Physicochemical Characteristics and Antioxidant Activities of God's Crown Fruit (*Phaleria macrocarpa*) with Variation of Roasting Processes

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Abstract

Roasting process is the most important process in processing Phaleria macrocarpa (also called as Mahkota Dewa/God's Crown) into dried tea product. It aims to change the color, texture, and reduce the water content of Phaleria macrocarpa to extend the shelf life and simplify the distribution and serving process. This study aims to determine the effects of temperature and time in the roasting process on the physicochemical properties of Phaleria macrocarpa including water content, color, texture, and their effect on antioxidant activity (AOA) using DPPH method. The design experiment for this study was by varying the treatments at temperature of 80°C, 100°C, and 120°C and time at 40, 60, and 80 minutes in the process of roasting Phaleria macrocarpa fruit. Furthermore, the tea of Phaleria macrocarpa produced in each treatment and the standard samples from the industry were analyzed for its physicochemical properties and antioxidant activities. The results of multiple regression analysis showed that the correlation coefficient (r value) between the variables of temperature and time on water content, color, and AOA was 0.827; 0.944; and 0.886 respectively. Increasing temperature and roasting time caused a decrease in water content, color and AOA; however, multiple regression analysis showed a weak correlation between temperature and time on the texture of Phaleria macrocarpa with a correlation coefficient (r value) of 0.095. The best treatment based on research that has been done was found at a temperature of 100°C for 60 minutes with a total score of effectiveness index (EI) of 0.688. In this treatment it was found the average water content at 1.31 ± 0.20%, lightness at 21.80, redness at 5.10, yellowness at 9.65, texture at 1.16 kgf, and AOA at 82.33 ± 0.30%. Meanwhile, the best physicochemical characteristics and AOA based on the effectiveness index showed results close to the standard sample test values. The slight difference was found in the value of the water content in which at the same temperature and roasting time it showed different values between the test samples and standard samples. The water content in standard samples showed a higher value, probably due to poor storage process. Hence, it is deemed necessary to improve the storage process of Phaleria macrocarpa tea product on industrial scale.

***Keywords**: antioxidant activities, color, Phaleria macrocarpa tea, physicochemical properties, roasting, texture, water content*

1. INTRODUCTION

Phaleria macrocarpa also known as Mahkota Dewa/God's Crown has been so long known as the fruit that has various excellences for health such as to reduce the risk of coronary heart disease, lowering blood pressure, curing rheumatic diseases, and controlling cholesterol level in blood, and used as an alternative treatment for breast cancer, prevent infections associated with periodontal disease, and has antioxidant and anti-inflammatory activities (Abed, 2020; Suksmanto in Dumanauw et al., 2020; Hasim et al., 2020; Radita and Widyarman, 2019; and Nunsio et al., 2019). *Phaleria macrocarpa* originates from Papua, growing in the tropics with an altitude of 10-1,200 meters above sea level. All parts of the plant consisting of roots, stems, leaves and fruit contain the compounds beneficial to the body, especially the fruit. In the past, before knowing the benefits of *Phaleria macrocarpa*, people considered this fruit to be poison due to the content of toxic compounds in it. However, today, *Phaleria macrocarpa* has gone through a processing process to remove toxic compounds making it safe to be consumed and the public can feel the benefits. Most of the compounds contained in agricultural product often called as divine drug are

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antioxidants such as saponins, flavonoids, and alkaloids. Qualitatively, the fruit of *Phaleria macrocarpa* contains several active substances such as detoxifying alkaloids, which are able to neutralize toxins, saponins useful as antibacterial and antiviral, reduce blood sugar level, reduce clotting, flavonoids function as antioxidants, and polyphenols that can act as antihistamines (Fiana and Oktaria, 2016; Novitasari and Putri, 2016; Kurang and Malaipada, 2021). However, *Phaleria macrocarpa* contains toxic compounds, namely lignan compounds, which can have an adverse effect on health. This fruit contains poison when consumed fresh or raw. If *Phaleria macrocarpa* is consumed freshly or raw, it can cause swelling and canker sores in the mouth (Rosa and Yulistiana, 2019). Therefore, in its processing it requires a proper handling, especially in its function in removing toxic compounds without reducing its physicochemical properties*. Phaleria macrocarpa* can be consumed in the form of tea, which can be combined with green tea and tea parasites made in dry form to make them lasting longer. Tea parasites is one of hemiparasite that lives on tea plant that suspected as an imustimulator agent (Yulianti et al., 2018)

The steps of processing *Phaleria macrocarpa* into tea consists of sorting, cutting, drying and roasting. The main process in utilizing *Phaleria macrocarpa* become dried tea is drying and roasting. The drying process acts to remove any toxic elements contained in the fruit flesh. It is carried out to reduce the water content in the material, so that it can inhibit the growth of microbes, fungi and unexpected reactions and can extend the shelf life (Aziz and Akolo, 2019). The roasting process, meanwhile, is carried out to kill the bacteria that stick during drying and can help to remove toxins existing in the seeds and flesh of *Phaleria macrocarpa* (Harmanto, 2005). The drying process on agricultural materials aims to reduce the water content in it. Reducing the water content can make molds and bacteria cannot easily overgrow the material, which prevents enzyme activity that could harm the active ingredient content (Wirawan and Utama, 2020).

Roasting is a process of providing heat energy to the material through a medium with large pressure accompanied by rotation of the roasting tool media to enable the absorption of heat energy to be evenly carried. Nazura, et al. (2022) stated that roasting is a process of heating a food product at high temperatures without the use of oil. It is done in a closed manner to provide a large pressure of heat energy allowing it to greatly affect the characteristics of the material physically and chemically. Roasting highly determines the color and taste of the product to be produced. Changes in physical and chemical properties occurred during the roasting process include the changes such as swelling, water evaporation, formation of volatile compounds, caramelization of carbohydrates, protein denaturation (Herlina, 2022). The higher the temperature and the longer the roasting time, the darker the color will be (Agustina et al., 2019). Temperature and roasting time also affect the texture of the processed material. The higher the temperature and the longer the roasting time, the more water content to be lost from the material so that the texture of the materials produced is getting drier and more brittle (Irmayanti, et al., 2017; Fikri, et al., 2021). Therefore, all the attributes in the roasting process greatly affect the output of the resulting materials.

According to Angelia (2018), the process of roasting coffee with various temperatures can cause some changes in the physical properties of the coffee beans, including a faster decrease in water content, an increase in brittleness and accelerating change for dark color. Another researcher, Yusdiali (2013) also stated that temperature and roasting time had a very significant effect on the water content and acidity level of Robusta coffee. According to Chruz in Utami, et al. (2017), the longer the roasting time, the lower the antioxidant activities. Based on some of these statements, it is deemed necessary to do research on the effects of temperature and roasting time on the physiochemical properties and antioxidant activities of *Phaleria macrocarpa*, and to find out the best temperature and time in the process of roasting *Phaleria macrocarpa*.

2. MATERIAL AND METHODS

2.1 Materials

The material used in this study was *Phaleria macrocarpa* (God's Crown). The first material used was a sample of *Phaleria macrocarpa* roasted in the industry at XYZ company in Kulonprogo and it was then used as the standard sample. The second material was 600 grams of dried *Phaleria macrocarpa* to be then roasted in accordance with the temperature and time variations

determined. Dried *Phaleria macrocarpa* obtained by conventional drying method using air for 2-3 days then followed by sun drying for about 3-6 days.

2.2 Method

Roasting was done using a roasting tool with a tool capacity of 1000 grams. This process used time variations that is 40, 60, 80 minutes, while the temperatures used were at 80°C, 100°C, and 120°C. For one process with one roasting temperature, it used 300 grams of dried *Phaleria macrocarpa*. Then, it was continued by sampling using 100 grams of roasted *Phaleria macrocarpa* taken in each time variation. Industrial samples are the samples roasted in the industry using a waiting heater with a capacity of 20 kg with a roasting temperature of 100°C for 60 minutes in accordance to standard process condition in the industry. In this study, checking temperature was conducted using mercury thermometer every 10 minutes. During the roasting process, the roasting tool must be continuously rotated to make the heat energy able to be evenly distributed. The design of roasting process in this research is presented in Table 1.

Table 1. Research Design of Roasting Process

Variation of Temperatures and Times	80°C	100°C	120°C
40 minutes	C_1M_1	C_2M_1	C_3M_1
60 minutes	C_1M_2	C_2M_2	C_3M_2
80 minutes	C_1M_3	C_2M_3	C_3M_3

2.2.1 Method of Testing Water Content

Testing the water content was carried out by weighing a sample of 2 grams of roasted *Phaleria macrocarpa* for each type of treatment. This test used the dry basis water content as the calculation was done with the difference in weight after drying. Testing the water content was done through the thermogravimetric method using an oven at temperature 105 °C for 50 minutes and then by calculating the difference in weight before and after baking. If the difference in weight after drying was above 0.02 gram, it must be re-baked for 50 minutes until the weight became constant. Then, the water content was calculated based on SNI on the Method of Testing Food and Beverages for testing water content (SNI 01-2891-1992). The calculation performed is presented as follows.

$$\text{Water Level} = \frac{W}{W_1} \text{ x } 100\% \quad (1)$$

Remarks: W = weight before being dried (g)
W_1 = difference of weight after being dried (g)

2.2.2 Color Testing Method

Color parameters were measured using a colorimeter type Konica Minolta Color Reader CR-10 by placing the sample on the light sensor and the results of the analysis would be displayed on the screen. The results of testing the quantitative color were seen based on the value of L (lightness), a (redness), and b (yellowness) on a scale of 0-100. The value of L indicated the level of brightness of the color or black and white, the value of a indicated the level, i.e. –a representing green and +a representing red. The b value indicated the color level, i.e. –b representing blue and +b representing yellow.

2.2.3 Texture Testing Method

Texture parameters were measured using the Brookfield CT3-100 Texture Analyzer tool that has been connected to a computer supported with texture analyzer software. The uniaxial compression test was carried out on a tea sample from *Phaleria macrocarpa* mounted on a platform. Samples were compressed at 30 mm/minute. The results of the analysis were displayed on the computer in graphic form and a list of outputs. The data taken was the hardness value indicating the hardness level of the sample in grams-force units.

2.2.4 Antioxidant Activity Testing Method Using DPPH

Antioxidant testing was carried out quantitatively using the DPPH method, which is one of radical scavenging assay methods widely used in determining antioxidant activity (AOA). Handayany et al. (2018) stated that DPPH compounds are stable free radicals at room temperature, frequently used to evaluate the AOA of several compounds or extracts of natural materials. They further explained that the interaction of antioxidants with DPPH either by transferring electrons or hydrogen radicals in DPPH would neutralize the character of free radicals in DPPH and if all the electrons in the DPPH free radicals become paired, the color of the solution changes from dark purple to bright yellow (Jami'ah, et al., 2018). The AOA test was carried out twice with repetition using the DPPH method quantitatively. The sample of extracted *Phaleria macrocarpa* used in one test was 2 mg, which was dissolved in 20 mL methanol. 5 mL of the supernatant was added as the AOA control, which was then mixed using a vortex. Then it was incubated in a dark room for 30 minutes to maximize the AOA process in the sample. The absorbance subsequently was measured using a spectrophotometer with a wavelength of 517λ. Based on the results of data analysis in spectophotometry, the calculation of the activity of capturing radiation was done as follows.

$$\text{Radiation capturing activity} = \frac{A_b - A_s}{A_s} x\ 100\% \qquad (2)$$

Remarks: Ab = control absorbance (µg/mL)
As = sample absorbance (µg/mL)

Control absorbance refers to the supernatant absorbance, which is incubated without any addition of samples/antioxidants. The results of the AOA test are expressed as a percentage, which indicates the level of antioxidants present in the sample of roasted *Phaleria macrocarpa*. According to Artanti and Lisnasari (2018), the results of testing the DPPH method are expressed quantitatively with 50% Inhibitory Concentration or IC_{50} as the concentration of antioxidants required to capture 50% of DPPH radicals within a range of certain time. The greater the results of the analysis, the greater the AOA in the sample.

2.3 Analysis and Evaluation Method

Data processing was done by creating a table containing data from the results of testing the parameters for water content, color, texture, and AOA along with the average value and standard deviation of each parameter. Furthermore, the table of the data from the test results was processed into a diagram to show a comparison of the average value of each parameter based on the variables of temperature and roasting time. Data from the test results of the four parameters from each sample were then processed using regression analysis with the table of Anova Two Ways and multiple regression utilizing software using Statistical Product and Service Solutions (SPSS). Regression analysis was used to determine the degree of closeness of the relationship between variables and parameters of physiochemical properties and AOA.

ANOVA analysis was carried out to determine the significance level of the test results data based upon the variations in temperature treatment and roasting processing time. The data taken were from the table of Test of between-subject effect, i.e. the F count results and the significance value (Sig.F) indicating the data probability. The data taken included the significance value of the variables of temperature and time as well as the interaction between the two variables affecting the physicochemical properties of the *Phaleria macrocarpa*. The ANOVA table shows the significance level of the relationship between variables. The value of Sig.F>0.05 indicated a high level of closeness of the relationship, while the value of Sig.F<0.05 indicated a low level of significance. In addition, there was the assessment of the hypothesis: H0 and H1 in which H0 indicated that the average test result for a variable was equal and H1was the average test result for each variable, at least one was different. If the significance value is >0.05; then H0 is accepted, whereas if <0.05; then H0 is rejected or H1 is accepted. If H0 is rejected and H1 is accepted, it means that the variables have a simultaneous and significant relationship (Nugroho, 2011).

Multiple regression is a regression analysis used to determine the closeness level of the relationship between the dependent variable and two or more independent variables. The multiple

regression analysis aims to make predictions about the estimation of X value (independent variable) and Y indicates the binding variable. These variables are written in the equation:

$$Y = a + b_1X_1 + b_2X_2 + ... + ... \quad (3)$$

Remarks: Y = Dependent variable
A = Constanta
b_1b_2 = Regression Coefficient
X_1X_2 = Independent variable

Y value or the dependent variable showed the value of the data from the test results for each test parameter, including water content, color, texture and antioxidant activities. X value or independent variable indicated the values of temperature and time during the roasting process. Multiple linear regression had two independent variables where X_1 referred to the variable temperature and X2 referred to the variable of length of roasting time. The results of multiple regression data in this analysis were used to determine the regression relationship and the straight line equation between the variables of temperature and roasting time with the test parameters (water content, color, texture, and antioxidant activities). The level of relationship or regression can be seen in the table of model summary on the R value. Then the analysis was also carried out on the R^2 value or the squared correlation value showing to what extent the factor of independent variable determined the dependent variable (Hidayat, 2012).

Furthermore, an analysis was carried out to determine the best roasting treatment using the effectiveness index method. The effectiveness index (EI) is a method aimed to determine the best treatment of the sample based upon the weight of the values used in the test parameters. Each parameter has a different value weight based upon the priority scale of the importance of the parameters in the sample quality test. Principally, it was to determine the observation parameters based upon priority, which was then determined by weight by determining the lowest value (Ntr), the highest value (Ntt) and the treatment value (Np) so that the effectiveness value (EI) can be calculated with the equation:

$$EI = \frac{(N_p - N_{tr})}{(N_{tt} - N_{tr})} \quad (4)$$

Remarks: EI = Effectiveness value
N_p = Treatment value
N_{tr} = Lowest value
N_{tt} = Highest value

3. RESULTS AND DISCUSSION

3.1. Variation in the process of roasting the Teh Mahkota Dewa

The sample used was roasted *Phaleria macrocarpa* in the industry of PT. XYZ with 3 times of proces, each of which 50 grams was used as the standard raw material for *Phaleria macrocarpa* in the industry. In addition, the sample of 600 grams of dried *Phaleria macrocarpa* was also taken for further roasting process based on variations in temperature and time.

The roasting process was carried out using a roasting tool with a tool capacity of 1000 grams. The process used time variations of 40, 60 and 80 minutes, while the temperature variations used included 80°C, 100°C and 120°C. Variation of temperature and time resulted in 9 treatments: C1M1, C1M2, C1M3, C2M1, C2M2, C2M3, C3M1, C3M2, and C3M3. In this study, industrial samples were used as control samples with a temperature of 100°C and a time of 60 minutes. In the roasting process at 80°C, 200 grams of dried *Phaleria macrocarpa* were used, and then after reaching 40 minutes, 70 grams of roasted *Phaleria macrocarpa* as the sample were taken. Sampling of 70 grams of roasted *Phaleria macrocarpa* was also carried out when the roasting process reached 60 minutes and 90 minutes. At temperature variations of 100°C and 120°C samples were also taken with the same time variation and method. The heat source for the roaster came from a stove with a fairly stable temperature. The temperature was checked

using a mercury thermometer in every 10 minutes. During the roasting process, the roasting tool must be continuously rotated to make the heat energy distributed evenly. The results of the process of roasting *Phaleria macrocarpa* are presented in Table 2.

Table 2. Appearances of Roasted *Mahkota Dewa* during 40, 60 and 80 minutes

	40 minutes	**60 minutes**	**80 minutes**
80°C	 C_1M_1	 C_1M_2	 C_1M_3
100°C	 C_2M_1	 C_2M_2	 C_2M_3
120°C	 C_3M_1	 C_3M_2	 C_3M_3

3.2. Changes in the Water Content of *Phaleria macrocarpa*

Water content is closely correlated to water activity (aW), which is shown by the tendency that the higher the water content, the higher the aW value (Lisa, et al., 2015). In general, foodstuffs that have a high aW content deteriorate rapidly both due to microbial growth and due to certain chemical reactions such as oxidation and enzymatic reactions. Fig. 1 shows the water content of *Phaleria macrocarpa* with variations in temperature and roasting time.

As shown in the table and diagram above, there were a number of differences in water content of *Phaleria macrocarpa* in various treatments with differences in temperature and roasting time. The water content of the material tended to decrease, based on both temperature and roasting time. Overall, it can be seen that the highest water content was found in the C1M1 treatment or by roasting at 80°C for 40 minutes and the lowest one was found at 120°C for 80 minutes. Based on the results of the research above, it can be seen that the higher the temperature and the longer the roasting time, the lower the water content of the material, although there were deviations in the increase in water content in some treatments. This is in line with research conducted by Manfaati, et al. (2019) that the higher the temperature, the greater the heat energy carried by the air, so that the greater the amount of liquid mass evaporated, the lower the resulting water content. In addition to temperature, drying time also plays an important role in determining the water content of a material. The longer a material in direct contact with heat, the lower the water content will be. According to Nugroho et al. (2009), heat causes a change in the mass of water, where the water content in the material has reached a saturated condition, causing the water contained in the material to change from the liquid phase to vapor. The data that have been obtained were then processed using ANOVA in which its results showed that each treatment with variation of temperatures and times had the different average of water content. The interaction between temperature and time was 24.99 with a probability of 0.000 (Sig.F<0.05). It can be concluded that the average of water content for the interaction of temperature and time was dissimilar

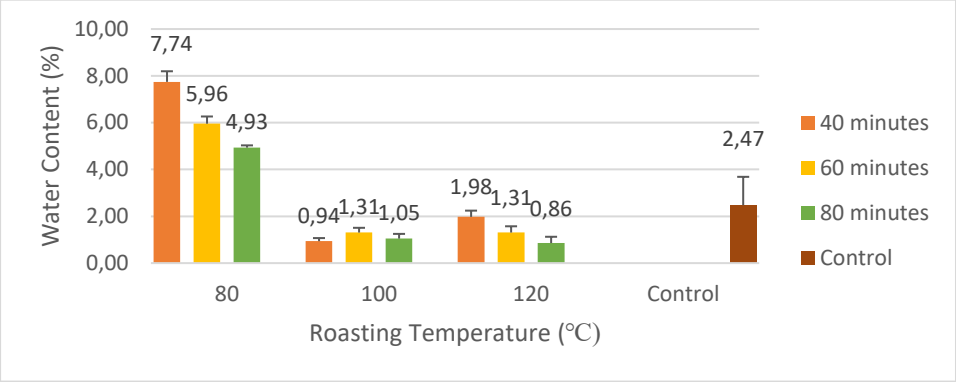


Figure 1. The change of water content of *Phaleria macrocarpa* during 40, 60, 80 minutes

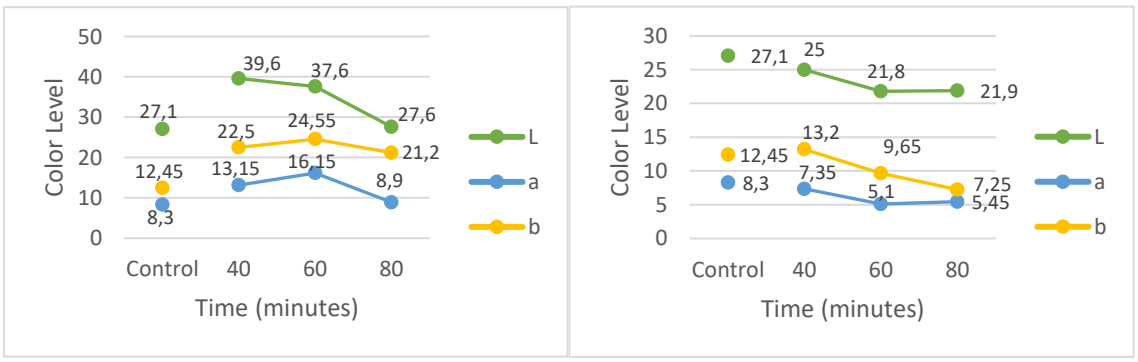
The next analysis carried out was multiple regression analysis of temperature and roasting time on water content of *Phaleria macrocarpa*. The analysis showed a strong correlation between temperature and time on the water content of *Phaleria macrocarpa* as indicated by the value of the correlation coefficient or r value of 0.827. The simultaneous contribution of the dependent variables of temperature and roasting time to water content was indicated by the R^2 value of 68.40%, while 32.60% came from other factors. It was then continued to overall analyze the significance level of the multiple correlation coefficient. Based on the table above, the probability value (Sig.F change) was 0.000. Because the Sig.F change value was 0.000 (Sig.F<0.05), then H0 was rejected and H1 was accepted. Based on these results it can be concluded that temperature and roasting time had a simultaneous and significant relationship to the water content in *Phaleria macrocarpa*. Straight line equation analysis was also carried out to determine the relationship between temperature and roasting time on the water content of *Phaleria macrocarpa*. The results of this analysis then formed the following equation.

$$Y = 9.001 + (-2.416)\, X_1 + (-0.637)\, X_2 \qquad (5)$$

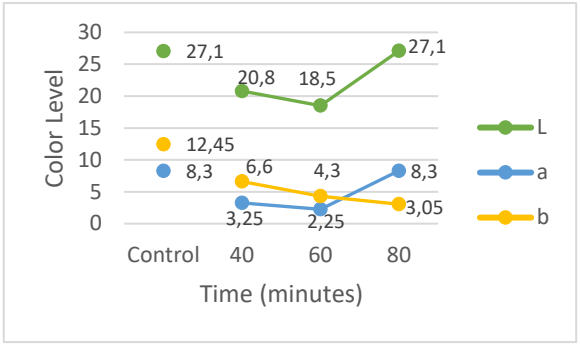
This equation indicates that every change in temperature (X1) resulted in a decrease in the water content (Y) of *Phaleria macrocarpa* by 2.42% with an assumption that the roasting time variable was of a fixed value. In addition, every change in roasting time (X2), there was a decrease in the water content of *Phaleria macrocarpa* by 0.64% by assuming that the temperature variable was a constant value.

3.3. The Change of the Color of *Phaleria macrocarpa*

Testing the color of *Phaleria macrocarpa* was done using a colorimeter and the test results had three assessment components including the values of L, a, b with a scale of 0-100. The L value indicated the brightness level with a white to black color index, the value of a indicated the level of –a greenish color and +a reddish. The b value referred to the color level, namely –b as bluish and +b as yellowish. Changes in color levels (L, a, and b) can be seen in Fig. 2 below.



a) b)



c)

Figure 2. Test of the color of *Phaleria macrocarpa* in the roasting process: a) at 80°C; b) at 100°C; and c) at 120°C

3.3.1 Lightness Value (L)

As shown in Fig. 2 the sample of *Phaleria macrocarpa* roasted at 80 °C for 40 minutes had the brightest color appearance compared to other samples, including the control which had a lightness score (L) of 27.10. ANOVA analysis showed that each treatment of temperature and time variations had a different average brightness level. The interaction between temperature and time was 18.88 with a probability of 0.000 (Sig.F<0.05). It can be concluded that the average brightness level for the interaction of temperature and time was dissimilar.

The next analysis carried out was multiple regression analysis of temperature and roasting time on the color of *Phaleria macrocarpa*. Multiple regression analysis showed a strong correlation between temperature and time on the brightness level (L) of the *Phaleria macrocarpa*, as indicated by the correlation coefficient or r value of 0.957 it was accepted. Based on these results it can be concluded that temperature and roasting time had a simultaneous and significant relationship to the level of brightness (L) on *Phaleria macrocarpa*. Straight line equation analysis was also carried out to determine the relationship between temperature and roasting time on the brightness level of the *Phaleria macrocarpa* in which the results of the analysis can be seen in the following equation.

$$Y = 92.289 + (-4.993)\, X_1 + (-1.860)\, X_2 \qquad (6)$$

This equation means that for every increase in temperature (X1), there was a decrease in the color brightness (Y) of *Phaleria macrocarpa* by 4.993 L by assuming that the roasting time variable was of a fixed value. In addition, each increase in roasting time (X2), there is a decrease in the color brightness (L) of *Phaleria macrocarpa* sample by 1.86 by assuming that the temperature variable had a constant value.

3.3.2 *Redness* value (a)

The redness value indicates the level of redness with the score of greenish -a and the score of reddish +a. As shown in Fig. 3 on the independent variable temperature of the roasting process it can be seen that the value of a tends to experience a significant decrease. In the independent variables based on the length of roasting time it did not show any significant change. The results of the analysis of the color scale of *a* showed that the higher the temperature and the longer the roasting time, the smaller the value of a, meaning that the color of the sample would change from green to reddish (dark). The ANOVA results showed that each treatment with temperature and time variations had a different average redness. The interaction between temperature and time was 318.06 with a probability of 0.000 (Sig.F<0.05). It can be concluded that the average redness for the interaction of temperature and time was dissimilar.

The next analysis carried out was multiple regression analysis of temperature and roasting time on the reddish *Phaleria macrocarpa*. Multiple regression analysis showed a strong correlation between temperature and time on the level of redness of *Phaleria macrocarpa*, as indicated by the correlation coefficient or r value of 0.911. Based on these results it can be

concluded that temperature and roasting time had a simultaneous and significant relationship to the level of redness in *Phaleria macrocarpa*. Straight line equation analysis was also carried out to determine the relationship between temperature and roasting time on the redness of *Phaleria macrocarpa* in which the results of the analysis can be seen in the following equation.

$$Y = 18.506 + (-4.900)\ X_1 + (-0.317)\ X_2 \qquad (7)$$

This equation indicates that in every increase in temperature (X1) there was a decrease in the level of redness (a) of *Phaleria macrocarpa* (Y) of 4.90 a by assuming the roasting time variable had a fixed value. In addition, in each increase in roasting time (X2), there was a decrease in the level of redness (a) of *Phaleria macrocarpa* by 0.371 a assuming the temperature variable had a constant value.

3.3.3 Yellowness value (b)

The b value indicated the level of yellowness with bluish -b and yellowish +b values. Based on the independent variable of temperature of the roasting process, it can be seen that the value of b tended to insignificantly decrease. The independent variables based on the length of roasting time did not show a significant change. The results of the b color scale analysis showed that the higher the temperature and the longer the roasting time, the smaller the b value, meaning that the color of the sample changed from blue to yellowish (dark). The results of the ANOVA showed that each treatment of temperature and time variations had a different average color level of yellowness. The interaction between temperature and time was 50.11 with a probability of 0.000 (Sig.F<0.05). It can be concluded that the average yellowness for the interaction of temperature and time was different.

The next analysis carried out was multiple regression analysis of temperature and roasting time on the yellowness of *Phaleria macrocarpa*. Multiple regression analysis showed a strong correlation between temperature and time on the level of yellowness of *Phaleria macrocarpa*, as indicated by the value of the correlation coefficient or r value of 0.956. Based on these results it can be concluded that temperature and roasting time had a simultaneous and significant relationship to the level of yellowness in *Phaleria macrocarpa*. Straight line equation analysis was also carried out to determine the relationship between temperature and roasting time on the level of yellowness of *Phaleria macrocarpa*. The results of the straight line equation analysis can be seen in the following equation.

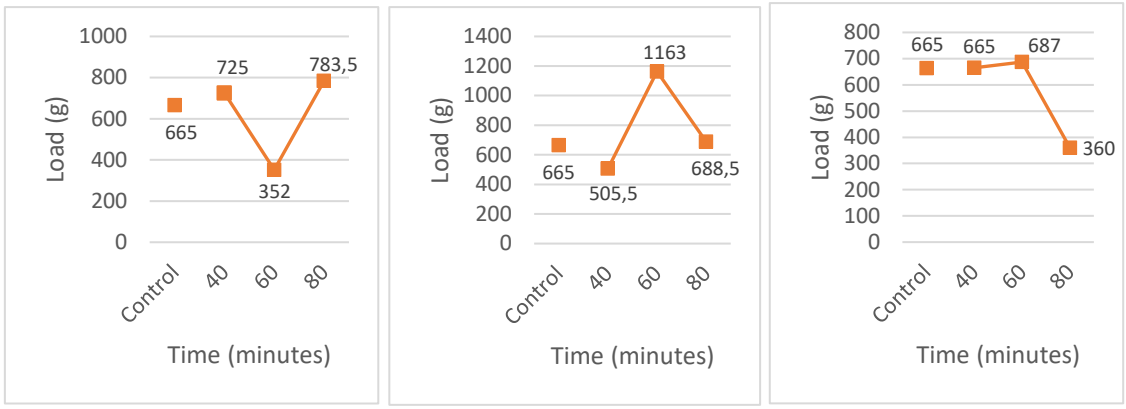
$$Y = 34.133 + (-9.050)\ X_1 + (-1.783)\ X_2 \qquad (8)$$

This equation indicates that in every increase in temperature (X1) there was a decrease in the level of yellowness (Y) of 9.05 b assuming that the roasting time variable had a fixed value. In addition, in each increase in roasting time (X2), there was a decrease in the level of yellowness of *Phaleria macrocarpa* by 1.78 b assuming that the temperature variable had constant value.

The results of color measurements showed that most of the samples experienced a decrease in the value of L, a, b where the color of the samples became black. The change in the color of *Phaleria macrocarpa* in the roasting process was due to the Maillard reaction causing a decrease in the brightness level of the material to become brown or darker. According to Palungan, et al. (2018), the Maillard reaction is a non-enzymatic browning reaction that produces complex compounds with high molecular weights. The Maillard reaction results in the appearance of compounds with a carbonyl group (reduction group) and an amino group. According to Wiljeng and Wikandari (2013), roasting with high temperatures and a long time can cause damage to carbohydrates, i.e. the occurrence of non-enzymatic browning reactions (Maillard reaction) and caramelization. The Maillard reaction occurs due to a reaction between the amino group of a protein and the carboxyl group of a reducing sugar producing a brown material.

3.4. The Change in the Texture of *Phaleria macrocarpa*

According to Hardiman in Ariani, et al. (2019), food texture testing aims to identify the proper texture parameters that must be an attribute of food quality. These food's texture have an impact on product quality, which ultimately affects consumer acceptance of these food products. Hence, an analysis of texture changes was carried out in the process of roasting *Phaleria macrocarpa*. Fig.3 presents the data of texture test results.



a) b) c)

Figure 3. Graph of Roasted *Phaleria macrocarpa* Texture Value: a) at 80°C; b) at 100°C; and c) at 120°C

Texture testing was carried out using the Texture Analyzer tool with one repetition in which the data taken was the hardness value or the strength level of the material. As shown in the table and diagram above, it can be seen that there were differences in the texture of *Phaleria macrocarpa* with differences in temperature and roasting time. The texture of the material tended to decrease, based on both temperature and roasting time. The results of texture testing, in terms of analysis based on temperature and roasting time, had a hardness value that tended to decrease.

The highest hardness value was at 80°C for 40 minutes, i.e. 1.16 kgf, and the lowest one was for the sample of *Phaleria macrocarpa* treated at 80°C for 60 minutes. Based on these data it can be seen that the temperature and time of the roasting process affected the texture of *Phaleria macrocarpa*. The higher the roasting temperature, the lower the hardness of *Phaleria macrocarpa* texture. It was similar with the time variable, the longer the roasting time, the lower the texture hardness level or the higher the fragility of *Phaleria macrocarpa* sample, even though there was an increase in the test results data on several treatments.

The results of data on the decrease the hardness of roasted *Phaleria macrocarpa* based on temperature and roasting time referred to research conducted by Nugroho (2009) on samples of coffee beans. Materials were getting softer at temperature variations during roasting. Materials roasted at higher temperatures will have lower hardness stresses. On the other hand, the material roasted at a lower temperature will have a higher average rupture stress. Furthermore, Nugroho et al (2009) added that the higher the temperature, the lower the hardness of the material. This proves that the roasting temperature affects the hardness value of the material. The temperature used for roasting affects the rate of decrease in the water content in the material, which in turn will also affect the rate of change in product hardness. When the temperature is higher, the water content will drop faster so that the coffee becomes more brittle.

The next analysis carried out was multiple regression analysis of temperature and roasting time on the texture of the *Phaleria macrocarpa*. Multiple regression analysis showed a weak correlation between temperature and time on the texture of *Phaleria macrocarpa*, as indicated by the correlation coefficient or r value of 0.095. The simultaneous contribution of the dependent variables of temperature and roasting time to the level of hardness was 9% in terms of the R^2 value in the form of a percentage, while 91% came from other factors. Based on these results, it can be concluded that temperature and roasting time had a non-simultaneous and significant relationship to the hardness level of *Phaleria macrocarpa*. Straight line equation analysis was also carried out to determine the relationship between temperature and roasting time on the texture of the *Phaleria macrocarpa* and the results of the analysis can be seen in the following equation.

$$Y = 0.729 + (-0.025)\, X_1 + (-0.011)\, X_2 \qquad (9)$$

This equation means that in every increase in temperature (X1), there was a decrease in the level of texture hardness (g) of *Phaleria macrocarpa* (Y) by 0.025 kgf assuming that the variable roasting time had a fixed value. In addition, in each increase in roasting time (X2), there was a decrease in the texture level of hardness (g) of *Phaleria macrocarpa* by 0.011 kgf assuming the temperature variable had a constant value

3.5. Changes in the Antioxidant Activities of *Phaleria macrocarpa*

Antioxidants are the compounds that function to inhibit any oxidation processes and free radical attacks both in human body and in plants. *Phaleria macrocarpa* contains several antioxidant compounds that have many benefits for the body such as saponins, polyphenols, sintocinone, antihistamines, oxytocin (Sugiwati, 2005). Antioxidant activity testing was carried out using the DPPH method with two repetitions. Based on the research regarding the effect of temperature and roasting time on the antioxidant activity of *Phaleria macrocarpa*, it was found that there were some differences in each variable of the roasting process treatment. The level of antioxidant activities of *Phaleria macrocarpa* with differences in temperature and roasting time can be seen in the diagram in Fig. 4.

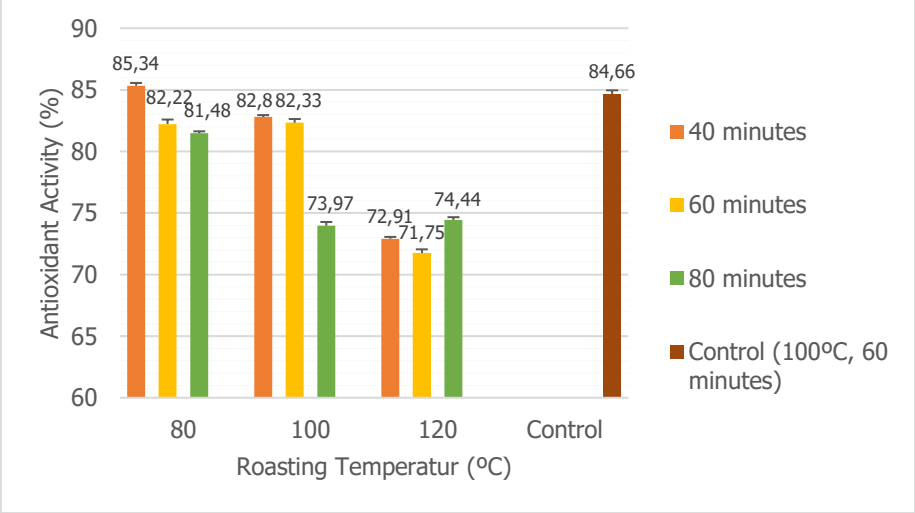


Figure 4. Antioxidant activities of *Phaleria macrocarpa* at 40, 60, and 80 minutes

Based on the diagram and table above, the temperature and length of roasting time affected the antioxidant activities of antioxidant activities of *Phaleria macrocarpa*. It can be seen that, in the independent variable roasting temperature, the highest antioxidant activity was at 80 °C with a roasting time of 40 minutes, i.e. 85.44%, while the lowest one was at 120 °C with 60 minutes, i.e. 71.53%. Changes in antioxidant activities based on roasting time tended to be more stable and had only a slight difference. In roasting with the independent variable of process temperature, it showed a quite significant change of reduction.

According to Dwiyanti et al (2014), an increase in processing temperature to storage can cause damage and rapid changes in anthocyanins through various stages. Changes in antioxidant levels are due to the hydrolysis of the anthocyanin glycosidic bonds and produce unstable aglycones. According to Husna, et al. (2013), the best heating process to prevent damage to antioxidants and other flavonoids is processing with high temperatures, but within a short period of time. This is because the heating time in the frying process is shorter than the time required in the boiling, steaming and drying processes.

The analysis of the significance level of the relationship between variables subsequently was carried out using Anova Two Ways. From the ANOVA results, each treatment with temperature and time variations had the different average antioxidant activities. The interaction between temperature and time was 318.03 with a probability of 0.000 (Sig.F<0.05). It can be concluded that the average antioxidant activities for the interaction of temperature and time is different.

The next analysis carried out was multiple regression analysis of roasting temperature and time on the antioxidant activities of antioxidant activities of *Phaleria macrocarpa*. Multiple regression analysis showed a strong correlation between temperature and time on the antioxidant activities of antioxidant activities of *Phaleria macrocarpa*, as indicated by the correlation coefficient or r value of 0.886. The simultaneous contribution of the dependent variable of temperature and roasting time to antioxidant activities was 78.55% as seen from the R2 value in the form of a percentage, while 21.45% came from other factors. Based on these results it can be concluded that temperature and roasting time had a simultaneous and significant relationship to the antioxidant activities of *Phaleria macrocarpa*. Straight line equation analysis was also carried out to determine the relationship between temperature and roasting time on the antioxidant activities of *Phaleria macrocarpa* and the results of the analysis can be seen in the following equation.

$$Y = 92.289 + (-4.993)\ X_1 + (-1.860)\ X_2 \qquad (10)$$

This equation shows that each increase in temperature (X1) results in a decrease in the level of antioxidant activities (Y) of 4.99% assuming the roasting time variable had a fixed value. In addition, in each increase in roasting time (X2), there was a decrease in antioxidant activities of 1.86% assuming that the temperature variable had a constant value of.

3.6. Optimal Treatment Determination Effectiveness Index

The test results of the sample of *Phaleria macrocarpa* with the treatment of differences in temperature and roasting processing time variables were then analyzed using the Effectiveness Index (EI) to determine the best roasting treatment. The effectiveness index is a method that aims to determine the best treatment of the sample based on the weight of the values used in the test parameters. Table 3 presents the results of the analysis of the Effectiveness Index of *Phaleria macrocarpa*.

Table 3. Effectiveness Index of *Phaleria macrocarpa* at temperatures of 80ºC and 100ºC for 40, 60, 80 minutes

No	Sample		Effectiveness Index (EI)				
	Temperature	Time	EI Antioxidant	EI Water Level	EI Color	EI Texture	Total
1	80ºC	40 minutes	0.650	0.000	0.011	0.023	0.683
2		60 minutes	0.501	0.057	0.000	0.000	0.558
3		80 minutes	0.465	0.071	0.023	0.027	0.586
4	100ºC	40 minutes	0.529	0.047	0.060	0.009	0.645
5		60 minutes	0.506	0.055	0.077	0.050	0.688
6		80 minutes	0.106	0.209	0.085	0.021	0.421
7	120ºC	40 minutes	0.056	0.228	0.092	0.019	0.395
8		60 minutes	0.000	0.250	0.100	0.021	0.370
9		80 minutes	0.129	0.200	0.095	0.000	0.425
10	Control (100ºC, 60 minutes)		0,617	0.013	0.061	0.019	0.710

The analysis was carried out by comparing the weight value of antioxidant activities 65%, water content 20%, color 10%, and texture 5%. The weighted percentage was based on the results of interviews with the owners of PT XYZ. Based on the results of the analysis of the effectiveness index with the measurement parameters (antioxidant activities, water content, color and texture), it can be seen that the highest test score was in the roasting treatment at 100ºC for 60 minutes with a final score of 0.688. In this treatment each parameter had an effectiveness

index score, including antioxidant activities at 0.506; water content at 0.055; color at 0.077 and texture at 0.050.

Then it was followed by a temperature treatment of 80ºC for 40 minutes with a score of 0.683, a temperature of 100ºC for 40 minutes with a score of 0.645, while the lowest result was the roasting treatment with a temperature of 120ºC for 60 minutes with a score of 0.370. Meanwhile, the industrial sample (100ºC for 60 minutes) had the highest score compared to the roasting treatment during the study with a score of 0.710. The sample of *Phaleria macrocarpa* in industry had an antioxidant activities of 0.617; water content at 0.013; color at 0.061 and texture at 0.019. This showed that the roasted *Phaleria macrocarpa* at PT XYZ already has a good process treatment, compared to the results of various treatments during the study.

4. CONCLUSION

Based on the research conducted, it was found that roasting temperature and time had an effect on antioxidant activities, water content, and color (L, a, and b) of *Phaleria macrocarpa,* also know as *Mahkota Dewa* or God's Crown with a correlation level of 0.886 on each; 0.827; 0.957; 0.911; and 0.965 or included in the category of *strong correlation*. Any increase in temperature and length of roasting time resulted in a decrease in the level of antioxidant activities, water content, and a decrease in the values of L, a, and b. While the temperature and roasting time did not have much effect on the texture of *Phaleria macrocarpa* with a regression level of 0.095 or included in the category of *very weak*. The hardness level of the *Phaleria macrocarpa* texture was seen based on the thickness level and the characteristics of the sample.

The best treatment based on research that has been done was found at a temperature of 100°C for 60 minutes with a score of 0.688. In this treatment, each parameter had an effectiveness index score, including antioxidant activities at 0.506; water content at 0.055; color at 0.077, and texture at 0.050. The results of the research are compatible with the industrial roasting process, i.e. 100°C for 60 minutes.

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REFERENCES

Abed, S. O. 2020. Potential of Flavonoid in Mahkota Dewa to Reduce Sistolic and Diastolic Blood Pressure in Patient with Hypertension. Cardiovascular Cardiometabolic Journal, 1, pp. 26-30. doi: 10.20473/ccj.v1i1.2020.26-30.

Agustina, R., Nurba, D., Antono, W., & Septiana, R. 2019. Effect of roasting temperature and duration on physico-chemical properties of arabica and robusta coffee (In bahasa: Pengaruh suhu dan lama penyangraian terhadap sifat fisik-kimia kopi arabika dan kopi robusta). In Prosiding Seminar Nasional Inovasi Teknologi Untuk Masyarakat, 53(9), pp. 285-299.

Angelia, I. O. 2018. Characteristic Test of Non-Caffeinated Coffee from Papaya Seeds with Variation of Irradiation Duration (In bahasa: Uji Karakteristik Kopi Non Kafein dari Biji Pepaya Dengan Variasi Lama Penyinaran). Journal Of Agritech Science (JASc), 2(1), pp. 16-16. doi**:** 10.30869/jasc.v2i1.174.

Ariani, Y., Bintoro, N., & Karyadi, J. N. W. 2019. Kinetics of Change in Physical Quality of Mango Fruit during Freeze Drying with Pre-cooling Treatment and Slice Thickness (In bahasa: Kinetika Perubahan Kualitas Fisik Buah Mangga Selama Pengeringan Beku dengan Perlakuan Pendinginan Awal dan Ketebalan Irisan). Agritech, 39(4), pp. 298-305. doi: 10.22146/agritech.42599.

Artanti, A. N., & Lisnasari, R. 2018. Antioxidant Activity Test of Ethanol Extract of Family Solanum Leaves Using DPPH Free Radical Reduction Method (In bahasa: Uji Aktivitas Antioksidan Ektrak Ethanol Daun Family Solanum Menggunakan Metode Reduksi Radikal Bebas

DPPH). Journal of Pharmaceutical Science and Clinical Research, 2, pp. 62-69. doi: 10.20961/jpscr.v3i2.15378.

Azis, R. 2019. Antioxidant Content and Moisture Content of Quini Mango Tea (Mangifera indica) (In Bahasa: Kandungan Antioksidan dan Kadar Air pada Teh Mangga Quini (*Mangifera indica*)). Journal Of Agritech Science (JASc), 3(1), pp. 1-9. doi**:** 10.30869/jasc.v3i1.327.

Dumanauw, J. M., Minggus, R. E., Rintjap, D. S., Rumagit, B., & Maramis, R. N. 2022. Pharmacological Effects of Crown of God Plant (Phaleria macrocarpa (Scheff.) Boerl) (Literature Study) (In bahasa: Efek Farmakologi Tanaman Mahkota Dewa (*Phaleria macrocarpa* (Scheff.) Boerl) (Studi Literatur). In E-PROSIDING Seminar Nasional 2022, 1(2), pp. 157-167.

Dwiyanti, G., Febrianti, A., dan Siswaningsih, W. 2014. Effect of Temperature and Heating Time on Antioxidant Activity and Total Anthocyanin of Sweet Potato Dodol (Ipomoea batatas L) (In bahasa: Pengaruh Suhu dan lama pemanasan terhadap Aktivitas Antioksidan dan Total Antosianin Dodol Ubi Jalar (*Ipomoea batatas L*)). Jurnal Pangan. 5(2), pp. 85-95.

El Husna, N., Novita, M., & Rohaya, S. 2013. Anthocyanin content and antioxidant activity of fresh purple sweet potato and its processed products (In bahasa: Kandungan antosianin dan aktivitas antioksidan ubi jalar ungu segar dan produk olahannya). Agritech, 33(3), pp. 296-302. doi: 10.22146/agritech.9551

Fiana, N., & Oktaria, D. 2016. Effect of Saponin Content in Dewa Crown Fruit Meat (Phaleria macrocarpa) on Blood Glucose Level Reduction (in bahasa: Pengaruh Kandungan Saponin dalam Daging Buah Mahkota Dewa (Phaleria macrocarpa) Terhadap Penurunan Kadar Glukosa Darah). Jurnal Majority, 5(4), pp. 128-132.

Fikri, M. K., Prihandono, T., & Nuraini, L. 2021. Effect of Roasting Temperature and Time on Density of Robusta Coffee Beans Using a Hot Air Roasting Machine (In bahasa: Pengaruh Suhu dan Lama Waktu Penyangraian Terhadap Massa Jenis Biji Kopi Robusta Menggunakan Mesin Roasting Tipe Hot Air). Jurnal Pembelajaran Fisika, 10(1), pp. 29-35. doi: 10.19184/jpf.v10i1.18025.

Handayany, G. N., Umar, I., & Ismail, I. 2018. Formulation and Antioxidant Effectiveness Test of Botto'-Botto' Leaf Ethanol Extract Cream (Chromolaena Odorata L.) with DPPH Method (In bahasa: Formulasi Dan Uji Efektivitas Antioksidan Krim Ekstrak Etanol Daun Botto'-Botto'(Chromolaena Odorata L.) Dengan Metode DPPH). Jurnal Kesehatan, 11(2), pp. 86-90. doi: 10.24252/kesehatan.v11i2.5944.

Hasim, H., Kurniawati, S. O., Priosoeryanto, B. P., Faridah, D. N., & Puspita, R. 2020. Antiproliferation Activity of God's Crown Fruit (Phaleria macrocarpa) Extract and Fractions Against MCM-B2 Breast Cancer Cells. Journal of Applied Pharmaceutical Science, 10(3), pp. 52-58. doi: 10.7324/JAPS.2020.103006.

Herlina, Y. 2022. Effect of Roasting Temperature and Duration on the Quality of Robusta Coffee Beans (In bahasa: Pengaruh Suhu dan Lamanya Sangrai Terhadap Kualitas Biji Kopi Robusta). Agrica Ekstensia, 16(2), pp. 49-56. doi: 10.55127/ae.v16i2.118.

Irmayanti, I., Syam, H., & Jamaluddin, J. 2017. Changes in Texture of Starchy Crackers Due to Temperature and Roasting Time (In bahasa: Perubahan Tekstur Kerupuk Berpati Akibat Suhu dan Lama Penyangraian). Jurnal Pendidikan Teknologi Pertanian, 3, pp. 165-174. doi: 10.26858/jptp.v3i0.5716.

Jami'ah, S. R., Ifaya, M., Pusmarani, J., & Nurhikma, E. 2018. Antioxidant activity test of methanol extract of plantain peel (Musa paradisiaca sapientum) by DPPH method (In bahasa: Uji aktivitas antioksidan ekstrak metanol kulit pisang raja (Musa paradisiaca sapientum) dengan metode DPPH (2, 2-difenil-1-pikrilhidrazil)). Jurnal Mandala Pharmacon Indonesia, 4(1), 33-38. doi: 10.35311/jmpi.v4i1.22.

Kurang, R. Y., & Malaipada, N. A. 2021. Phytochemical Test and Antioxidant Activity of Methanol Extract of Dewa Crown Fruit Meat (Phaleria macrocarpa) (In bahasa: Uji Fitokimia dan Aktivitas Antioksidan Ekstrak Metanol Daging Buah Mahkota Dewa (Phaleria macrocarpa)). Sebatik, 25(2), pp. 767-772. doi: 10.46984/sebatik.v25i2.1353.

Lisa, M., Lutfi, M., & Susilo, B. 2015. Effect of Temperature and Drying Time on the Quality of White Oyster Mushroom Flour (Plaerotus ostreatus) (In bahasa: Pengaruh Suhu dan Lama Pengeringan Terhadap Mutu Tepung Jamur Tiram Putih (Plaerotus ostreatus)). Jurnal Keteknikan Pertanian Tropis dan Biosistem, 3(3), pp. 270-279. doi: 10.21776/jkptb.v3i3.293.

Manfaati, R., Baskoro, H., & Rifai, M. M. 2019. Effect of Time and Temperature on the Drying Process of Shallots using Tray Dryer (In bahasa: Pengaruh Waktu dan Suhu terhadap Proses Pengeringan Bawang Merah menggunakan Tray Dryer). Fluida, 12(2), pp. 43-49. doi: 10.35313/fluida.v12i2.1596.

Nazura, F., Dhafir, M., & Syafriandi, S. 2022. Design of Coffee Roasting Machine Using Electric Heating Element (Heater) and Electric Motor Drive Power (In bahasa: Desain Mesin Penyangrai Kopi Menggunakan Elemen Pemanas Listrik (Heater) dan Tenaga Penggerak Motor Listrik). Jurnal Ilmiah Mahasiswa Pertanian, 7(1), pp. 526-534. doi: 10.17969/jimfp.v7i1.19024.

Novitasari, A. dan Putri, D. Z. 2016. Isolation and Identification of Saponins in Dewa Crown Leaf Extract by Maceration Extraction (In bahasa: Isolasi dan Identifikasi Saponin Pada Ekstrak Daun Mahkota Dewa Dengan Ekstraksi Maserasi). Jurnal sains, 6(12), pp. 10-18.

Nunsio, P. N., Wenardi, K., Jayadi, T., Wuryaningsih, N. S., Danu, S. S., Siagian, J. W. 2019. Hepatoprotective Effect of A 70% Ethanol Extract of God's Crown Fruit (Phaleria macrocarpa) Against Paracetamol Hepatotoxicity in Swiss Webster Mice. Berkala Ilmiah Kedokteran Duta Wacana, 4(1), pp. 18-25. doi: 10.21460/bikdw.v4i1.127.

Palungan, M. B., Rapa, C. I., & Salu, S. 2018. Process of Coffee Processing of Arabic Powder and Physical Changes Due to Adjustment Temperature. Makassar: Prosiding SNTTM, 17, pp. 271-274.

Radita, D. C., & Widyarman, A. S. 2019. Mahkota Dewa (God's Crown) Fruit Extract Inhibits the Formation of Periodontal Pathogen Biofilms In Vitro. Journal of Indonesian Dental Association, 2(2), pp. 57-62. doi: 10.32793/jida.v2i2.404.

Riansyah, A., Supriadi, A., & Nopianti, R. 2013. Isolation and Identification of Saponins in Dewa Crown Leaf Extract by Maceration Extraction (In bahasa: Pengaruh perbedaan suhu dan waktu pengeringan terhadap karakteristik ikan asin sepat siam (Trichogaster pectoralis) dengan menggunakan oven). Jurnal Fishtech, 2(1), pp. 53-68.

Rosa, Y., & Yulistiana, D., 2019. Antibacterial Activity Test of Ethanol Extract of Dewa Crown Fruit (Phaleria macrocarpa) against Staphylococcus aureus (In bahasa: Uji Aktivitas Antibakteri Ekstrak Etanol Buah Mahkota Dewa (Phaleria macrocarpa) Terhadap Staphylococcus aureus). Jurnal Kesehatan: Jurnal Ilmiah Multi Sciences, 9(02), pp. 134-139. doi: 10.52395/jkjims.v9i02.162.

Wahdaningsih, S., Wahyuono, S., & Setyowati, E. P. 2013. Isolation and Identification of Antioxidant Compounds from Pakis Stems (Alsophila Glauca J. Sm) by DPPH Method (2, 2-Diphenyl-1-Picrylhydrazyl) (In bahasa: Isolasi dan Identifikasi Senyawa Antioksidan dari Batang Pakis (Alsophila Glauca J. Sm) dengan Metode DPPH (2, 2-Difenil-1-Pikrilhidrazil)). Jurnal Kaunia, 9(1), pp. 93-109.

Wilujeng, A. A. T., & Wikandari, P. R. 2013. Effect of Fermentation Duration of Arabica Coffee (Coffea arabica) with Lactic Acid Bacteria Lactobacillus Plantarum B1765 on Product Quality (In bahasa: Pengaruh Lama Fermentasi Kopi Arabika (Coffea arabica) dengan

Bakteri Asam Laktat Lactobacillus Plantarum B1765 Terhadap Mutu Produk). UNESA Journal of Chemistry, 2(3), pp. 1-10.

Wirawan, I. K., Kencana, P. K. D., & Utama, I. M. S. 2020. Effect of Drying Temperature and Time on Chemical and Sensory Characteristics of Tabah Bamboo Leaf Tea (Gigantochloa nigrociliata BUSE-KURZ) (In bahasa: Pengaruh Suhu dan Waktu Pengeringan terhadap Karakteristik Kimia serta Sensori Teh Daun Bambu Tabah (Gigantochloa nigrociliata BUSE-KURZ)). Jurnal BETA (Biosistem Dan Teknik Pertanian), 8(2), pp. 249-256. doi: 10.24843/jbeta.2020.v08.i02.p08.

Yulianti, R., Dimas, M., Hafiz, A., & Amalia, M. 2018. The Activity Test of Ethanol Extract Tea Parasite Herb (Scurrulla Artopurpurea) as an Immunostimulator on Wistar Strain Rat Sensititized with Sheep Red Blood Cell. Journal of Physics 970, pp. 2-7. doi: 10.1088/1742-6596/970/1/012008.