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Effect of drying method and bad thickness on physical, chemical, and organoleptic quality of dry herbal Moringa (*Moringa oleifera*) leaves

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Abstract. The purpose of this study was to determine the effect of the drying method and bed thickness on the physical quality test (moisture content, color), chemical (ash content, flavonoids, total phenol, carotenoids, ascorbic acid, or vitamin C and antioxidant activity) and organoleptic test of Moringa leaf tea. The experimental research was a Split Plot Design with dryers as the main plot and bed thickness as a subplot. Analysis of variance (ANOVA) and Duncan's Multiple Range Test (DMRT) at a significant level of 5% was used to analyze the experimental data. The organoleptic scores were analyzed using the Friedman test. The ANOVA results indicated that the drying method significantly affected whereas the bed thickness did not influence the experimental parameters. The best result in terms of herbal moisture content (5.94%) and color was obtained by YSD UNIB 2022 assisted with a fan. The highest ash content was in the range of 7.78 % -7%, total phenol was 50.78 GAE/g, carotenoids content was 17, 57 mg/g, ascorbic acid (vitamin C) was 117, 33%, and the strongest (antioxidant activity) was at an IC50 value of 37.85 ppm. The best (flavonoids) showed a red color on drying YSD UNIB12.

1 Introduction

Tea is one of the most popular beverages in the world. Dry herbals are commonly called herbal tea and are generally made from plant parts i.e., dry leaves, seeds, wood, fruit, flowers, and others having various benefits. Moringa plant is rich in free radical inhibitors, such as phenolics (phenolic acids, flavonoids, coumarins, quinones, tannins, and stilbenes), nitrogen (alkaloids, amines, b-alanine), vitamins, terpenoids (carotenoids), and other endogenous metabolites [1]. The levels of polyphenols and flavonoids in moringa leaves are known to be higher than in other leaves such as pumpkin leaves and fern leaves [2].

Utilization of Moringa leaves to produce tea products can increase the economic value or additional income of the community. The drying process is the most important activity

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in the manufacture of herbal teas due to the effect on the quality of the resulting product. Drying refers to the process of removing water content which aims to prevent microbial and enzymatic activity for the preservation process and to extend the shelf life of the product [3]. Drying can be done by various methods such as traditional drying that utilizes direct sunlight and artificial dryer such as an oven. Drying using an oven has the advantage of a controllable drying temperature [4], but it is capital-intensive. Sun drying is the most practical drying for almost all commodities. Although it is easily done, sun drying is hindered by several inconsistencies such as intensive space, the risk of disturbing drying due to bad weather, resulting in damage and loss, rat and insect attacks, product contamination, and time and effort consumption, especially in the rainy season [5], one solution to increase the effectiveness and efficiency of drying is to use a solar dryer called YSD UNIB 2012. The working principle of a solar dryer is to capture heat from sunlight as much as possible and flow it automatically across the material being dried so that the moisture content is evaporated from the material with the gained heat. YSD UNIB 2012 solar dryer can be modified by providing an additional device in the form of a fan to blow hot air into the drying chamber so that the drying rate can be run in a shorter time.

The drying process, drying time, and temperature are thought to affect the quality of the herbal tea produced. In general, the temperatures for drying materials are in the range of 30°-90°C, but the best temperature is not more than 60°C [6]. Drying Moringa leaves using *cabinet drying* at a temperature of 50°C produced a dry product of 15.43% moisture content [6]. Drying Moringa leaf flour using room temperature and an oven of 60°C temperature produced dry materials with a moisture content of 13.21% and 13.02% respectively and the improved oven method resulted in dry material with a moisture content of 11.79% and ash content of 8.53% characterized by blackish green color [7]. Drying fig leaf tea with a temperature of 55°C and a bed thickness of 4 cm resulted in a dry product with a moisture content of 6.551% [8]. These results did not meet the quality standards of dry moringa in packaging. Aerating Moringa leaves obtaining a dry product with yellowish green color indicating the presence of flavonoid on the other hand dried Moringa leaves with a cabinet dryer at 50°C and 60°C resulted in dry products with 5.15 GAE /g and 6.94 GAE/g [9].

The purpose of this study was to investigate the effect of the drying method and bed thickness on the results.

2 Material and methods

2.1 Research tools and materials

Thermohygrometer, analytical balance, oven, grinder, separating funnel, petri dish, kiln, cuvette, filter paper, funnel, test tube, tongs, freezer, and measuring cup. UV-Vi Spectrometer, Hot Plate Stirrer, dropper and erlenmeyer.

The materials used in this study were Moringa leaves, distilled water, label paper, water, DPPH, tissue, methanol, Follin-Ciocalteu, sodium carbonate, 80% acetone, starch, 10% NaOH, and HCl.

2.2 Experimental design

The experimental design used in this study was a *Split Plot Design,* with the drying method as the main plot (first factor) and the bed thickness as the subplot (second factor). The drying methods were Oven (P1), YSD UNIB 2012 (P2), and YSD UNIB 2012 assisted a Fan (P3). The bed thicknesses of Moringa leaves were 0.25 cm (K1), 0.5 (K2), 0.75 cm (K3), and 1 cm (K4). Each treatment was repeated 3 times so that all treatments consisted of 36 samples. The drying processes were terminated when the Moringa leaves reached 8% moisture content according to SNI 3836:2013. The drying process was observed by measuring temperature and relative humidity in and outsides the dryer, drying air velocity in the chimney of the dryer, and the weight of the prepared sample as a means of drying process termination. These parameters were observed for one hour until the sample moisture content reached 8%.

2.3 Observed parameters

2.3.1 Physical parameters

Moisture content. Moringa leaf powder samples were prepared and put in the oven for 3 hours at a temperature of 105°C. The calculation of water content referred to INS 3836: 2013 is as follows.

$$Moisture\ Content = \frac{W1 - W2}{W1 - W0}\ x\ 100\% \qquad (1)$$

where:
W1: Weight of cup + material before drying (g)
W2: Weight of cup + material after drying (g)

Color. Measurement of color was carried out using *Munsell color charts for plant tissues.* The colors of the samples were observed and compared to the color spectrums of the Munsell and then were given the list numbers. The list numbers were (1) *hue*, (2) *value,* and (3) *chroma.*

2.3.2 Chemical parameters

Ash content. The prepared sample of 3 grams for every treatment was put in the porcelain dish and then placed into a furnace at 525°C for 3 hours. The ash content was calculated using the equation:

$$Ash\ Content = \frac{W1 - W2}{W1 - W2}\ x\ 100\% \qquad (2)$$

where:
W0: Weight of empty cup (g)
W1: Weight of cup + sample before ashing (g)
W2: Weight of cup + sample after ashing (g)

Flavonoid. The reagent used in the flavonoid examination was the Wilstater reagent. This reagent was mixed with 1 ml extract and was then added with a few drops of concentrated HCl and a little magnesium powder (Mg). A positive reaction was marked by a red-orange color.

Total phenol. Total phenol analysis referred to BSN (2013) regarding packaged tea in which as much as 2 mg of dried Moringa leaf samples was extracted using 75% methanol. The extracted sample was added to 1.2 ml of 7.5% sodium carbonate and 1.5 ml of follin ciocalteau and was then homogenized and allowed to stand for 10 minutes, furthermore, the absorbance of the solution was measured using a UV-Vis spectrophotometer at a wavelength of 765 nm. The solution was allowed to stand for 30 minutes and was then measured the absorbance using a UV - Vis spectrophotometer at a max of 765 nm. Total Phenol content was calculated using the standard curve of linear regression of gallic acid y = ax+b.

Carotenoid level. Calculation of carotenoid levels was carried out using the spectrophotometer method. Moringa leaves a sample of 0.05 g was dissolved in 5 ml 80% acetone until a filtrate was produced. The filtrate was then placed in a cuvette tube on the spectrophotometer. The absorbance was measured at wavelengths of (480, 645, 663) nm.

$$Carotenoids\ (\mu mol/L = \frac{(A480+(0{,}114xA663-0{,}638xA645)xVx10^3}{112{,}5x\ w} \quad (3)$$

where:
A480: Absorbance wavelength 480nm
A663: Absorbance wavelength 663nm
A645: Absorbance wavelength 645nm
V: extract volume (ml)
W: sample weight (g)
Conversion: 1 mol/1 = 27.25 mg/l

Ascorbic acid test (Vitamin C). The crushed samples weighed as much as 5 grams. The sample was then dissolved in a 100 ml volumetric flask. The solution obtained was filtered and the filtrate was then pipetted using a dropper of 25 ml. A few drops of the pipetted filtrate were put on the starch indicator and were then titrated with 0.01 N iodine solution so that the solution changed color to blue. The content of vitamin C was calculated using the formula [10].

$$Vit.C = \frac{(V\ x\ 0.88\ x\ Fp)}{W}\ x\ 100\% \quad (4)$$

where:
V: Iodine Volume (mL)
Value of 0.88: 0.88 mg of ascorbic acid was equivalent to 1 mL of 0.01 N I_2 solutions
Fp: Dilution Factor
W: Sample weight (g)

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Antioxidant activity testing. Analysis of antioxidant activity was performed using the free radical scavenging method *1,1-diphenyl-2-picrylhydrazil* (DPPH), in IC 50 [11]. A total of 2 grams of powder was extracted with 100 ml of methanol. The extraction results were made in various concentrations, namely 5 ppm, 10 ppm, 15 ppm, 20 ppm, and 25 ppm. Each solution was then pipetted as much as 1 ml to be added with 2 ml of DPPH. The mixture was then shaken and incubated for 30 minutes in a dark place. The same procedure was done on the blank sample (DPPH solution). The blank solution consisted of 2 ml of DPPH and 1 ml of methanol. The solution was then measured for its absorbance at a maximum value of 514 nm. Data from the measurement results of Antioxidant Activity Analysis were calculated using the equation:

$$Antioxidant\ (\%) = \frac{A\ blanko - A\ sampel}{A\ blanko}\ x\ 100\% \qquad (5)$$

where A: Absorbance Value.

2.3.3 Organoleptic test

Organoleptic testing parameters included taste, color, and aroma in Moringa leaves herbal powder using a hedonic quality test with 25 untrained panelists to assess their preference for the products.

2.3.4 Data analysis

The quantitative data obtained were analyzed using the A (*Analysis of Variance*) with SPSS statistic 25.0 software to determine the effect of the experimental treatments. If there were a significant effect, the data were further analyzed by the DMR T-*test* (*Duncan's Multiple Range Test*) at a significant level of 5%. Organoleptic data were analyzed using *Friedman Test.*

3 Results and discussion

The results of the ANOVA and DMRT test for physical and chemical parameters are presented in Tables 1 and 2.

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Table 1. ANOVA test results.

Parameter		Drying method (P)	Bed thickness (K)	P*K
Physical characteristics	Moisture content	*	ns	ns
	Colour	Descriptive		
Chemical characteristics	Ash level	*	ns	ns
	Flavonoids	Qualitative		
	Total phenol	*	ns	ns
	Carotenoids	*	ns	ns
	Vitamin C	*	ns	ns
	Antioxidant activity	*	ns	ns

Description: (*) indicates significant, (ns) indicates non-significant treatment.

Table 2. DMRT test results.

Treatments		Moisture content	Ash level	Total phenol	Carotenoids	Vitamin C	Antioxidant activity
Drying method (P)	Oven (P1)	b	b	c	a	a	b
	YSD UNIB 2012 (P2)	b	a	a	c	c	a
	YSD UNIB 2012 + Fan (P3)	a	b	b	a	b	a
Bed thickness (K)	0.25cm	a	a	d	b	a	a
	0.50cm	a	a	c	ab	a	a
	0.75cm	a	a	b	ab	a	a
	1.00 cm	a	a	a	a	a	a

Note: The same symbol shows the results that are not significantly different, while the notation of symbols that show a significant difference, (a) the bed thickness shows that the treatment is not significantly different.

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3.1 Drying parameters

3.1.1 Drying air temperature

Temperature is a measure of the heat energy content where the higher the drying air temperature, the greater the ability to heat and evaporate the moisture content of the material being dried. The profiles of drying air temperature of three different drying methods are presented in Figures 1, 2, and 3.

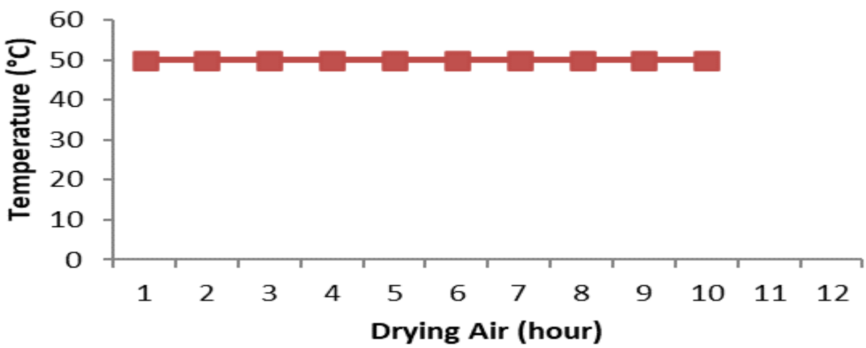

Fig. 1. Drying air temperature profile of Oven method.

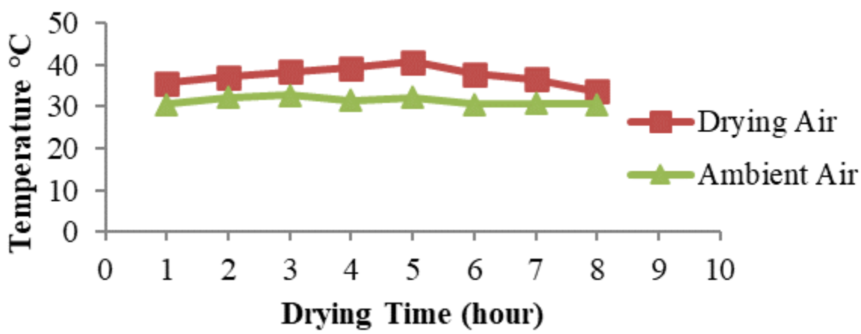

Fig. 2. Drying air and ambient temperatures of YSD UNIB 2012 method.

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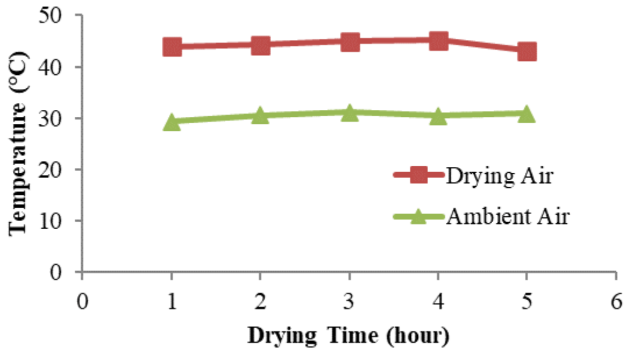

Fig. 3. Drying air and ambient temperatures of YSD UNIB 2012 assisted with a fan method.

From Figures 1, 2, and 3 the oven, YSD UNIB 12, and YSD UNIB 12 assisted with a fan produced average temperatures of 50°C, 41.8°C with an ambient temperature of 31.6°C, 44.9°C with the ambient temperature of 30.9°C so that YSD UNIB 12 assisted with a fan, generated temperature gain higher (13°C) than that of YSD UNIB 12 (10.2°C) suggesting higher drying rate.

3.1.2 Drying air relative humidity

The profiles of drying air humidity are shown in Figures 4 and 5.

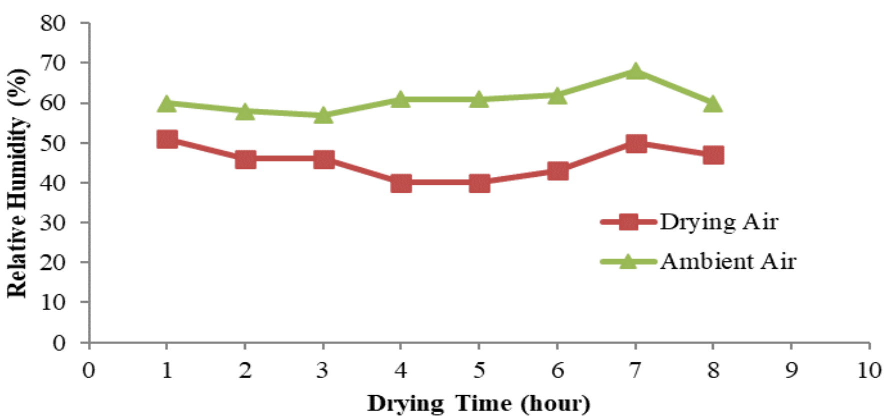

Fig. 4. Profile of drying air and ambient air relative humidities of YSD UNIB 2012.

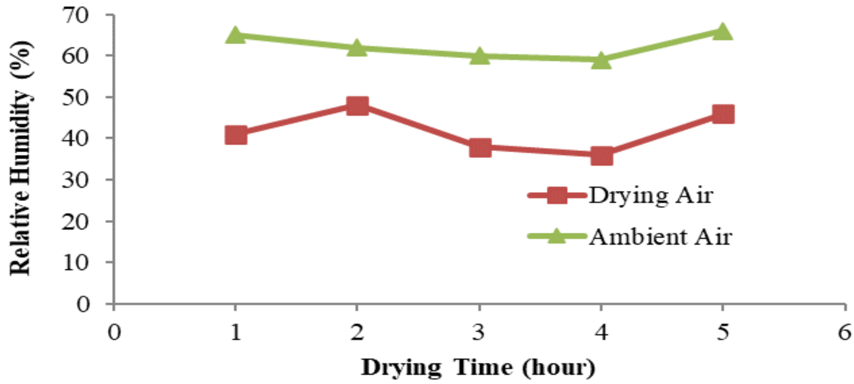

Fig. 5. Profile of drying air and ambient air relative humidities of YSD UNIB 2012 assisted with a fan.

From Figure 5 the average drying air relative humidity of YSD UNIB 2012 was 45%, lower than that of the ambient air (62%) and from Figure 5 the average drying air relative humidity of YSD UNIB 2012 assisted with a fan was 40%, lower than that of the ambient air (70%) suggesting that this last dryer produced drier drying air potential for higher drying rate.

3.1.3 Drying air velocity

The velocity of airflow serves to carry heat energy which then transfers to the material and carries water vapor out of the drying chamber. The profile of drying air velocity in the chimney and ambient air during the drying process is presented in Figures 6 and 7.

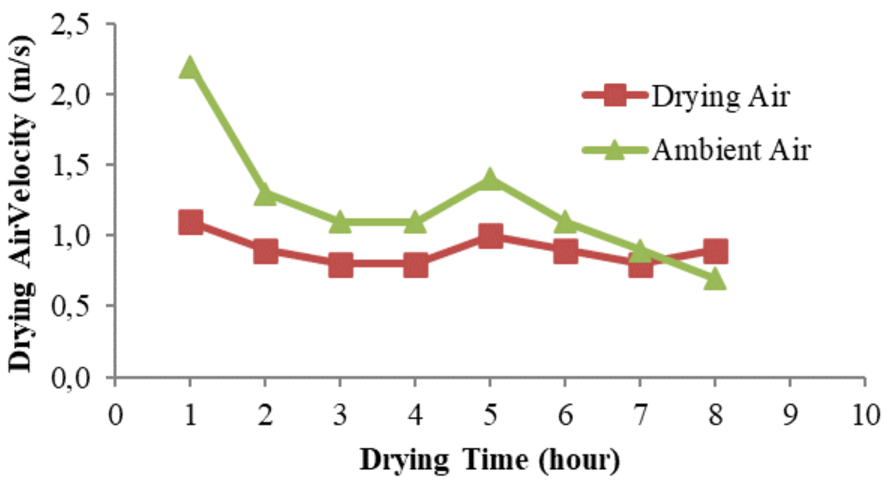

Fig. 6. Profile of drying air and ambient air velocities of YSD UNIB 2012.

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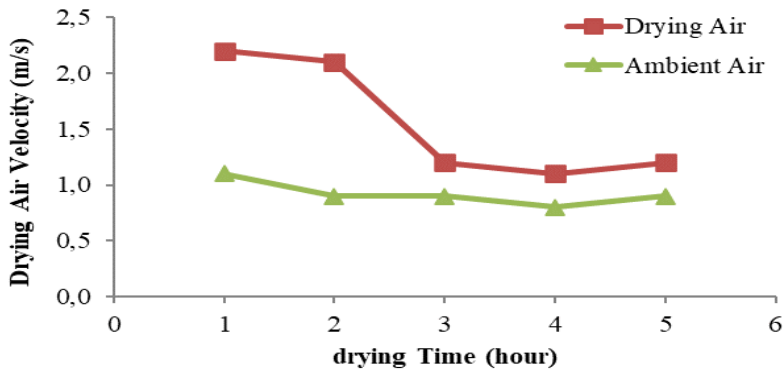

Fig. 7. Profile of drying air and ambient air velocities of YSD UNIB 2012 assisted with a fan.

Figure 6 shows that the drying air velocity in the chimney of YSD UNIB 2012 was lower than that of the ambient air whereas Figure 7 indicates that the drying air velocity in the chimney of YSD UNIB 2012 assisted with a fan was higher than that of the ambient air which leads to increase drying rate [12].

3.1.4 Drying completion time

The completion time of drying was observed until the Morina leaves reached a moisture content of less than 8% (SNI 3836: 2013) using dryers, namely an Oven, YSD UNIB 2012, and YSD UNIB 2012 assisted with a fan. The relationships between moisture content and drying time are presented in Figures 8, 9, and 10.

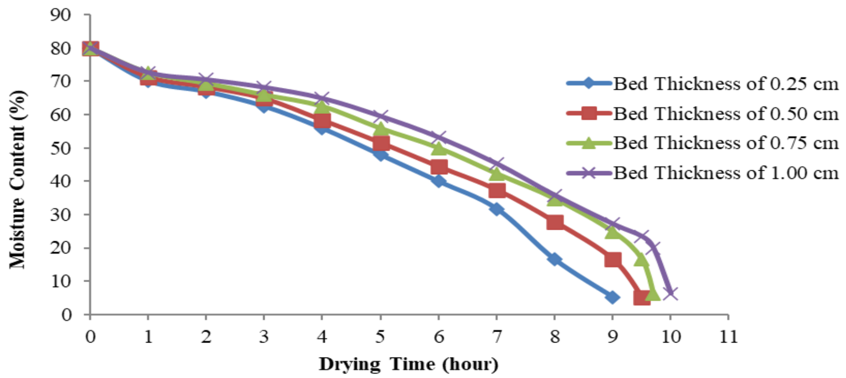

Fig. 8. Relationship between drying time and moisture content of dry Moringa leaves of oven drying.

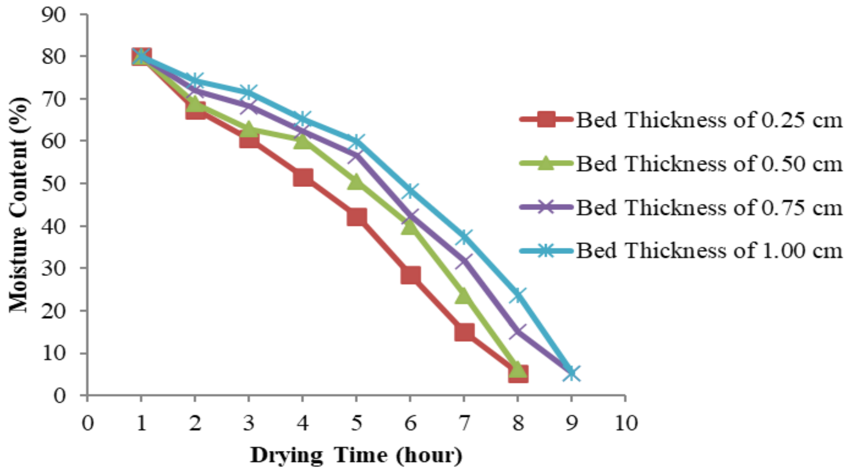

Fig. 9. Relationship between drying time and moisture content of dry Moringa leaves of YSD UNIB 2012 drying.

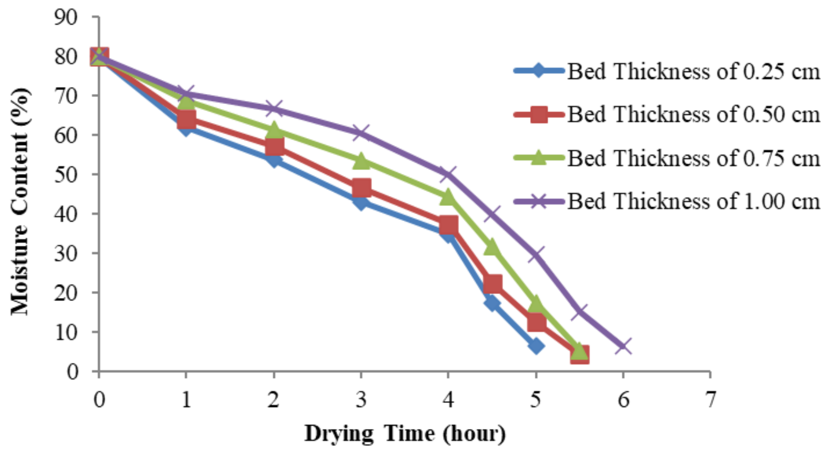

Fig. 10. Relationship between drying time and moisture content of dry Moringa leaves of YSD UNIB 2012 assisted with a fan.

Based on the three above figures, the YSD UNIB 2012 dryer assisted with a fan, and completed the drying process of Moringa leaves faster time than YSD UNIB 2012 dryer and the oven dryer. The addition of a fan on the YSD UNIB 2012 dryer can deliver heat faster to the surface of the dried Moringa leaves so that the dried material evaporates well and drying can be carried out in a shorter time. Furthermore, the capacity of the YSD UNIB 2012 dryer is larger than that of the oven dryer so operating this dryer to produce Moringa leaves dry Moringa leaves can reduce its production cost.

3.2 Physical characteristics

3.2.1 Moisture content

Moisture content has an important role in determining the characteristics and product life circle. The moisture content of the resulting dry Moringa leaves is presented in Figure 11.

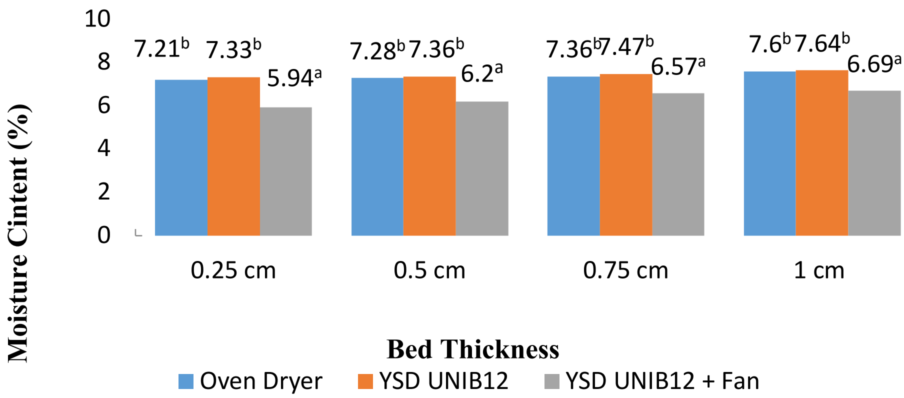

Fig. 11. Moisture content of.

Figure 11 shows that the highest moisture content was found in herbal powders produced by the YSD UNIB 2012 dryer with a thickness of 1 cm (7.64%) and the lowest moisture content was found in YSD UNIB 2012 dryer assisted with a fan with a thickness of 0.25 cm (5.94 %). The result of the ANOVA showed that the drying apparatus had a significant effect on the product with a significant level of 0.002 (<0.05), while the bed thickness did not significantly affect the moisture content with a level of 0.390 (>0.05). The DMRT test results showed that the oven dryer and YSD UNIB 2012 dryer were not significantly different, but significantly different from the YSD UNIB 2012 dryer assisted with a fan. Meanwhile, the bed thickness of 0.25 cm was not significantly different from the bed thickness of 0.5 cm, 0.75 cm, and 1 cm. The product moisture contents obtained in this experiment were better than the result reported for the drying Moringa leaves using a *cabinet drying dryer* at a temperature of 50°C that produced the dry product with 15.43% moisture content [7]. The Moringa leaves moisture contents produced by all drying methods with various bed thickness in this experiment has met INS 3836:2013 for packaged dry tea (< 8%) [10].

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3.2.2 Moringa leaf tea colour

Fig. 12. Moringa leaf herbal tea color.

In general, the *hue letter notation* of dried Moringa leaf samples was in the GY *(Green Yellow) spectrum* which meant the color of green and yellow dried Moringa leaves. The brightest color was observed from the amount of *value* and the strongest color intensity observed from the magnitude of the *chrome value* was found in the sample in the YSD UNIB 2012 assisted with a fan with a bed thickness of 0.25 cm (see Figure 12). Suggested that the higher the temperature used for drying, the darker the color produced. The color of the tea was influenced by the color of leaf pigments, namely chlorophyll, carotenoids, and tannins [13]. Direct sunlight drying caused green in color began to fade to brown, aerated drying changed green in color to reddish, and 40°C oven drying transformed green in color to yellow, due to the process of chlorophyll degradation from the herbal leaves [14].

3.3 Chemical characteristics

3.3.1 Ash content

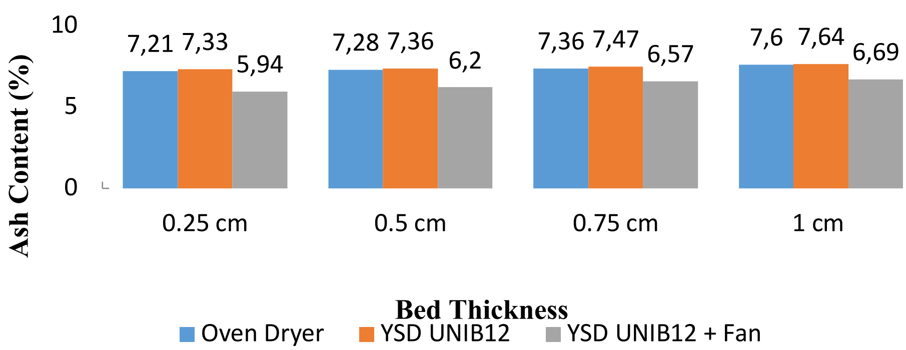

Fig. 13. Ash content of.

Based on Figure 13, the results of the ANOVA test showed that the drying method and the bed thickness had no significant effect on the ash content with significant levels of 0.098 (<0.05) and 0.651 (>0.05) respectively. The treatment that had a significant effect was continued with the DMRT test. The highest ash content of dry Moringa was found in the oven drying with a value of 7.78% while the lowest ash content was found in YSD

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UNIB 2012 drying with a value of 4.89%, both values were higher than the ash content reported by Syafrida et al. [15] which were 16.33% obtaining from oven drying at 40°C and 14.34% obtaining from oven drying at room temperature of 28-29°C. The higher the drying temperature produced the higher the ash content [15]. The ash contents met the maximum value of ash content of 8% prescribed by INS 3836:2013 for packaged dry tea [10].

3.3.2 Flavonoids

Flavonoids have anti-oxidative, anti-inflammatory, anti-mutagenic, and anti-carcinogenic properties, as well as the ability to modulate the function of major cellular enzymes. The content of flavonoids in Moringa leaf extract *(Moringa Oleifera)* was identified by yellow, red, and orange spots after adding HCL and magnesium powder. Moringa leaves were highest in the sample of the YSD UNIB 2012 dryer assisted with a fan and the lowest was found in the sample of the oven dryer. The presence of flavonoids in the puzzle grass as much as 4.84 mg/g, 4.80 mg/g, and 3.98 mg/g when the leaves were dried at temperatures of 30°C, 40°C, and 50°C respectively, suggesting that the flavonoids content tends to decrease because of the oxidation process [15].

3.3.3 Phenolics content

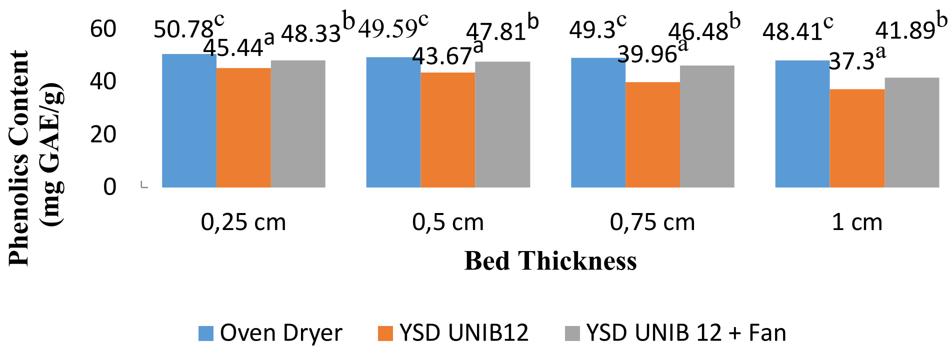

Fig. 14. Phenolics content of.

The results of the ANOVA test showed that the drying method and bed thickness affected the phenolic content with significant levels of 0.000 < (0.05) and 0.000 < (0.05) respectively. The DMRT test results showed that the YSD UNIB 2012 dryer was significantly different from the 2012 YSD UNIB dryer assisted with a fan and an oven, while the bed thickness of 1 cm was significantly different from the bed thickness of 0.75 cm, 0.5 cm, and 0.25 cm.

Figure 14 shows that the phenolics content of Moringa leaves in the oven dryer ranged from 50.78 - 48.41 mg GAE/g. This result was in line with the total phenol in the amount of 68.04 mg GAE/g reported by other researcher [15]. The total phenol of Moringa leaf flours produced by the cabinet drying dryer at a temperature of 50°C and 60°C were 5.15 GAE/g and 6.94 GAE/g [6]. The total phenol obtained in this experiment met INS 3836:2013 for packaged dry tea by 5.2 % [10].

3.3.4 Carotenoid content

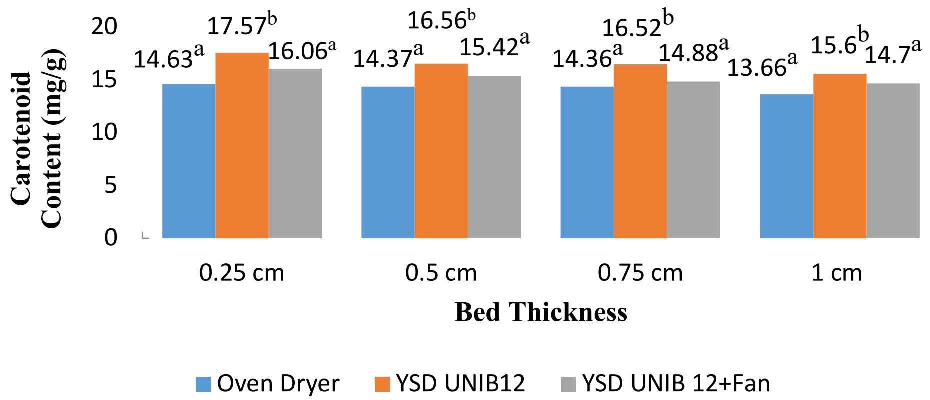

Fig. 15. Carotenoid content of.

The results of the ANOVA test showed that the drying affected the carotenoid content with a significant level of 0.005 (<0.05) whereas the bed thickness had no significant effect on the carotenoid content with a significant level of 0.057 (<0.05). The results of the DMRT test showed that the oven dryer was significantly different from YSD UNIB 2012 assisted with a fan and YSD UNIB 2012. YSD UNIB 2012 dryer produced the highest carotenoid content with a value range of 17.57 mg/g – 15.6 mg/g while YSD UNIB 2012 assisted with a value range of 16.06 mg/g – 14.7 mg/g whereas the lowest carotenoid content was found in oven dryer with a value of 14.63 mg/- 13.66 mg/g (see Figure 15).

3.3.5 Ascorbic acid content (Vitamin C)

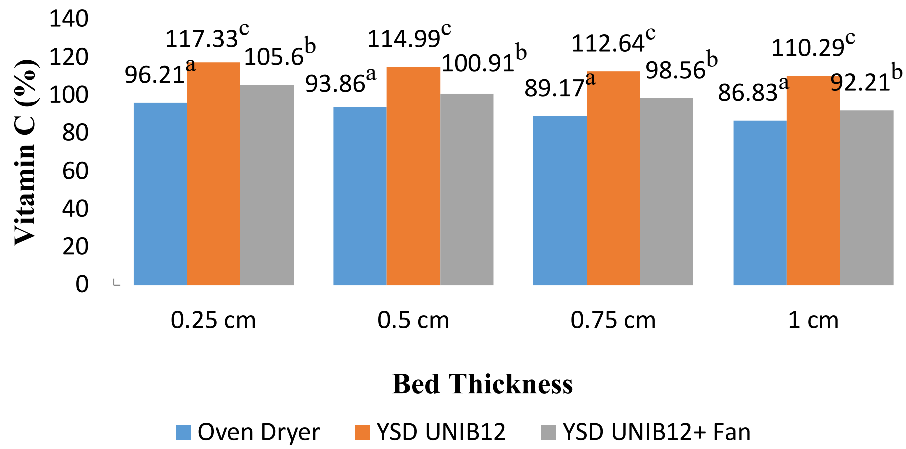

Fig. 16. Vitamin C of.

The results of the ANOVA showed that the drying method had a significant effect on the vitamin C content with a significant level of 0.035 (<0.05) while the bed thickness had no significant effect on the vitamin C content with a significant level of 0.214 (>0.05).

The result of the DMRT test showed that the oven dryer was significantly different from YSD UNIB 2012 and YSD UNIB 2012 assisted with a fan.

Figure 16 shows that the highest vitamin C content was found for YSD UNIB 2012 drying ranging from 117.333% - 110.29%, for YSD UNIB 2012 drying with the addition of a fan it ranged from 105.6% - 92.21%, and in the oven drying it ranged between 92.21% - 86.83% which is the lowest level of vitamin C. The value of vitamin C in Moringa tea bags with the addition of lemon peel was 145.39% [14]. The decrease in vitamin C was caused by the high drying temperature factor at the time of the oven. The higher the drying temperature, the vitamin C content will decrease due to damage to vitamin C compounds during the oven process.

3.3.6 Antioxidant activity

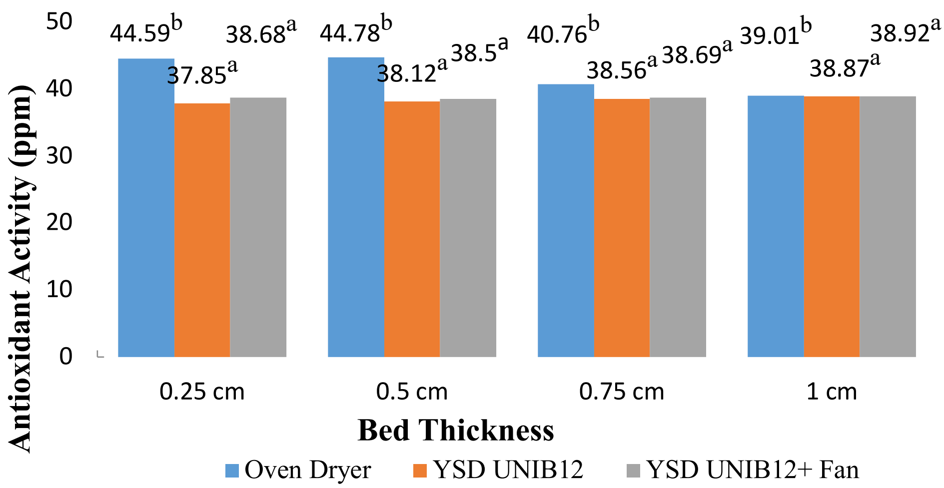

Fig. 17. Antioxidant activity of.

The results of the ANOVA test indicated that the drying method and bed thickness had no significant effect on the antioxidant activity with a significant level of 0.098 and 0.325 (> 0.005) respectively. Antioxidant activity expressed by IC value[50] ranged from 37.88 ppm - 38.87 ppm (Very strong) for YSD UNIB 2012, from 3.68 – 38.92 ppm (Very strong) for YSD UNIB 2012 assisted with fan, and from 44.59-39.01 ppm (Strong) for oven dryer. The antioxidant content of 49.86 g/ml of Moringa leaves was obtained using methanol extraction [16]. Stated that the drying process can reduce the active substances contained in food affecting the antioxidant activity (see Figure 17).

3.4 Organoleptic assessment

Scores given by the panelists for color, smell, flavor, and overall are presented in Figures 18, 19, 20, and 21.

3.4.1 Colour

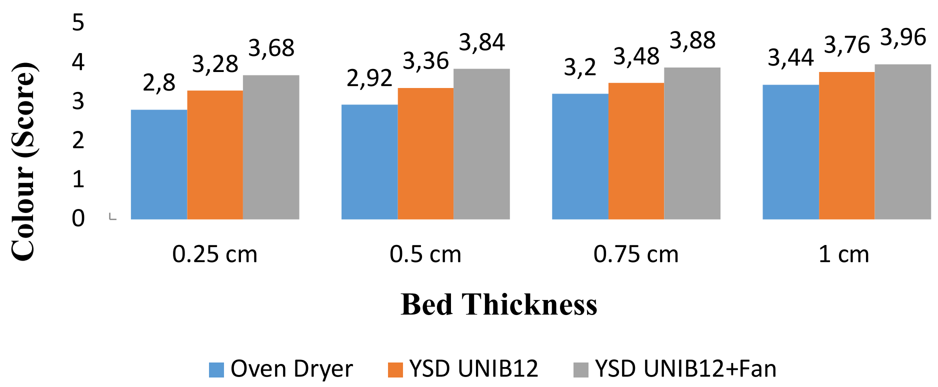

Fig. 18. The organoleptic score for color.

From Figure 18 panelist's scores for the color of Moringa leaves produced by YSD UNIB 12 dryer assisted with a fan, YSD UNIB 12 dryer, and oven dryer were in the range of 3.68 - 3.96 (like enough), 3.28 - 3.76 (neutral - quite like) and 2.8 – 3.44 (dislike – quite like). Friedman *test* resulted in a significant value of 0.002 (< 0.05) indicating that there was a difference in the average level of preference of the panelists on the color of dry Moringa leaves. The results of the color test showed average panelists in the category of quite liking. The steeping of Moringa leaves herbal was yellowish green which indicated that Moringa leaf tea was included in the green tea organoleptic quality requirements of SNI 3945: 2016.

3.4.2 Smell

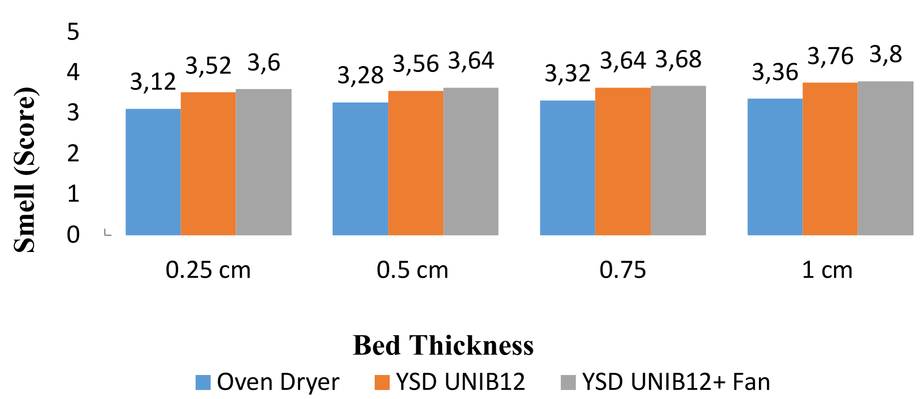

Fig. 19. The organoleptic score for the smell.

Figure 19 shows that the panelist's highest level of preference for the smell of was found in the YSD UNIB 12 dryer assisted a fan in the range of 3.6-3.8 (Like) followed by that of YSD UNIB 12 which was 3.52 - 3.76, Like). The lowest panelist's level of preference was found in oven-drying with a value range of 3.12 – 3.36 (quite like).

Friedman *test* resulted in a significant value of 0.553 (< 0.05) indicating that there was a difference in the average level of preference of the panelists for the smell of dry Moringa leaves. They produced a distinctive odor which is recognized in the quality standard of dry tea in packaging SNI 3836:2013 that tea has a distinctive green tea smell that meets the organoleptic quality requirements of green tea described in SNI 3945:2016 [10].

3.4.3 Flavor

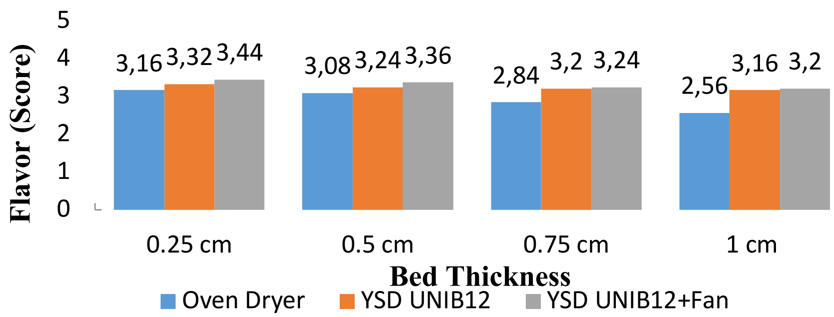

Fig. 20. The organoleptic score for flavor.

Based on Figure 20, the taste of food and drink is a sensory attribute related to the components in the material which will be captured by the sense of taste (tongue). The highest panelist preference for flavor was obtained by YSD UNIB 2012 with a preference level ranging from 3.6 – 3.32 (like) followed by YSD UNIB 2012 dryer assisted with a fan with a preference level of 3.44 – 3.32 (quite like) and oven dryer with a preference level ranging from 3.16 – 2.56 (neutral – disliked). Friedman *test* resulted in a significant value of 0.003 (< 0.05) which indicated that there was a difference in the average level of panelists' preference for the taste of dry Moringa leaves. The taste of dry Moringa leaves was associated with astringent compound corresponding to antioxidant compounds such as saponins, tannins, and flavonoids. Saponins are glycosides in plants consisting of steroids and triterpenoids, which have a bitter taste [13]. Some of the flavonoid content also affects the taste of food products significantly had a distinctive taste described on the quality standard of dry tea in tea packaging of INS 3945: 2016.

3.4.4 Overall rating

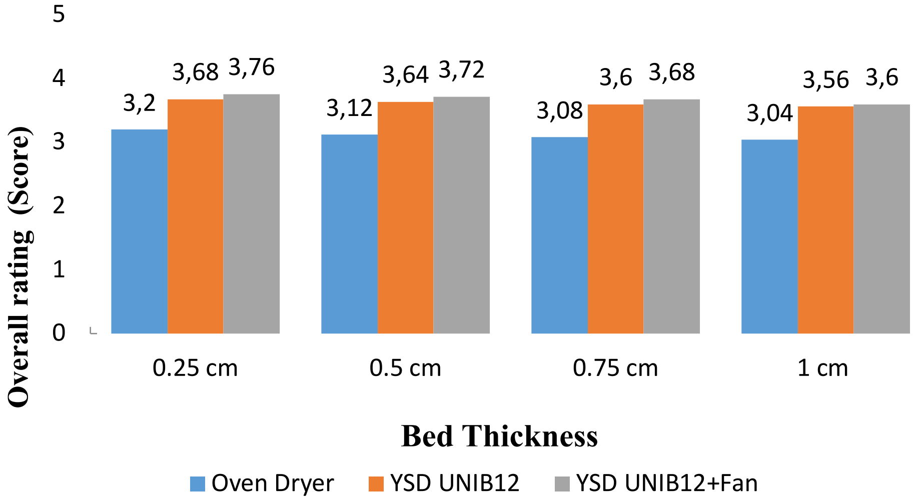

Fig. 21. The organoleptic score for the overall rating.

Based on Figure 21, the highest preference score by the panelists for overall rating was given for the produced YSD UNIB 2012 dryer assisted with a fan. The results showed that there was a relationship between chemical characteristics and the organoleptic assessment. Stated that catechin compounds do not exhibit color but generate properties that can dissolve in the water bringing bitter and astringent properties and a distinctive smell to steeping tea. The color of Moringa leaf herbal tea is influenced by chlorophyll pigments, flavonoids, and carotenoids. The astringent taste is caused by the presence of catechin and tannin compounds. Tannins that do not present tanning properties and agglomerate proteins generate an astringent taste in a product [16].

4 Conclusion

The drying method had a significant effect on the drying rate of Moringa leaves. YSD UNIB 2012 dryer assisted with a fan and was able to dry the sample within 5 hours only. The drying method had a significant effect on water content, ash content, total phenol, carotenoids, and ascorbic acid (Vitamin C) antioxidant activity. The bed thickness was only affected by the flavonoid compound where the highest value was found in the sample of the YSD UNIB 2012 dryer assisted with a fan. The drying method affected the organoleptic assessment. The best color and flavonoid content were found obtained in YSD UNIB 2012 dryer assisted a fan.

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