changing the reactive oxygen type to be less toxic; prevent reactive oxygen capability; and repair the resulting damage. Primary antioxidants play a role in preventing the formation of new free radicals by breaking the chain reaction and turning them into more stable products. Examples of primary antioxidants are the *enzyme superoxide dimustase* (SOD), catalase, and glutathione dimutase. Secondary antioxidants function to capture radical compounds and prevent chain reactions. Examples of secondary antioxidants include vitamin E, vitamin C, and β-carotene. Tertiary antioxidants function to repair cell and tissue damage caused by free radicals. An example is the enzyme that repairs DNA in the nucleus of a cell is methionine sulfoxide reductase.

IV. Conclusion

Based on the research that has been carried out on the Moringa leaf flouring process which intends to determine the degradation pattern of functional compounds from Moringa leaves after being powdered and aims to obtain the beneficial value of Moringa leaf powder, the following research results can be obtained.

1. Handling before drying (HBD) of Moringa leaves and the level of drying temperature conditions significantly affect the degradation of the functional values of Moringa leaf powder after the drying process.
2. Functional compounds of vitamin C, β-carotene, and antioxidant activity contained in Moringa leaves can be declared sensitive to temperature, this is evidenced by the occurrence of degradation for each increase in drying temperature.
3. Handling before drying (HBD) by pulping with the addition of cold water (5 ^{o}C) can reduce the degradation of the functional compounds of Moringa leaf powder after the drying process.

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