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THE APPLICATION OF LAMP DRYER ON PRODUCTION OF MORINGA (Moringa oleifera) LEAF FLOUR

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ABSTRACT

The utilization of moringa leaf can increase by flour processing where drying is the main step. This research was conducted to determine the physical and chemical characteristics of moringa leaf powder produced by lamp drying compared to solar and ovens dryers. Five variations of drying methods were applied (sunlight, oven 40ºC and 60ºC, lamp dryer 40ºC and 60ºC). The results showed, the lamp dryer produced moringa leaf flour that have good physical and chemical properties, that are yield 35.21 – 35.10%; the highest green degree 4.60 – 4.70; the bulk angle 8.09 – 8.44 and the bulk density 0.43 – 0.43. The water content fulfill the SNI standard, that is :10.03 – 10.13%. Meanwhile, the levels of vitamin C 26.48 – 28.28%; chlorophyll 18.41 – 19.25 mg/L and antioxidant activity 43.45 – 43.84 % of DDPH inhibition. However, the total polyphenol content of moringa leaf flour obtained from lamp drying was the lowest, that is 4.88 – 4.98 mg/L.

Keywords: Drying method, Lamp dryer, Moringa leaf flour, Temperature

INTRODUCTION

Moringa plant has been called “The Miracle Tree” because almost all of its parts have benefits. The leaves of moringa have many benefits for the human health, Consist of 100 grams of moringa leaf contains 220 mg of vitamin C, 2.6 mg of vitamin B1 (thiamine), 20.5 mg of vitamin B2 (riboflavin) and 8.2 mg of vitamin B3 (nicotinic acid). In addition, every 100 grams of moringa leaf also contains 16.3 mg of vitamin A, 113 mg of vitamin E (alpha-tocopherol acetate), 19.2 g of fiber and various minerals such as calcium, magnesium, phosphorus and iron (Johnson, 2005). This increases the use of moringa leaf as a fortification material in food where Rahayu and Nurindahsari (2019) reported that 30 toddlers who consumed 10 g of moringa leaf flour for 7 days experienced an average BMI (Body Mass Index) increase of 13%.

However, moringa leaf are easily wilted and deteriorated, so processing them into flour can extend their shelf life. In the form of flour, moringa leaf has potential to use as a fortification ingredient in processed foods such as biscuits, baby porridge, noodles and so on.

Drying is an important step that determines the quality of the product, during the manufacture of flour. Drying oven is equipment that has been widely applied in flour production because the drying temperature can be regulated at certain value in other the drying operation run more efficient (Huriawati *et al.,* 2016). Setyowatik (2011) reported that moringa leaf dried in an oven at 60ºC contained 15.02 mg/g of vitamin C, 0.53 mg/g of chlorophyll, and 11.03% of water. In addition, Hanarisetya (2019) stated that the hedonic quality of of color of dried moringa leaf produce by oven drying method had the closed value (4.2) compared with fresh moringa leaf (4.9). Thus hedonic value of color was higher compare with moringa Flour produced by sun drying.

The disadvantages of oven dryer are high electricity demand and relatively expensive especially for small scale industry. Therefore, several homescale industries have developed lamp dryers for moringa leaf flour production. Wijianti *et al.* (2017) reported that drying pepper

using an incandescent lamp as a heat source can reduce water content up to 12%. Zahro et al. (2009) also stated that the used of incandescent lamps in drying temulawak produced a brighter color and the drying process run faster than used sun dryer. The advantages of lamp dryer over oven and sun dryer are low electricity demand and cost and also can be done continuously without depend on the weather (Chandra and Witono, 2018).

Temperature is one of the factors that can affect the drying process. Different temperatures in drying will cause different drying times wherein the higher the temperature, the faster the drying time and vice versa (Leviana and Paramita, 2017). Other studies also mention that drying temperature will affect the physical and chemical characteristics of flour (Rizal *et al.,* 2013; Lisa *et al.,* 2015). This study aims to determine the physical and chemical properties of moringa flour prepared with a lamp dryer compared to sun drying or oven drying. The temperatures in the lamp dryer and oven are varied (40^{o}C and 60^{o}C). The results of this study are expected can give information for homescale industry that uses lamps drying to prepare moringa leaf flour.

METHODOLOGY

Materials

The main material used in this study were moringa leaf that were obtained from mumbul garden, Jember, East Java. The leaves were picked five stalks from the shoots. The materials used for the chemical analysis were technical ethanol, DPPH, Follin-cialceteu reagent, Na_2CO_3 (Merck), aquades, starch, 0.1 N iodine, aluminum foil.

Equipment

The equipment used in this research were: drying oven (regulating oven, selecta), analytical balance (analytic plus 310, ohaus), color reader (Minolta, CR-400), measuring cup, glass funnel, erlenmeyer, burette (pyrex), ruler, magnetic stirrer (Ika, C-MAG HS7), centrifuge (Yenaco, YC-1180), spectrophotometer (Thermo Scientific), Vortex (Thermo Scientific), lamp dryer with the design in Figure 1.

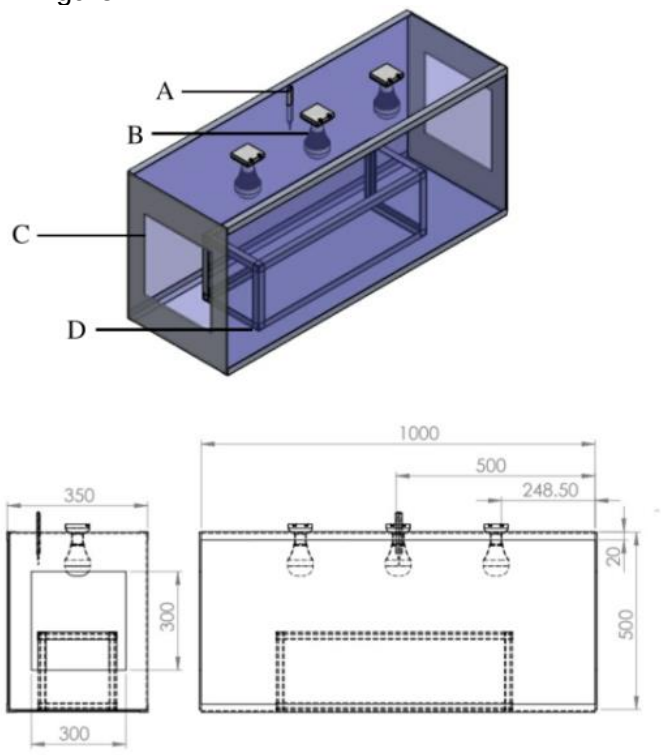

Figure 1. The design of lamp dryer apparatus
(A: thermometer; B: lamp; C: air circulation; D: tray)

Research Design

There were five samples in this study that were P0 (moringa leaf flour produced by sun drying), P1 (moringa leaf flour produced by oven drying 40ºC), P2 (moringa leaf flour produced by oven drying 60ºC), P3 (moringa leaf flour produced by lamp dryer 40ºC), and P4 (moringa leaf flour produced by lamp dryer 60ºC). The evaluated parameters in this study were yield (AOAC,1995), color intensity (green degree; colour reader), bulk angle (Priastuti *et al.,* 2016), bulk density (Okaka and Potter, 1979), moisture content (Okaka and Potter, 1979), vitamin C content (iodine titration), chlorophyll content (Fajri *et al.,* 2018), antioxidant activity (Burda and Oleszek, 2001) and total polyphenols (Conde *et al., 1997)*

Research Description

Moringa Leaf Flour Producion

The production of moringa leaf flour begun with the process of separating the leaves from the stems and then removed the damaged and yellow leaves. The cleaned moringa leaves then washed to remove dirt such as dust and soil. The moringa leaf put into a baking sheet and then flattened with a thickness of approximately 1 cm in other the drying process run more effective. The drying of moringa leaf was carried out using a Selecta oven and a lamp dryer Figure 1. The lamps used in the design of Figure 1 are a 40-watt incandescent lamp (Philips) for 40ºC and a 100-watt incandescent lamp (Philips) for 60ºC. Drying was carried out until the dried moringa leaf can be broken, namely 6 hours at 60ºC, 8 hours at 40ºC and 7 hours for sundrying. The dried moringa leaves were mashed using a food processor then were sifted using an 80 mesh sieve.

Research Method

This research is an experimental study in which the analysis and samples preparation was carried out in a laboratory using randomized block design. The one factorial design was used wherein the factor was drying method. There are three repetitions and then the result of parameters measurement analyzed by data processing methods.

Analysis Procedure

The analysis procedure of yeild

The yield was measured according to the AOAC (1995). The yield was calculated by the following formula:

$$\text{Yeild (\%)} = \frac{The\ weight\ of\ flour\ after\ sieving}{Innitial\ weight\ of\ leaves}\ x\ 100\%$$

The analysis procedure of green degree (a)

The green degree was measured using a color reader (Minolta, CR-400) wherein the observed parameter was a*. The a* value indicates the level of green to red with a range number of -80 to 100.

Bulk angle

The measurement of bulk angle refers to Priastuti et al. (2016). A sample of 10 g of moringa leaf flour was dropped at a height of 15 cm through a funnel on a flat surface (white paper). The height is calculated from the bottom of the funnel. The formed pile then was measured for the diameter and height.The formula for determining the bulk angle is as follows:

$$\text{Bulk angle (º)} = arc\ tan\frac{2t}{dl}$$

Information:
t : height, dl : diameter

Bulk Density

Bulk density measurement refers to Okaka and Potter (1979). The sample was weighed 10 g, then the sample was put into a 100 ml measuring cup. The bulk density was calculated by the following formula:

Bulk density (g/ml) $= \frac{weight\ (g)}{volume\ (ml)}$

Moisture Content

The measurement of moisture content refers to AOAC (1995). A 2 grams sample was put into a cup whose weight has been measured. Previously, drying procedure to ensure the cup was heated in 100ºC oven for 24 hours. The moisture content was calculated by the following formula:

Moisture content (%) $= \frac{initial\ weight - final\ weight}{sample\ weight}\ x\ 100\%$

Vitamin C Concentration

The vitamin C content of moringa leaves flour was determined using the iodine redox titration. 0.5 g moringa leaf was extracted in 30 ml of distilled water. The filtrated was separated using centrifuge for 10 minutes at a speed of 3,000 rpm. This extraction process was carried out three times for maximum results. The filtrate was added with distilled water until 100 ml. 5 ml of filtrate was put into an erlenmeyer and added with 2 ml of 1% starch and 20 ml of distilled water and then shaken until homogeneous. The sample solution was titrated using 0.01 N of iodine until a blue color was formed. This titration was repeated three times. Vitamin C levels can be calculated using the following formula:

Vitamin C content (%)$= \frac{VI\ x \left(\frac{Vt}{Vf}\right) A}{W}\ x\ 100\%$

Keterangan :

VI : volume of iodine
Vt : volume of total filtrate
Vf : volume of filtrate had been used
A : equivalence of I_2 to vitamin C
W : weight of sample

ChlorophyllCcontent

The measurement of chlorophyll content refers to Fajri *et al.,* (2018). The resulting filtrate was added with ethanol reach to 50 ml. The absorbance of moringa leaves filtrate was measured in the range of wavelengths 649 and 665 nm lengths. Chlorophyll content was calculated using the following formula:

Chlorophyll content $= 20 \times A_{665} - 6{,}1 \times A_{649}$

Total Polyphenol

The measurement of total polyphenols refers to Conde *et al.* (1997) used the follin-cialceteu method. The absorbance of solution was measured at a wavelength of 765 nm. The absorbance value was used to make a standard curve for gallic acid so that the equation Y= 0.337x-0.354 was obtained. The formula used to determine the total polyphenols was as follows:

Total polyphenol = $\frac{absorbans + 0{,}354}{0{,}337}$

Antioxidant Activity

The measurement of antioxidant activity refers to Burda and Oleszek (2001) using the

DPPH method. The absorbance of the solution was measured at a wavelength of 517 nm. Antioxidant activity was measured using the following equation:

Antioksidant activity = $\frac{abs.blanko - abs.sampel}{abs.blanko}$ x 100%

Data Analysis

The data obtained from the research were analyzed using completely randomized design wherein minitab v 14 was used. Then the result was displayed in the form of a table which was then discussed according to the literature.

RESULTS AND DISCUSSION

1. Results of the Physical Properties Measurement

The results of physical properties/parameters observations in this study are presented in Table 1.

Tabel 1. The result of yield, green degree, bulk degree and bulk density measurement

Samples	Yeild (%)	Green degree (a)	Bulk degree (º)	Bulk density(g/ml)
Po (sun dried moringa leaf flour)	37.3 ± 0.6 b	-2.2 ± 0.1 c	8.8 ± 0.1 c	0.43 ± 0.01 a
P1 (40ºC oven dried moringa leaf flour)	35.2 ± 0.9 a	-3.6 ± 0.1 b	8.1 ± 0.1 a	0.44 ± 0.01 b
P2 (60ºC oven dried moringa leaf flour)	34.9 ± 1.0 a	-4.6 ± 0.3 a	7.9 ± 0.1 a	0.44 ± 0.01 b
P3 (40ºC lamp dried moringa leaf flour)	35.2 ± 0.9 a	-4.6 ± 0.1 a	8.4 ± 0.1 b	0.43 ± 0.01 a
P4 (60ºC lamp dried moringa leaf flour)	35.1 ± 0.7 a	-4.7 ± 0.1 a	8.1 ± 0.1 a	0.43 ± 0.01 a

Yeild (%)

The yield is the ratio between weight of product to raw materials. Table 1 showed the yield value of samples which is ranging from 34.91% to 37.33%. The water content is the main factor that affected to the yield value. Sample P0 has the highest yield value because the sample was dried using sunlight. According to Winangsih and Parman (2013), The sun drying temperature usually ranged from 30-35ºC that result in the evaporation of free water is not optimal. The other disadvantages of sun drying is uncontrolled environmental due to being in an open space..

Table 1 shows that the yield values of oven dried and lamp dried samples (P1, P2, P3 and P4) were not significantly different, whereas the 40ºC of lamp dried sample was the highest and 60ºC oven dried sample was the lowest. This shows that the lamp dryer that was designed in this study was able to evaporate water almost the same as the oven dryer. The differences in yield of that two drying methods is only 0.02 for 40ºC and 0.195 for 60ºC. The difference in yield can be caused by the different of environmental conditions due to differences in the equipment design. In addition, the lamp dryer in this study was not equipped with a temperature sensor. According to Tamaheang *et al.* (2017), the uncontrolled drying temperature affected the evaporation process result in high water content of product.

Green Degree (a)

The color of flour is one of important parameters that can affect the results in quality of foodstuffs especially the preferences of consumer. The color evaluated in this study is the green degree (a). The lower of a value, result in more intensive of green color.

The data in Table 1 shows that sun dried sample has the lowest green degree, while the highest value is 60ºC lamp dried sample which is not significantly different with 60ºC oven dried and 40ºC lamp dried samples. The results show that the lamp dryer can produce the higher green degree than oven dried moringa leaf. Thus can be concluded that lamp dryer designed in this study can preserved the green color of moringa leaf.

The change of color happened because the degradation of chlorophyll. The sunlight can cause the green color to fade due to the presence of ultraviolet in sunlight. The present of ultraviolet wave causes photochemical reactions that make the chlorophyll pigment unstable and degrade (Rohmat *et al.,* 2014).

Changes of color in moringa leaf flour can also be influenced by the presence of other compounds such as polyphenols. Moringa leaf flour also contains polyphenolic compounds which will be oxidized due to the presence of oxygen that result in the brown color of the material (Nirmala, 2019). These things are likely contribute to the green degree decrease of sun dried and 40ºC lamp dried samples.

Bulk Degree (º)

Bulk angle is the angle performed between the slope side of the flour that is poured and the flat plane. Table1 shows the result of bulk angle measurement wherein sample P0 has the highest value. Samples P2 has the lowest value that was not significantly different to P1 and P4. Sample P3 has the significant higher value than P2, P1 and P4. Bulk angle measurement data obtained from this study were in line with water content data. The bulk angle of flours can be influenced by several factors, one of which is water content (Syah *et al.,* 2013). Mwithiga and Sifuna (2006) stated that the higher the water content in the material, the higher the bulk angle formed by the material.

The bulk angle can also be affected by the bulk density. This is in accordance with the research of Priastuti and Suhandy (2017) which states that the lower the bulk angle, the material will flow easily because the flow of a material is influenced by the ratio of the weight and volume of the material.

Bulk Density (g/ml)

Bulk density is one of the parameters that influce determination of storage, packaging, processing equipments and transportation facilities. Rohmah (2012) wrote that high bulk density value mean it has a large volume but light weight. The bulk density of a product can be influenced by the moisture content, particle size, and mass of the material. High water content will cause the bulk density decrease (Wiratakusumah et al., 1992).

The data in Table 1 shows sample P0, has the lowest bulk density value, the highest bulk angle and yield value, this was probably related to the moisture content. The result of bulk density measurement of samples P1, P2, P3 and P4 related to the result of yield and bulk angle measurements. The result of these parameters measurement associated with the ability of the dryer to evaporate water. This showed that the lamp dryer designed in this study had the ability to evaporate water which was almost the same with oven dryer.

2. The Result Of Chemical Properties Analysis

The results of the chemical properties/parameters measurement performed on the moringa leaf flour in this study are presented in Table 2.

Moisture Content (%)

Moisture content is one of important parameters in dry food products such as powder or flour because it can affect the quality. The moisture content of moringa leaf flour ranged from 9.71-12.12% Table 2. This indicates that all samples of moringa leaf flour in this study met the requirement of flour quality in accordance with SNI 3751-2009 for wheat flour and SNI 3451-2011 for cornstarch, which is stated the maximum moisture content ranged from 14 to 14.5%.

Moringa leaves flour which has the highest average value of moisture content is sample P0. The lowest value is sample P2 which are not significantly different with sample

P1, P3 and P4. Moringa leaf flour treatments P1, P2, P3 and P4 did not differ much from the smallest sample P2. This shows that the lamp dryer designed in this study is able to produce flour with the quality requirements of moisture content according to SNI as well as oven dryer.

Tabel 2. The results of moisture content, vitamin C, Chlorophyl, total polyphenol and antioxidant activity measurement.

Samples	Moisture Content (%)	Vitamin C (a)	Clorophyl (mg/mL)	Total polyphenol (mg/mL)	Antioxidant activity (%)
Po (sun dried moringa leaf flour)	12.12 ± 0.19 b	31.48 ± 0.92 c	14.00 ± 0.02 b	5.24 ± 0.16 b	53.20 ± 0.89 c
P1 (40ºC oven dried moringa leaf flour)	10.10 ± 0.01 a	27.80 ± 0.68 a	12.75 ± 0.07 a	5.45 ± 0.17 b	28.27 ± 0.56 a
P2 (60ºC oven dried moringa leaf flour)	9.71 ± 0.18 a	30.26 ± 0.98 c	18.44 ± 0.19 c	6.10 ± 0.05 c	66.93 ± 0.94 d
P3 (40ºC lamp dried moringa leaf flour)	10.13 ± 0.14 a	26.48 ± 0.98 a	18.41 ± 0.21 c	4.88 ± 0.04 a	43.45 ± 0.60 b
P4 (60ºC lamp dried moringa leaf flour)	10.03 ± 0.03 a	28.28 ± 0.98 b	19.25 ± 0.18 d	4.98 ± 0.05 a	43.84 ± 0.31 b

Vitamin C Content (%)

Vitamin C is one of the water-soluble vitamins which is very required to the human body. Vitamin C has a strong antioxidant activity (Padayatty *et al.,* 2003). Vega-Gálvez *et al.* (2009) stated that vitamin C is an unstable compound and the decrease of concentration is accelerated by increasing temperature.

The highest vitamin C content was obtained from the P0 sample which the value was not significantly different with P2 sample. Wherein sample P3 had the lowest value of vitamin C which was not significantly different with sample P1. The vitamin C content in this research seems to be not only depend on drying temperature. Although, for sun dried it was supposed to be the low drying temperature, that is ranging 30 - 35ºC (Winangsih and Parman, 2013).

At the same drying temperature and time, the vitamin C content of lamp dried samples (P3 and P4) were lower than oven-dried samples (P1 and P2). The result of this study indicate that light rays have the ability to degrade vitamin C. Research by akmakçi and Turgut (2005) showed that vitamin C levels in milk samples stored in areas exposed to fluorescent and tungsten light were lower than samples stored in non-contact areas, where the decrease in vitamin C levels is greater if the light intensity is increased.

Chlorophyll Content (mg/L)

Chlorophyll is a green pigment that is usually contained in many green leaves and foodstuffs. The measurement of chlorophyll content in this research was ranged from 12.68 - 19.44

Based on Table 2, P1 sample has the lowest chlorophyll content and P4 had the highest. These results indicate that the lamp drying designed in this study was able to maintain the chlorophyll content and degree of green when compared to sun drying and oven drying.

Total Polyphenol (mg/ml)

Total polyphenols or commonly known as soluble tannins are one of the phytochemical compounds that can be found in plant parts such as leaves, seeds, and fruit. Polyphenols have many benefits for the human body because most polyphenols have antioxidant activity. The total polyphenol content in moringa leaf flour was measured using the Follin cialceteu method.

The results total polyphenols the measurement in this study are presented in Table 2. The data in Table 2 shows that the lowest total polyphenol content is in samples P3 and P4 the dried lamp sample. This mean that the degradation of polyphenols is not only because of oxidation and high temperatures, but the light can also degrade polyphenols.

Antioxidant Activity (%)

The antioxidant activity of a food ingredient can be determined using the DPPH method. The results of antioxidant measurement are represented as percentage of inhibition. The higher the percentage of inhibition, the stronger the antioxidant activity of moringa leaf flour.

The results of antioxidant activity measurement in this study are presented in Table 2. The datas shows that the lowest antioxidant activity was in sample P1 and the highest was in sample P2, both of which were moringa leaf flour made by oven drying. Meanwhile, the antioxidant activity values of the samples with P3 and P4 were not significantly different, although they were dried at different times and temperatures. Sample P0, the sun dried sample, had the second highest value after P1.

This evidence showed that the antioxidant activity were not in line with the value of color and chlorophyll content. This was in accordance with the result of the research by Alves *et al.* (2017) which showed that the decolorization process in the manufacture of moringa leaf flour affected the chemical content but did not reduce the value of antioxidant activity.

Antioxidant activity is influenced by levels of chlorophyll, vitamin C, and polyphenols, beside several other bioactive compounds in moringa leaf flour. The result of these research was agree with that statement, it can be seen that the higher the concentration of these three compounds, the higher the antioxidant activity of moringa leaf flour. This is in accordance with the literature which states that these three compounds have antioxidant activity (Siddhuraju and Becker, 2003; Sreelatha and Padma, 2009).

CONCLUSION

The results showed that the lamp dryer that was designed in this study can produce moringa leaf flour which had good physical and chemical properties. The properties are 35.22 – 35.10% of yield; 4.60 – 4.70 of green degree which is the highest score among all samples; 8.09 – 8.44 of bulk angle and 0.43 – 0.43 of bulk density. Other than that the lamp dryer can produce moringa leaf flour that has 10.03 – 10.13% of moisture content wherein meets the SNI standart; 26.48 – 28.28% of vitamin C; 18.41 – 19.25 mg/L of chlorophyll ; 43.45 – 43.84% of antioxidant activity. The results of the total polyphenol content measurement showed that lamp dried moringa leaf flour has the lowest content compare to sun dried and oven dried moringa leaf. The total polyphenol of lamp dried moringa leaf was 4.88 – 4.98 mg/L.

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