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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

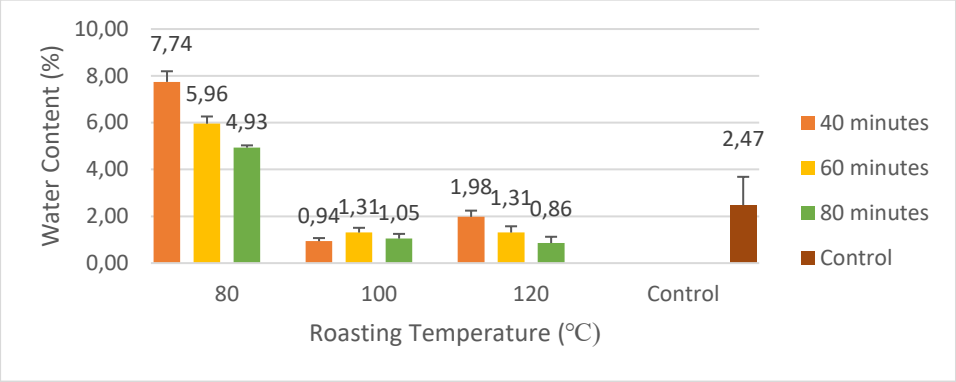


Figure 1. The change of water content of *Phaleria macrocarpa* during 40, 60, 80 minutes

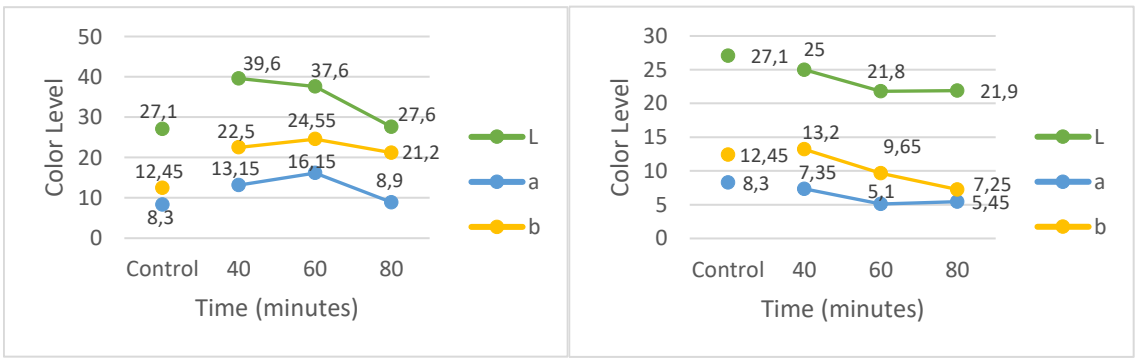
The next analysis carried out was multiple regression analysis of temperature and roasting time on water content of *Phaleria macrocarpa*. The analysis showed a strong correlation between temperature and time on the water content of *Phaleria macrocarpa* as indicated by the value of the correlation coefficient 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.

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

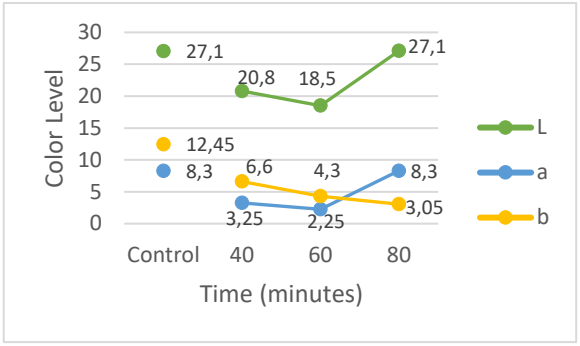
This equation indicates that every change in temperature (X1) resulted in a decrease in the water content (Y) of *Phaleria macrocarpa* by 2.42% with an assumption that the roasting time variable was of a fixed value. In addition, every change in roasting time (X2), there was a decrease in the water content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

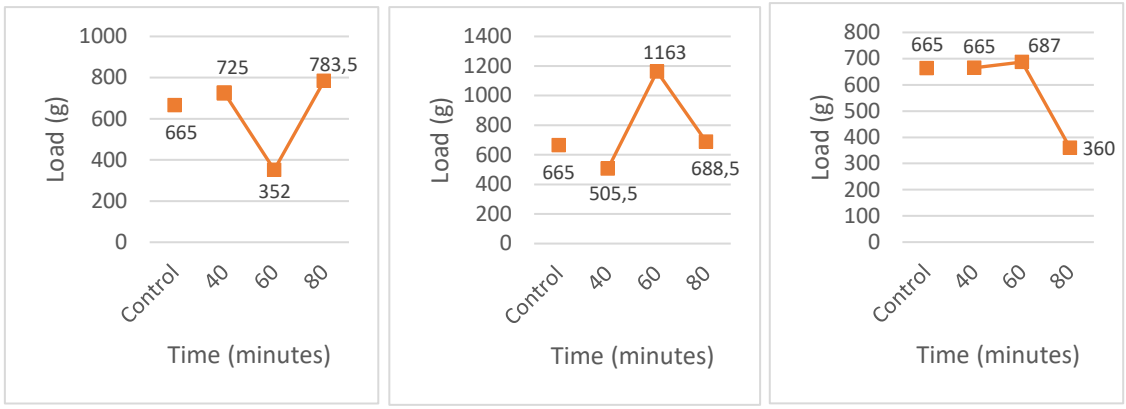
$$Y = 34.133 + (-9.050)\ X_1 + (-1.783)\ X_2 \qquad (8)$$

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.

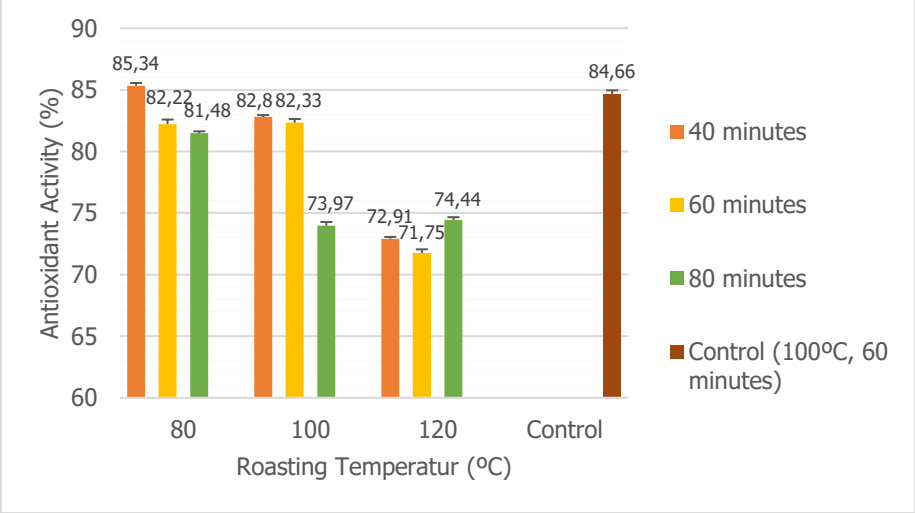


Figure 4. Antioxidant activities of *Phaleria macrocarpa* at 40, 60, and 80 minutes

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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Usability and Display Evaluation of Job Vacancy Platform (Website X and Website Y)

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Abstract

One of the impacts of the COVID-19 pandemic is the delay in face-to-face activities, one of which is the delay in holding job fair event. The reduction in the implementation of offline job fairs has encouraged job seekers to seek work through online media. Website X and Website Y are examples of websites used to find jobs online. With the current increase in find jobs through Website X and Website Y, the usability and display of their website need to be evaluated. Usability and display evaluation aims to identify usability problems and correct these problems, to increase the usability of a design. The objective of this study is to find out whether there is a significant difference of the time needed to find job vacancy between Website X and Website Y website, to find out whether there is a significant difference of the time needed to find job vacancy between male and female on both Website X and Website Y website, and to find out user perspective on both Website X and Website Y website related to system aspects, user aspects, and interaction aspects by using usability questionnaire. The advantage of this research is that it can help website developers by pointing out areas that require development or improvement. Other than that, this study might provide suggestions for job vacancy websites that are more user-friendly. Based on the results of the study it was found that Website X and Website Y had problems related to user perceptions of the safety of using the website, user comfort with using colors on the website, and the user's ability to remember menus and website appearance. The results also show that there is a significant difference between the time needed to carry out activities on Website X and Website Y.

Keywords: *Display, job, usability, website*

1. INTRODUCTION

Indonesia is one of the countries affected by the ongoing Corona virus 2019 (COVID-19) pandemic throughout the world. This disease is caused by the SARS-CoV-2 virus (Yunus and Rezki, 2020). The positive case of COVID-19 in Indonesia itself was detected for the first time on March 2 2020. The COVID-19 pandemic has hampered several face-to-face activities, one of which is job fair activities. A job fair is a place where the company's Human Resource and Development (HRD) and job seekers meet in one place. Fortunately, currently job vacancy advertising information services are very easy to find on online media. With technology, it makes it easier for companies to recruit employees online with e-recruitment. According to In Marwansyah (2012), e-recruitment is a practice and activation carried out by organizations by utilizing various electronic means to fill vacant positions or positions effectively and efficiently. Information on job vacancy advertisements can be posted on social media or websites, for example Website X and Website Y.

According to Widiantoro (2020) Website X is a leading provider of job vacancy information in Asia which was founded in 1997 in Malaysia. The company acts as a facilitator of job matching and communication between job seekers and employers, in Malaysia, Philippines, Singapore, Indonesia and Vietnam. Website X's vision is to connect business with talent and improve lives through better careers. Meanwhile, Website Y is a career development and recruitment platform in Southeast Asia which was founded in 2013 in Singapore. Media job search online is used by many people. Therefore, the media must be able to meet the needs and be comfortable for use by users.

With the current increase in e-recruitment, user interface need to be user friendly, easy to learn, and easy to use so that computer use is more effective and efficient. Usability is related to the

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level of ease, understanding, use and effectiveness of a software or system. Usability plays an important role in user interface design. Therefore, a high level of usability is very important in designing software interfaces. Usability and display evaluation is a part that must be done in designing software, especially user interfaces where humans currently interact with computers, especially in this research is for user to find a job. Usability and display evaluation aims to identify usability problems and correct these problems, so as to increase the usability of a design. Interface design with good usability will help users carry out their activities (Tjandra, 2011). For this reason, The objective of this study is to find out whether there is a significant difference of the time needed to find job vacancy between Website X and Website Y website, to find out whether there is a significant difference of the time needed to find job vacancy between male and female on both Website X and Website Y website, and to find out user perspective on both Website X and Website Y website related to system aspects, user aspects, and interaction aspects by using usability questionnaire.

2. MATERIAL AND METHODS

The research was conducted by experimenting with carrying out several tasks on Website X and Website Y which were then followed by filling out a questionnaire. The sample of this study were 12 student, which are 6 women and 6 men. Sample selection was done by purposive sampling. Purposive Sampling is a Nonprobability Sampling Techniques that a researcher uses to choose a sample of subjects/units from a population. Although nonprobability sampling is not a good representative of the population due to several weaknesses coming from its subjective sample selection process, it can nevertheless be useful in situations where randomization is not feasible, such as in very large populations. When a researcher is working with limited funds, time, or staff, it may be helpful. It can also be applied in situations when the goal of the study is not to produce findings from which broad generalizations about the population can be made (Etikan et al., 2016). Consequently, nonprobability sampling approaches must be used.

This research was carried out during the pandemic and had to be completed within 2 weeks, so researchers had limited space, relations, and time in determining research subjects. Therefore, this research only examined 12 research subjects which are have final semester student as their backgrounds during the pandemic. Those samples were selected because after completing their education, they will look for job vacancy through online. Therefore, this study was done by purposive sampling with limited respondent.

In collecting data, respondent were asked to perform several tasks on Website X and Website Y. The web order used by each respondent was randomized to avoid bias from the learning effect. The time required for each respondent to complete each task was measured using a stopwatch. The following is the task performed. This section should explain how the research was conducted. It should be detailed to describe the procedure. The given tasks for the respondent shown in the Table 1.

Table 1. Tasks given to the respondent

Number	Task
1	Looking for job vacancy in Jakarta
2	Filter jobs that have been found with a minimum salary of IDR 1,000,000.00.
3	Filter job type into Internship
4	Filter by job vacancies that have been found in the last 7 days
5	Filter the job vacancies found by the most recent date.

After completing the tasks on both sites, respondents were asked to fill out a usability questionnaire. Usability is a qualitative analysis of how easy it is for users to use the interface of an application. An application is called usable if its functions can be carried out effectively, efficiently and satisfactorily (Firmansyah, 2018). The questionnaire consists of 11 questions that assess system aspects, user aspects, and interaction aspects. Each question is scored by using likert scale, on a scale of 1 to 5. The interpretation of each scale shown in Table 2, and the questions used for the questionnaire shown in Table 3.

Table 2. Likert scale interpretation

Scale	Meaning
1	Strongly Disagree
2	Disagree
3	Neither Agree or Disagree
4	Agree
5	Strongly Agree

Table 3. Questions on the Questionnaire

Aspect	Number	Question
System Aspects	1	Is the website interface easy to recognize?
	2	Is the website easy to operate?
	3	What is the color display on the website comfortable to look at and not boring?
User Aspects	4	Is the menu display on the website easy to recognize?
	5	Is the information on the website easy to find?
	6	Is the writing easy to read?
	7	Are the existing symbols, icons and images easy to understand?
Interaction Aspects	8	Is it easy to access the information offered?
	9	Are the functions offered fit the purpose?
	10	Is the security of the website guaranteed?
	11	Is the menu and appearance of the website easy to remember?

Data of tasks completion time then used in the MANOVA test to determine whether there is a difference in processing time on Website X and Website Y, whether there is a difference in processing time between female and male respondents on Website X, and whether there is a difference in processing time for female and male respondents on Website Y. The results of the questionnaire are used to evaluate the usability of Website X and Website Y. The results of the assessment are also used to provide recommendations for display improvements at Website X and Website Y. Figure 1 shows the stages of the research.

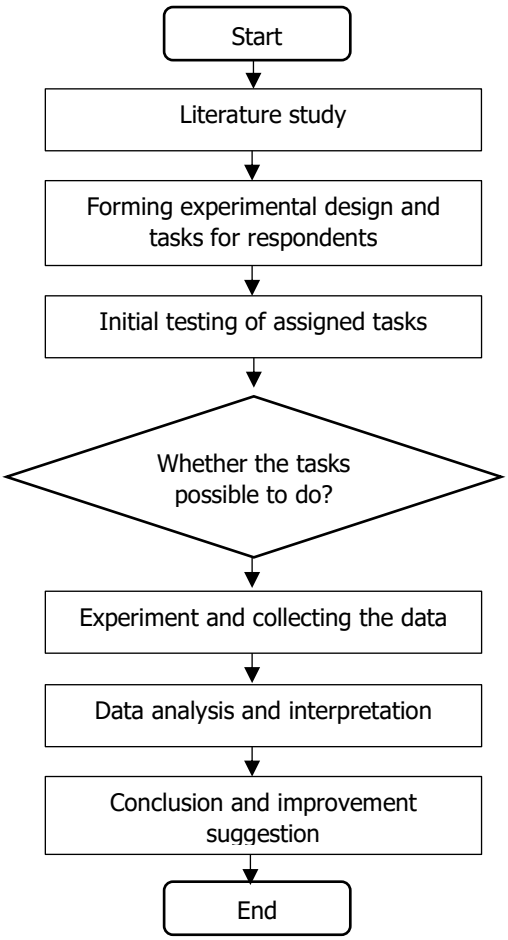

Figure 1. Research Stages

3. RESULTS AND DISCUSSION

3.1 Comparison of Task Completion Time of the Website X and Website Y Website

The data obtained from the experiment and questionnaire were tested using MANOVA. Task completion time on the Website X and Website Y Website shown in Table 4 and Table 5 respectively. Based on the MANOVA test results, the significance value of Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root was 0.007. This value is less than 0.05 so it can be concluded that there is a difference in the time needed to complete tasks on the Website X and Website Y websites.

The significance value obtained in the Tests of Between-Subjects Effect for task 1 was 0.692, task 2 was 0.009, task 3 was 0.669, task 4 was 0.279 and task 5 was 0.525. sig. value Tasks 1, 3, 4 and 5 are more than 0.05 so there is no difference in time to complete tasks 1, 3, 4 and 5 on the Website X and Website Y websites. The sig value on task 2 is less than 0.05 so it can be concluded that there is a difference in time to complete task 2 on the Website X and Website Y websites.

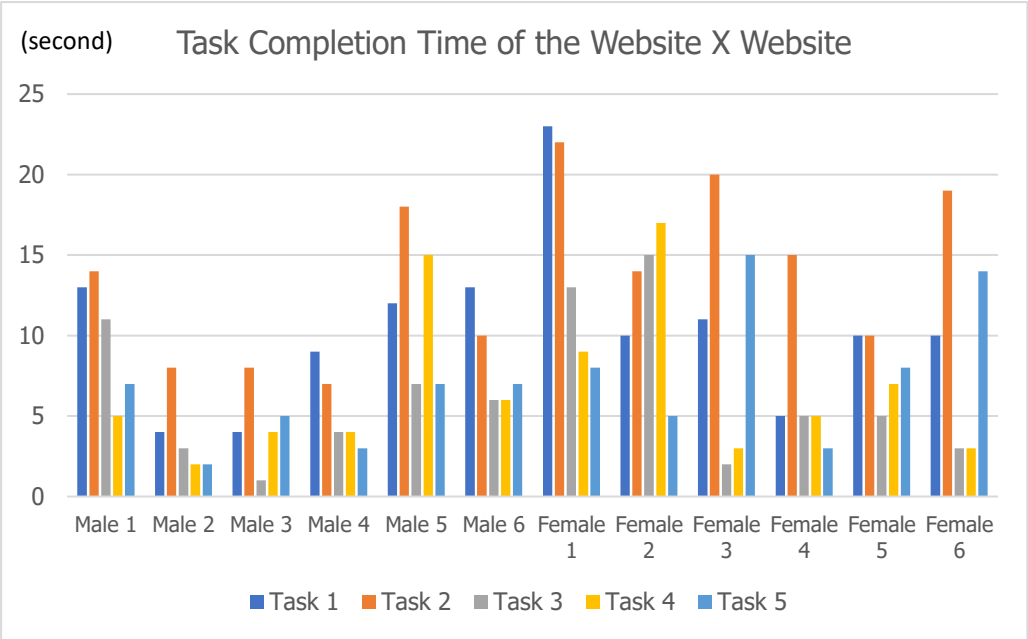

Figure 2. Task Completion Time of the Website X Website

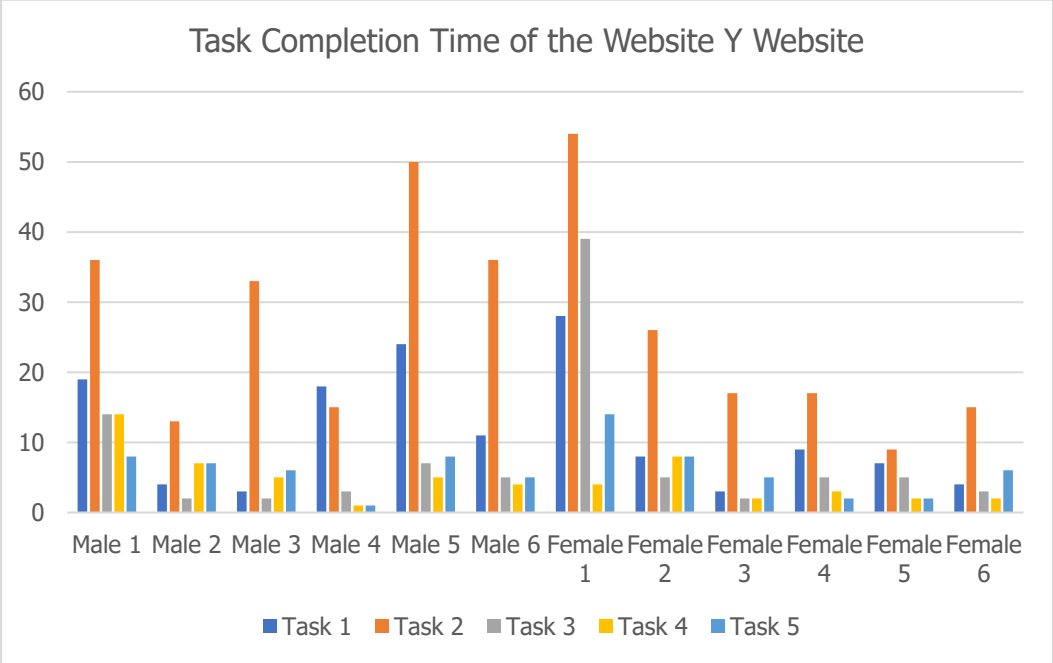

Figure 3. Task Completion Time of the Website Y Website

Task 2 is to filter a minimum salary of IDR 1,000,000.00. Based on descriptive analysis, the average time needed to complete task 2 on the Website Y website is 26.75 seconds while on Website X it is 13.75 seconds. Respondents spent more time on the Website Y website to complete task 2. This is because the salary filter is located at the bottom of the website, making it difficult for users to find it. Users must scroll down the website first. In addition, another factor that makes it long is that on the Website Y website, users must first select a currency, then the website will reload the search page, only then can users enter the specified minimum salary value.

3.2 Comparison of Task Completion Time of Male and Female on the Website X Websites

Based on the experimental results on 12 student consisting of 6 males and 6 females (see Table 4 and Table 5), the Manova Test was carried out with SPSS to see the effect of gender on the user's ability to search for certain features on Website X website. Then obtained a significance value of Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root of 0.052. This value is more than 0.05 so it can be concluded that there is no significant difference in the time needed by male and female users in completing tasks on the Website X website.

The significance value obtained in the Tests of Between-Subjects Effect for task 1 was 0.457, task 2 was 0.044, task 3 was 0.504, task 4 was 0.651 and task 5 was 0.120. sig. value Tasks 1, 3, 4, and 5 are more than 0.05 so there is no significant time difference for male and female Website X users to complete tasks 1, 3, 4, and 5 on the Website X website. However, in task 2, a significance value of less than 0.05 was obtained so that there was a significant time difference between male and female users in carrying out the task.

Based on the results of all analyzes, it can be concluded that there is no difference in the average duration of time between male and female users for the five types of tasks provided on the Website X website. This shows that the display on the Website X website does not make a significant difference to male and female users in finding a job, determining the appropriate salary, looking for a certain type of job, displaying vacancies within a certain period of time, and sorting them based on the latest date.

3.3 Comparison of Task Completion Time of Male and Female on the Website Y Websites

Based on the experimental results on 12 student consisting of 6 males and 6 females (see Table 4 and Table 5), the Manova Test was carried out with SPSS to see the effect of gender on the user's ability to search for certain features on Website Y website. The MANOVA test was conducted to determine whether there were differences in working time between men and women when using the Website Y website. Based on the MANOVA test results, the significance value of Pillai's Trace, Wilks' Lambda, Hotelling's Trace and Roy's Largest Root was 0.523. With a significance value greater than 0.05, it can be concluded that there is no difference in task processing time between men and women in using the Website Y website.

The significance value obtained in the Tests of Between-Subjects Effect for task 1 was 0.531, task 2 was 0.411, task 3 was 0.497, task 4 was 0.246 and task 5 was 0.879. With a significance value greater than 0.05, there is no difference in completing tasks 1, 2, 3, 4, and 5 for male and female respondents when using the Website Y website. This shows that both men and women can complete work with no significant time difference when using the Website Y website.

3.4 Usability Evalution of Website X Website by Questionnaire

After completing the tasks on both websites, respondents were asked to fill out a usability questionnaire. The questionnaire consists of 11 questions that assess system aspects, user aspects, and interaction aspects. Each question is scored by using likert scale, on a scale of 1 to 5. The result of the questionnaire shown in the Table 6. Based on the results of the Website X usability assessment questionnaire, it was found that questions 3, 10, and 11 had the lowest average score of 3.7; 3,4; and 3,6. The 3rd question is "Is the color display on Website X comfortable to look at and not boring?" then the 11th question is "Is the Website X menu and appearance easy to remember?". It can be seen that this is related to the display on the website.

According to Trapsilawati (2021a), the displayed display must include 13 display principles. To be able to make a display that is easy to remember and a color that is easy on the eyes, one of the principles that can be applied is the discriminability principle. The principle of Discriminability is a principle that avoids similarities in information or stimuli that can confuse recipients, so that differences are given to clarify information (Trapsilawati, 2021a).

Table 4. Questionnaire Result of the Website X Website

Number of Question (see Table 3)	Average score
1	4.2
2	4.1
3	3.8
4	4.2
5	4.2
6	4.2
7	4.1
8	4.2
9	4.3
10	3.4
11	3.6

Apart from the Discriminability principle, another principle that should be applied is the Principle of Consistency. The Principle of Consistency is a principle that designs displays in a way that is consistent with other views that users may see simultaneously or may have felt in the past (Trapsilawati, 2021a), for example the red color indicates danger and the green color indicates something safe.

Then the 10th question is "Is Website X safe?" also get low scores from respondents. This shows that users feel less secure when providing personal information to the Website X website. According to Trapsilawati (2021b) this can be overcome by applying the Provide Feedback principle. The Provide Feedback principle is a principle that suggests providing feedback when the user takes an action (Trapsilawati, 2021b). In this case, the Website X website should provide feedback in the form of a statement guaranteeing the security of data and personal information when users enter their personal data.

3.5 Usability Evalution of Website Y Website by Questionnaire

Based on the results of the Website Y usability assessment questionnaire, it was found that questions 10, 11, 2, and 3 had the lowest average scores, namely 3.5 respectively; 3.7; 3.8; and 3,8. The 10th question is "Is the security of Website Y guaranteed?". The low rating on this question indicates that users do not feel safe when using the Website Y website. This feeling of discomfort can be caused by problems with leakage of personal data or related to existing vacancies, whether genuine or fake. The principle that can be applied to deal with this is Provide Feedback which can be realized with a statement guaranteeing the security of data and personal information when users enter personal data.

Questions 11 and 3 relate to website display. The 11th question is "Is the Website X menu and appearance easy to remember?" and the 3rd question is "Is the color display on Website Y pleasing to the eye and not boring?". Just like the recommendations given for Website X, the Website Y website also needs to pay attention to the principles of Discriminability and the Principle of Consistency. To apply the Discriminability principle, Website Y can provide different icons on its menus so that users can easily remember the existing menus and distinguish one menu from another. To apply the Principle of Consistency, the use of icons, colors and layouts can be adjusted to standards that are widely recognized by users. By using color choices that many users recognize, it is hoped that users will be more comfortable with the colors used in Website Y.

Table 5. Questionnaire Result of the Website Y Website

Number of Question (see Table 3)	Average score
1	4.0
2	3.8
3	3.8
4	4.1
5	4.0
6	3.9
7	3.9
8	4.0
9	4.2
10	3.5
11	3.7

The 2nd question is "Is Website Y easy to operate?". The low score on this question indicates that users still have difficulty operating Website Y. The appearance of the Website Y website is quite complex because all available options or features are immediately displayed on the left side of the website. Users tend to get confused when they see many features and options at one time. Therefore it is necessary to make improvements with the Avoid Crowding of Display Elements principle. Sometimes designers are tempted to create a display by placing too much information in a limited space. This can reduce the readability of the display (Wickens, et al, 2013). It is better to eliminate which features will be displayed so that users have no trouble operating the Website Y website.

3.6 Improvement Suggestion

According to Trapsilawati (2021a), the displayed display must include 13 display principles. To be able to make a display that is easy to remember and a color that is easy on the eyes, one of the principles that can be applied is the discriminability principle. The principle of Discriminability is a principle that avoids similarities in information or stimuli that can confuse recipients, so that differences are given to clarify information. By applying this principle, users could find the information more conveniently and easily.

Apart from the Discriminability principle, another principle that should be applied is the Principle of Consistency. The Principle of Consistency is a principle that designs displays in a way that is consistent with other views that users may see simultaneously or may have felt in the past (Trapsilawati, 2021a), for example the red color indicates danger and the green color indicates something safe.

Based on the questionnaire result, it can be seen that users feel less secure when providing personal information to the Website X website. According to Trapsilawati (2021b) this can be overcome by applying the Provide Feedback principle. The Provide Feedback principle is a principle that suggests providing feedback when the user takes an action (Trapsilawati, 2021b). In this case, the Website X website should provide feedback in the form of a statement guaranteeing the security of data and personal information when users enter their personal data.

Both Website X and Website Y website also needs to pay attention to the principles of Discriminability and the Principle of Consistency. To apply the Discriminability principle, both website can provide different icons on its menus so that users can easily remember the existing menus and distinguish one menu from another. To apply the Principle of Consistency, the use of icons, colors and layouts can be adjusted to standards that are widely recognized by users. By using color choices that many users recognize, it is hoped that users will be more comfortable with the colors used.

On the other hand, this study found that users tend to get confused when they see many features and options at one time. Therefore it is necessary to make improvements with the Avoid Crowding of Display Elements principle. Sometimes designers are tempted to create a display by placing too much information in a limited space. This can reduce the readability of the display (Wickens, et al,

2013). It is better to eliminate which features will be displayed so that users have no trouble operating the website.

4. CONCLUSIONS

Based on the experimental results, we found that there is a significant difference between the time needed to carry out activities on Website X and Website Y. The activity that has a significant difference in processing time between Website X and Website Y is filtering jobs based on salary, where the average time needed at Website Y is longer than Website X. Then, for both Website X and Website Y, overall there was no significant difference in the time to complete work between men and women.

Based on the results of the Website X and Website Y usability evaluation questionnaire, it was found that both of them had problems with the user's perception of the safety of using the website, the user's comfort with using colors on the website, and the user's ability to remember menus and website appearance. This problem can be overcome by applying the principles of Discriminability, Principle of Consistency, and Provide Feedback.

In addition to the three problems above, Website Y has problems with ease of operation, where users still have difficulty operating Website Y. To overcome this, Website Y can reduce website complexity by applying the Avoid Crowding of Display Elements Principle.

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Analysis of Good Manufacturing Practices (GMPs) Implementation In Gudeg SMEs to Improve Food Safety Product

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Abstract

Gudeg is one of traditional food prefered by public in Yogyakarta. To meet the standard and quality requirements for Gudeg product the industry is required to be capable of making improvement to production procedure in each flow of its production activities. An analysis of the implementation of GMPs (Good Manufacturing Practices) to Gudeg SMEs in Yogyakarta is deemed important. It aims to identify the factors of the highest non-conformities and to provide solutions in creating a better food production procedure for Gudeg SMEs in Yogyakarta. The aspects that had the highest incompatibility values were formulated using the 5 Why's Analysis method and Ishikawa diagrams. The research aims: 1) to analyze the implementation of GMPs in one of the SMEs in Gudeg production in Yogyakarta; 2) to analyze the factors of the highest discrepancy with the implementation of GMPs; and 3) to give suggestions for the improvements such nonconformities. The results of the assessment of the implementation of GMPs in Gudeg SMEs showed that the level of GMPs implementation was good with a conformity (93.30%). The highest discrepancy was found in the employee aspect (37.5%) due to the absence of employee training regarding food sanitation and safety in the industry, also the lack of reference standards for the application of GMPs in industry.

Keywords: *Good Manufacturing Practices, food safety, Gudeg production, industrial sanitation*

1. INTRODUCTION

Compared to other sectors, the culinary industry is one of the largest contributors to Gross Domestic Product (GDP). As revealed from data from the Ministry of Cooperatives and Small and Medium Enterprises in March 2021, the number of SMEs reached 64.2 million with a contribution to GDP of 61.07% or 8,573.89 trillion Indonesian Rupiahs. SMEs were able to absorb 97% of the total existing workforce, and collect up to 60.42% of total investment in Indonesia (Ministry of Finance of Republic of Indonesia, 2021). The large number of SMEs engaged in the culinary field has caused a number of SMEs to be capable of competing with other similar SMEs.

Gudeg SMEs, being one of Yogyakarta's indigenous culinary delights, were also under intense competition. The number of *Gudeg* SMEs in Yogyakarta is growing, as is competition in the business sector (Hendrix and Nasution, 2022). The large number of similar industries selling *Gudeg* both as food and as special gift from Yogyakarta has made the producers to improve their competitiveness performance in industrial. The enhancement of the competitiveness can be achieved by producing good quality product which is safe to be consumed.

Quality products are able to be made using high-quality raw materials and standard-compliant processing methods. Young jackfruit, chicken, eggs, tofu, tempeh, and spices are some of the basic ingredients utilised in the production of *Gudeg* and its supplement. The process of making *Gudeg* has various operations, such as sorting, washing, cutting, boiling, and cooking (Khairani and Amalia, 2022). Thus, to support the production process, production control is required at the level of production areas as well as production support facilities.

Implementing a Food Safety Management System is a critical aspect of the production of high-quality products that adhere to Good Manufacturing Practices (GMPs). GMPs developed regulations for certain food sectors, such as meat, poultry, seafood, dairy products, feed, and pet food (Lee et al., 2021). The raw materials of *Gudeg* were considered to be a part as these as well (Khairani and Amalia, 2022). Several criterias, such as applicable standards, personal hygiene, process control, pest control, and production sanitation facilities were the important concerns in implementing GMPs (Purwantiningrum, 2018). To meet the standards and quality requirements for *Gudeg* product, particularly in certain moments, such as long holidays at which is the industry will experience a peak production, the industry was required to be capable of making

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improvements for production activities. Based on the preliminary study, several irregularities were found in its operational activities, such as the presence of cross-contamination of products due to the lack of sanitation implementation on the employee aspect. In addition, pests were still found in the production room due to a lack of pest control and inappropriateness in raw materials handling, such as placing the raw materials directly on the floor.

The aims of this research were: 1) to analyze the implementation of GMPs in *Gudeg* SMEs; 2) to analyze the causes of discrepancies in GMPs implementation; 3) to provide recommendations for improvement of the most severe discrepancy. It refers to the Regulation of the Minister of Industry of the Republic of Indonesia No. 75/M-IND/PER/7/2010 on GMPs wit Thus, solutions can be provided to SMEs to improve production procedures and enable the SMEs to compete with other similar industries.

2. MATERIAL AND METHODS

The research was conducted in a food industry producing *Gudeg* in Yogyakarta city. Observations were carried out in the production area, labor support facilities, and supporting production facilities. The observations were conducted using the assessment form for 17 aspects of GMPs referring to the Regulation of the Minister of Industry of the Republic of Indonesia No. 75/M-IND/PER/7/2010 on GMPs. The application of GMPs covered 17 aspects of research, including the aspects of location, buildings, sanitation facilities, machinery/equipment, materials, process control, final products, workers, packaging, labelling and product descriptions, storage, maintenance and sanitation programs, transportation, documentation and recording, training, product recall, and implementation of guidelines. To support the observational analysis, in-depth interview was conducted with operational manager regarding the factors of discrepancies. In-depth interviews were carried out based on 17 aspects that were observed in detail. Operational managers have the authority and the responsibility to organize production activities, which made it appropriate to be respondent. The accumulated GMPs implementation assessment was calculated by the percentage of compatibility and incompatibility in each aspect. The calculation was done using equation 1. Thus, the analysis was carried out using descriptive statistics.

$$\text{Percentage of aspect of GMPs values} = \frac{\text{values of compatibility/incompatibility}}{\text{total number of sub aspect}} \times 100\% \quad (1)$$

Pareto diagrams were constructed to identify the highest factors of discrepancies by using the 5 why's technique to formulate a Cause-Effect Diagram with the Addition of Cards (CEDAC). The formulation of the CEDAC regarding the highest discrepancy in GMPs implementation at *Gudeg* SMEs was supported by the results of the interviews. On the other hand, a CEDAC diagram was generated to identify the highest discrepancy factor on GMP implementation. Kuswandi and David (2018) stated that the Ishikawa diagram was a representation of the cause and effect of a problem by analysing the main causal factors in the form of machines, people, methods, materials, measurements, and the environment.

3. RESULTS AND DISCUSSION

3.1. The Assessment of GMPs' Implementation

The results of the GMPs assessment on *Gudeg* SMEs in Yogyakarta have been carried out using a GMPs form covering 17 aspects as seen in Table 1 (Ministry of Industry of Republic of Indonesia, 2010). The accumulation of the assessment of the GMPs implementation in SMEs showed that the results of the GMPs implementation level in *Gudeg* SMEs were quite good with a total compatibility of 93.30% and deviation of 6.70%. However, improvements are still needed, particularly in the aspects where there have been incompatibilities in the GMPs implementation to improve the product quality of *Gudeg* SMEs. The incompatibility was found in several aspects, including location, building, sanitation facilities, employees, storage, maintenance and sanitation programs, and transportation.

3.1.1. The aspect of location

The first incompatibility in the aspect of location was found in the selection of industrial locations on the side of major roads in which the location has not managed to reduce pollution from motor vehicle fumes. The second discrepancy was related to the industry's location in a

lower land area with potential for floods. In addition, the drainage system was deficient, evidenced by the presence of poor water flow and the presence of rubbish.

3.1.2. The aspect of building

Floor and wall intersections have formed dead corners where dirt can accumulate. The accumulation of dirt can lead to food safety issues such as the contamination of *Gudeg* products. On the other hand, the wall surface in the production room was dark and made of a material that was not easy to clean. All production activities were carried out traditionally, such as cooking using the firewood. Thus, the production room became darker eventhough it has been repainted. The design of industrial rooms that are in direct contact with food must meet standards (easy to clean) to avoid food contamination (Lelieveld et al., 2005). In addition, the production space was lack of light and had a poor air circulation. The importance of airflow in food production areas was to provide a high level of air quality. Air has become one of the sources of contamination in food products, hence air quality should be maintained to prevent the spread of bacteria from the air to food products (Moracanin et al., 2019).

3.1.3. The aspect of sanitation facilities

The discrepancy in the aspect of sanitation facilities is the unavailability of a warning that every employee must wash their hands with soap or use a hand sanitizer after using the toilet. In addition, sanitation facilities for workers have not been equipped with work shoe rinse aid, considering that the shoes are often used by employees to went to warehouses, toilets, and other places that can be the cause of cross-contamination in food products. Poor sanitation practices enhanced the environmental quality of bacteria and other infectious agents (Kibret and Abera, 2012).

Table 1. Accumulation of the Assessment of GMPs Implementation in *Gudeg* SMEs

No	Aspect	Number of sub-aspects	Compatibility		Incompatibility	
			Value	Percentage (%)	Value	Percentage (%)
1	Location	7	5	71.43	2	28.57
2	Building	36	32	88.89	4	11.11
3	Sanitation facilities	21	19	90.48	2	9.52
4	Machine/equipment	12	12	100	0	0
5	Materials	6	6	100	0	0
6	Process control	25	25	100	0	0
7	End-product	3	3	100	0	0
8	Employees	8	5	62.5	3	37.5
9	Packaging	6	6	100	0	0
10	Label & product description	6	6	100	0	0
11	Storage	8	7	87.5	1	12.5
12	Maintainance and sanitation program	37	36	97.3	1	2.7
13	Transportation	8	7	87.5	1	12.5
14	Documentation and recording	11	11	100	0	0
15	Training	6	6	100	0	0
16	Product withdrawal	6	6	100	0	0
17	Guideline implementation	3	3	100	0	0
	Total	209	195	**93.30%**	14	**6.70%**

3.1.4. The aspect of employees

Employee discrepancy was caused by the lack of regulations regarding hand washing before and after work, as well as the ban of smoking, spitting, and other acts in the production area that could lead to product contamination. Employees and visitors who accessing the

workplace, particularly production rooms, were not required to use guest identity cards, Personal Protective Equipment (PPE), or adhere to hygiene standards. Furthermore, the industry has not appointed and delegated the person in responsibility of executing the food safety management system to skilled and competent employee.

3.1.5. The aspect of storage

Raw materials that have not been used for the production process were placed on the floor. CFR (2016) mentioned that floors can be a source of contaminants, especially if there are piles of water or liquid waste. Raw material storage should be arranged on pallets to avoid touching the floor, not against the wall, and away from the ceiling. This minimises contamination and the potential for insects on the floor, walls, and ceiling to transfer to the raw materials.

3.1.6. The aspect of maintenance and sanitation programs

The SMEs was still deficient appropriate pest control. In the absence of pest control, there may be a few discrepancies in the maintenance and sanitation programs. The food sector should have pest trapping devices on readiness to catch flies, flying insects, and cockroaches. A rodent box station would also be useful for trapping mice. Furthermore, pest control in the food industry can be utilized alongside integrated pest management (IPM). The method is particularly effective for pest management in food industries due to the uses relatively few potentially harmful pesticides (Kloosterman and Mager, 2014).

3.1.7. The aspect of transportation

The incompatibility in the transportation aspect was a distribution procedure. It was unable to protect the goods against contamination, particularly dust and dirt. This would be due to the fact that the truck merely delivered the products stored in stainless steel containers without covers. The product should be stored in a well-sealed packaging to prevent contamination. In aside from protecting the product from contamination, packaging was an essential aspect to consider when preserving *Gudeg* products (Nurhayati et al., 2017).

3.2. Incompatibility in the GMPs Implementation in *Gudeg* SMEs

There were 10 out of 17 aspects that have been compatible in the relation to the GMPs implementation, as shown in Table 1. However, the 7 aspects were not compatible with the GMPs implementation in *Gudeg* SMEs. The results of the calculation of the assessment of discrepancy of GMPs implementation in *Gudeg* SMEs were analyzed. The aspect with the highest discrepancies value, as shown in Figure 1, was deployed into a Pareto diagram. The aspect of employee became the main priority that needed to be improved for industry of *Gudeg* SMEs. The aspect of employee obtained the highest incompatibility value with a total deviation value of 37.5% of the overall GMPs assessment and 32.78% of incompatibility of GMPs in *Gudeg* SMEs.

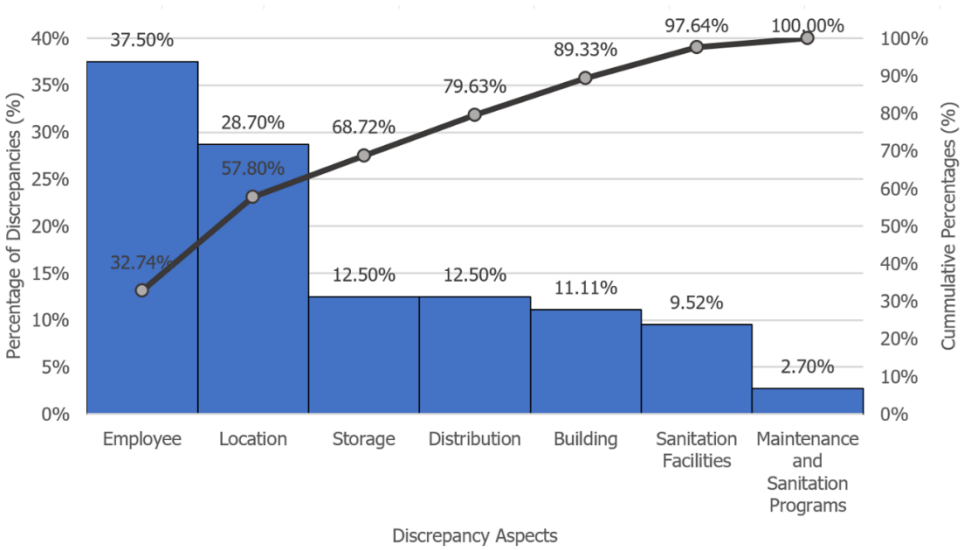

Figure 1. Pareto Diagram of GMPs Discrepancies

Table 2 presents the results of the analysis using CEDAC regarding the incompatibility of GMPs implementation in the aspect of employees of SMEs *Gudeg*. Based on the 5 Why's Analysis method and the Ishikawa diagram (Figure 2), several factors of the incompatibility of GMPs implementation in the aspect of employee were found in terms of three causative factors including environment, human, and method.

Environmental factor was related to the lack of trained personnel in charge of implementing the food safety management system. It was found that this is related to many branches which spreaded across various regions. Moreover, the quantity of human resources was found still limited. While on the method factor, employees were not equipped with the PPE required in the food production process to prevent any cross contamination. This is due to the lack of employee training on the importance of using PPE. For the human factor, employees carried out activities that can contaminate the products, such as not washing their hands and smoking around the production area. It may caused due to the lack of references of the sanitation standard.

Table 2. Incompatibility of GMPs Implementation in the Aspect of Employees

No	Factor	Cause I	Cause II	Cause III
1.	Environment	Lack of trained personnel who is in charge of implementing the food safety management system	Lack of resources in the implementation of food safety management system	Many branches spread across various areas
2.	Method	Unavailability of PPE that is in accordance with the industrial need	Lack of knowledge of employees about the importance of the use of PPE as the manisfestation of GMPs	Unavaibility of training for employees about the importance of the use of PPE as the manisfestation of GMPs in industry
3.	Human	Employees carried out the activities that can contaminate the products	No SOP regulating the GMPs in industry	Lack of reference standard about the implementation of GMPs in industry

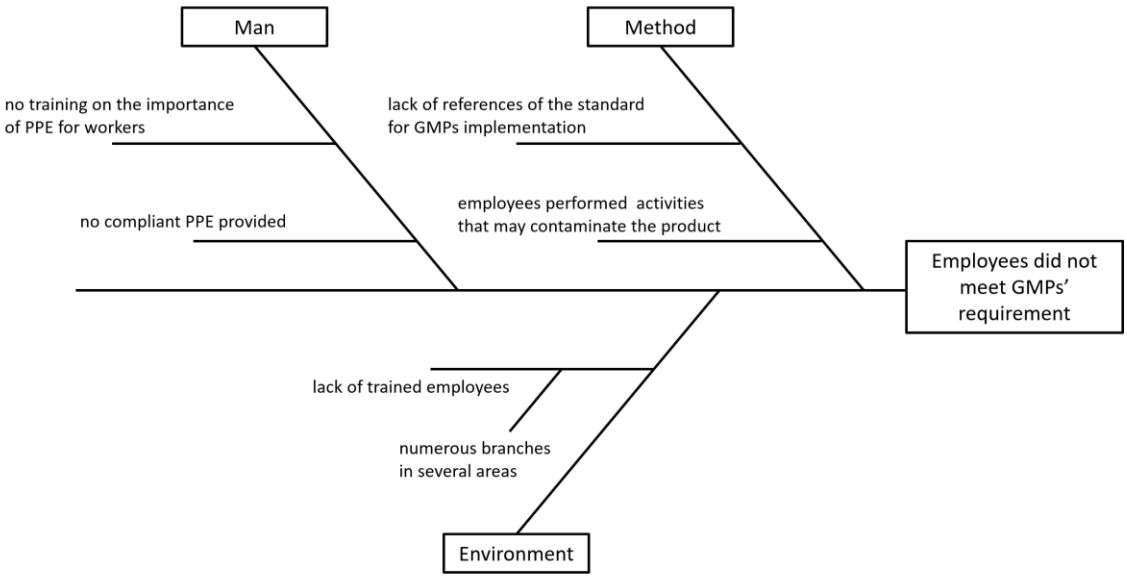

Figure 2. Ishikawa Diagram of the Factor of Incompatibility in the Aspect of Employees.

3.3. Recommendation for the Improvement of the GMPs Implementation in *Gudeg* SMEs

Gudeg SMEs ought to carry out well-organized management, in accordance to the recommendations. Employees must be trained in order to put into operation a food safety management system. This aim is to increase the quality of personnel, particularly those who have direct contact with food products. In addition, GMPs training for employees can be provided to ensure the food safety and product quality. Furthermore, certain established industrial branches can strengthen their food safety systems. According to Medeiros et al. (2011), training and provision of sanitation hygiene visual media have proven to influence health behavior or practice; for this reason, it is deemed important to hold training related to hygiene and sanitation for employees to increase the awareness of food safety.

In addition, PPE was still required to the extent that it served as one of the employee support facilities. It was beneficial for both the personnel and the products that are produced. Aprons, headgear, and tools for taking food (gloves or food tongs) are all necessary PPE for food industry employees. (Khairina et al., 2018). SMEs is a labor-intensive industry, hence cross-contamination can be expected where the main contributor was contamination from food handlers (Lee et al., 2021). Thus, Cross-contamination could be prevented by using appropriate PPE in the food industry.

The industry management may establish a reference standard for GMPs implementation by referring to the Regulation of the Ministry of Industry of Republic of Indonesia No. 75/M-IND/PER/7/2010 about GMPs Guidelines. These regulations include a variety of measurements that have not been found in *Gudeg* SMEs' GMP implementation. The *Gudeg* SMEs was intended to further improve the efficiency of GMPs implementation in the industry.

Furthermore, the industry may introduce controls on personnel hygiene by developing Standard Operating Procedures (SOPs), encouraging workers to be more concerned and maintain personal hygiene when they enter or leave the production area. Employee habits consisted of eating and drinking at workstation, smoking, spitting, sneezing in front of food, and wearing jewellery should be prevented due to the potential contamination of the food in production area (Latif et al., 2017). This is in line with the requirement that workers wore PPE such as workwear, gloves, masks, and boots. They required to wash their hands with soap after work, particularly when after using the restroom.

4. CONCLUSIONS

The level of GMPs implementation in one of the *Gudeg* SMEs in Yogyakarta was found already good with compatibility of 93.30% with a deviation of 6.70%. However, it still needs improvements, especially on the aspect of employees. The incompatibility of the GMPs implementation in *Gudeg* SMEs were the absence of employee training on food safety and personnel hygiene in industry and the lack of reference standard for the GMPs implementation in the industry. The improvements to the GMPs implementation in *Gudeg* SMEs on the aspect of employees were highly suggested. The SMEs management should be able to organize, add, and distribute the trained personnel who were in charge of implementing a food safety management system, able to provide PPE, and establish reference standards for the GMPs implementation in *Gudeg* SMEs in Yogyakarta by referring to the Regulation of the Minister of Industry of the Republic of Indonesia. In addition, making SOPs related to employee hygiene would be necessary to improve the personnel hygiene of the food handlers in *Gudeg* SMEs.

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Evaluation of Worker Discomfort on Manual Palletization Activities of Bottled Water Products

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Abstract

The risk of Musculoskeletal Disorders (MSDs) is one of the problems that often occurs in manual handling workers with heavy loads in repetitive work movements for a long time. One example of this movement is the manual palletization activity of Bottled Drinking Water products at PT XYZ. Initial observations showed that 18 workers felt limb discomfort while stacking cardboards of 18kg water bottles. This study aims to determine the Recommended Weight Limit (RWL) used to measure the lifting load limit for workers; Lifting Index (LI) measurement that can describe the level of safety of lifting loads.The results showed that the load limit in drinking water palletization activities exceeded RWL, while the results of the LI calculation showed that manual palletization activities of bottled drinking water had a score of 6.4 where the LI score according to the safety standards of lifting activities was 1. These results indicate that manual palletization activities are not safe for workers and are at risk of causing MSDs. This is evidenced by the results of the assessment of the level of work posture discomfort using NBM which shows the highest pain score in the lower back of the body. Furthermore, workload measurement results vary from heavy to very heavy. From all parameters measured, it can be seen that the manual palletization activity of Bottled Drinking Water products at PT XYZ is very poor. The recommendation that can be proposed is to change the work system of manual palletization activities to a mechanical or automatic system.

Keywords: *LI, MSDs, Palletizing, RWL, Workload*

1. INTRODUCTION

Ergonomics is a science that studies the relationship between humans and the environment and work equipment used to solve the problem of incompatibility between humans and work equipment (Bridger, 2003). Ergonomics aims to design equipment, technical systems, and tasks in such a way as to improve safety, health, comfort and human performance (Dul &; Weerdmeester, 2001). Ergonomic problems are closely related to the risk of work accidents caused by the wrong posture and movement of workers. One of the causes of ergonomic problems that occur in industries involving manual handling is the presence of repetitive movements carried out for a long time with a heavy load on a work system. If the work system is not immediately repaired, then workers can experience Musculoskeletal Disorders (MSDs).

MSDs is an illness caused by wrong attitudes or work positions (Ulfah et al., 2014). MSDs often result in pain in muscles, nerves, tendons, blood vessels, and ligaments. Manual work is prone to MSDs due to repeated performance and excessive use of force. In increasing production capacity, companies often increase working time without paying attention to aspects of worker ergonomics, thereby increasing the risk of workers experiencing MSDs (ulfah et al., 2014).

PT. XYZ is a company engaged in drinking water. Production Area 1 has two production lines, namely 600 ml and 1500 ml Bottled Drinking Water. In its processing, there are several stages in the production of bottled water in Production Area 1. These stages start from the preparation of raw materials (water, bottles, and cardboard), filling water into bottles, infeed cardboard raw materials, visual, and palletizing. The process of feeding cardboard, visual, and palletizing raw materials includes manual material handling because it still uses human labor as operators.

Based on preliminary research conducted using the OWAS method, the palletizing workstation on the 1500 ml production line is a work station that requires improvement because it has a score of 2 which means the work is in the rather heavy category. This work is harmful to the musculoskeletal system (work attitude affects significant tension), so future improvements are needed due to poor work posture. Workers have to bend down to put down the cardboard and do it repeatedly quickly with a fairly heavy load of 18 kg. Both infeed workstations and visual workstations have a score

of 1, meaning that work on both workstations is normal and therefore does not require repair. In addition, the 600 ml production line has the same score for all manual material handling activities. Significant differences can be seen in the weight of cardboard and the dimensions of cardboard. The difference in cardboard weight affects the palletizing process by workers. The total weight of 12 bottled waters is 18 kg with a length of 34 cm, a width of 26 cm and a height of 32 cm.

The results of the preliminary questionnaire revealed that 27.8% of workers were aged 18-27 years and 72.2% were aged 28-37 years. As many as 100% of workers feel sick after work. A total of 77.8% of workers' pain was slightly reduced after rest and 22.2% of workers' pain was greatly reduced after rest. As many as 100% of workers stated that palletizing workstations are not in accordance with the wishes of the workers because they are not ergonomic and not in accordance with the wishes of the workers. As many as 100% of workers state that work aids are needed to help the palletizing process and there is a problem that is less ergonomic work position. This study aims to determine the Recommended Weight Limit (RWL) used to measure the lifting load limit for workers; Lifting Index (LI) measurement that can describe the level of safety of lifting loads.

2. MATERIALS AND METHODS

The object to be studied in this study is palletizing workstation workers. Things observed in this study were lifting loads and work posture when placing cardboard. This research was conducted at PT. XYZ which is located at Jl. Cokro-Wangen, Klaten.

The study began in December 2019 to February 2020. The tools used in this study include preliminary questionnaires, posture assessment using the OWAS method, Recommended Weight Limit assessment, NBM questionnaire, Borg RPE scale questionnaire, and SPSS software.

RWL assessment aims to obtain lifting load limits for workers. The Revised NIOSH Lifting Equation is based on the assumption that manual material handling activities do not require significant energy expenditure, especially when performing repetitive lifting work. This lifting activity is limited to only moving 1-2 steps with a very short moving time. RWL is calculated using the formula (Waters et al., 1993)

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM \quad (1)$$

With a multiplier factor

Multiple rs		Metric
LC	Load constant	23 kg
HM	Horizontal multiplier	(25/HOUR)
DM	Vertical multiplier	(1 – 0.003|V – 75|)
AM	Distance multiplier	(0.82 + 4.5/s)
FM	Asymmetric multiplier	(1 – 0.0032 A)
CENTIMETRE	Frequency multiplier	Table
	Clutch multiplier	Varies from 0.9 (ugly) to 1.0 (good)

RWL is used to calculate the Lifting Index which describes the level of physical stress which is the ratio of the weight of the load lifted to the lifting limit of the load. The largest LI value is 1 which means the size of the load lifted is equal to the recommended load weight

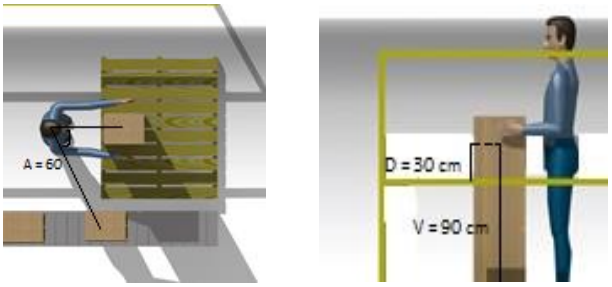
$$LI = \frac{Load\ weight}{RWL} \quad (2)$$

After obtaining results that prove that the work posture of workers is at high risk, proceed with measuring the discomfort of workers' work posture using the NBM questionnaire. Workers' fatigue levels are measured based on heart rate. The design is made based on the assessment that has been done. The results of data processing are used as a reference to develop work system engineering.

3. RESULTS AND DISCUSSION

3.1. Recommended Weight Limit

The National Institute for Occupational Safety and Health (NIOSH) devised a formula that can be used to determine the limit on the amount of weight lifted in lifting activities called the Recommended Weight Limit (RWL). Figure 1 shows (a) the position of the worker when retrieving the cabinet from the conveyor, (b) the position of the worker when placing the cabinet on a pallet (Kroemer, 1994).



(a) (b)

Figure 1. (a) the position of the worker looking up when retrieving the cabinet; (b) side view of the worker's position when lifting the cabinet

RWL calculation requires data when picking up products from the origin area and data when products are placed in the destination area. In company XYZ the initial data is data when cardboard arrives using a conveyor. The original RWL is the weight of cardboard that is recommended to be lifted in the initial area where the goods arrive for pickup and forwarding to the destination area. Destination RWL is the recommended cardboard weight value to be lifted at the destination position.

When a worker lifts an 18 kg cardboard without a handle, the worker will hold cabinets at the bottom and back. The coupling value is 0.9 (C = 0.9). When picking up cabinets, the worker's posture stands upright, the horizontal distance of the hands to the midpoint of the body (Ho = 60 cm), the vertical height of the conveyor from the V floor (Vo = 90 cm), the height of the cabinet (D = 34 cm), the worker faces towards the closet (Ao = 00).

When placing on a pallet (destination area) the worker must bend his body because the height of the pallet is only 25 cm from the floor (Vd = 25) by turning his body to the right by 600 (AD = 60). Given that workers must arrange cabinets on pallets, the destination RWL must also be calculated. Cabinet lifting is carried out 5-8 times per minute with a working time of 1-2 hours then a break (FM =). These numbers are then fed into the multiplier factor formula in the RWL formula. RWL assessment is performed on the stack closest to the body to obtain the lowest Lifting Index (LI) value. An illustration of the arrangement of cardboards is shown in Figure 2 which shows the posture of workers when placing cardboard on pallets. Figure 3 illustrates when workers arrange cabinets in piles on pallets.

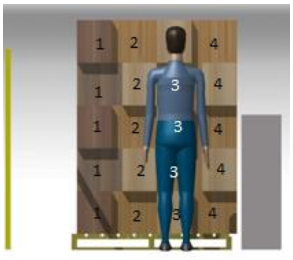


Figure 2. Cardboard Arrangement Illustration

Figure 3. Illustration of the arrangement of cabinets on pallets
(Source: secoptot.com/ergonomic-consultation)

Using the RWL and LI formulas in equations 1 and 2, the original RWL obtained is 2.8 kg and the destination RWL obtained is 2.7. The original RWL value of 2.8 kg indicates that the recommended load weight for workers working between 2-8 hours a day, moving cabinets without handles at a height of 90 cm with a lifting frequency of 5 cabinets/min is 2.8 kg. Given that the actual weight of the moved cabinet is 18 kg, the Lifting Index value is 6.4. This value is very large compared to the value of secure LI 1. The higher the LI value, the greater the risk by workers (Waters et al., 1993).

For destination RWL, the value is smaller than the original RWL. This is because at the destination RWL (placing the cabinet on the pallet) the worker rotates the body 60 degrees and the difference between the height of the pallet and the standard height of 75 cm is very large (75-25=50). This is not an ergonomic posture when workers place and arrange cabinets on pallets. The RWL results show a very serious value, that it is difficult to find solutions administratively. in their research did not find an ideal position that could reduce the LI to 1. Therefore, the recommendation given is to add bench and rolling track at the end of the conveyor belt (Umami et al., 2014).

According to the Regulation of the Minister of Manpower of the Republic of Indonesia, the threshold value of manual lifting by male workers is 20 kg if lifted at elbow level with objects raised close to the body. The activity of lifting the cardboard at an intensity of five to eight times per minute requires a 50% reduction in weight limits. Tarwaka (2004) explains that prevention of MSDs can be done with administrative control or Engineering control (Anonim, 2018). Administrative control at PT XYZ for lifting loads is lifted 5-8 times per minute, so that the recommended lifting load is only half of the total load. However, this cannot be done. Although this lifting activity is allowed only 1-2 steps with a very short movement time, it does not help. Technical control can be carried out if the results of administrative control are not optimal. The use of mechanical or automatic equipment is highly recommended to overcome this problem (Waters et al., 1993).

3.2. Worker Muscle Pain

The Nordic Body Map (NBM) is a questionnaire filled out by workers to assess muscle pain experienced while working (Wilson and Corlett, 1995). Fifteen worker limbs were self-assessed by assigning a score of 1 for limbs that felt no pain, a score of 2 for slight pain, a score of 3 for pain and a score of 4 for very high pain. The questionnaire is filled out before and after palletizing. All workers do not feel any pain before work. Figure 4 shows the number of scores for each limb for 18 workers. The highest score indicates the limb feels the most pain for all workers. The three highest scores were leg numbers 7,8,9 which means that the lower back is the most followed by pain in the left hand and right hand.

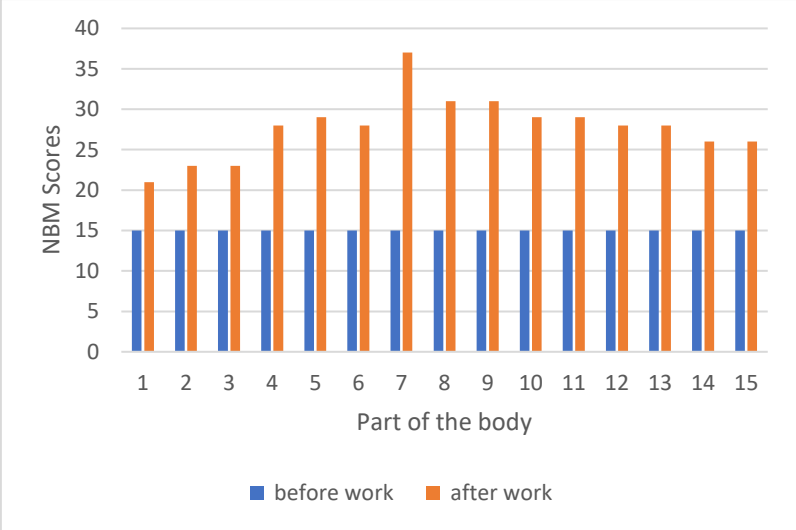


Figure 4. Discomfort Scores Before (blue) and After Work (red)

Based on Figure 4, it can be seen that the highest score is part number 7, which is low back pain (LBP). The lower back is used to support weight when bending over to place a cardboard on the first stack and experiencing tension when standing on tiptoe to place the cupboard on the fifth pile. Bridger (2003) states that awkward postures and repetitive work can lead to reduced blood supply, lactic acid accumulation, and stress on muscles. Based on the discomfort of limb number 7, improvements are needed for the work design to reduce or eliminate the discomfort experienced by workers.

3.3. Worker Workload Tier

Heart rate measurement using the Borg scale shows results as in Table 1 (Borg, 1982) mentions the category of workload level, which in the assessment is selected based on the worker's perception of the level of fatigue he feels (Table 1).

Table 1. Borg Scale and Pulse Score Measurement Results

Not	Worker	Age (year)	*Rating*	Pulse Rate Score (pulse rate/min)	*Business Perception*
1.	W1	28	14	140	*It's a bit difficult*
2.	W2	32	14	140	*It's a bit difficult*
3.	W3	26	14	140	*It's a bit difficult*
4.	W4	24	13	130	*It's a bit difficult*
5.	W5	34	14	140	*It's a bit difficult*
6.	W6	29	14	140	*It's a bit difficult*
7.	W7	35	15	150	*Hard*
8.	W8	34	15	150	*Hard*
9.	W9	30	14	140	*It's a bit difficult*
10.	W10	37	15	150	*Hard*
11.	W11	27	14	140	*It's a bit difficult*
12.	W12	32	14	140	*It's a bit difficult*
13.	W13	29	14	140	*It's a bit difficult*
14.	W14	26	14	140	*It's a bit difficult*
15.	W15	32	14	140	*It's a bit difficult*
16.	W16	34	14	140	*It's a bit difficult*
17.	W17	28	14	140	*It's a bit difficult*
18.	W18	24	13	130	*It's a bit difficult*

Heart rate measurements using the Borg scale show results as shown in Table 1. This showed that 18 workers felt very tired which was supported by a high heart rate indicating a very high workload (Kroemer et al, 1997).

Table 2. Workload categories by heart rate frequency

Workload Categories	Heart rate frequency (beat/minute)
Very light	Less than 75
Light	75 – 100
Quite heavy	100 – 125
Heavy	125 – 150
Very heavy	150 – 175
Extreme	More than 175

(Kroemer et al, 1997).

The results showed that the work system at PT XYZ palletization workstations must be improved. The main cause of ergonomic problems that occur is that the cardboard that must be lifted by workers is too heavy. Changing the packaging to contain 6 packages weighing 9 kg is not possible. This problem is exacerbated by a fairly high lifting frequency of 5-8 cardboards / minute and the accumulation of cardboard on pallets is quite high. The impact felt by workers is feeling very tired and pain in the lower back (Low Back Pain). Work system administration improvements cannot be done at PT XYZ. Changes in manual labor systems to mechanical or automatic work systems.

4. CONCLUSION

Workers in the palletizing work station of PT XYS feel uncomfortable and hope that the work system will be improved. The results of the workload level assessment show that the workload is very heavy, there is pain in the lower back which indicates Low Back Pain. The calculation of the lifting load limit shows that lifting 12 bottles @ 1,500 ml in an 18 kg cabinet is beyond the safe lifting limit. The recommendation for the pelletizing work system to be ergonomic is to change the work system from manual to mechanical or automatic.

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Productivity Analysis of PT Perkebunan Nusantara VIII Kebun Pasirmalang's Black Tea Processing Process Utilizing Objective Matrix (OMAX) Method

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Abstract

PT Perkebunan Nusantara VIII Pasirmalang (PTPN VIII) is a tea processing industry that has effectively transitioned into a shareholder in black tea powder. The attainment of tea processing outcomes did not rise in response to the increased demand. In actuality, 2020's product output never quite reached the production goal. The pandemic conditions at the time had an impact on black tea processing as well. The company hasn't looked into the causes of unsteady manufacturing in more detail. Consequently, in order to assess the performance of the business, production productivity must be measured. By using a variety of input elements to determine the company's performance value, the Objective Matrix (OMAX) method is the tool utilized. Three inputs are taken into consideration while calculating productivity: labor, electricity, and raw materials. The OMAX method was used to measure manufacturing process productivity, and the results indicate that in 2020, December 2020 had the best achievement and February 2020 saw the lowest.

Keywords: *Black tea, Ishikawa Diagram, OMAX, Performance, Productivity*

1. INTRODUCTION

The development of the industrial sector is growing rapidly. Various companies in various sectors emerge and continue to strategize to develop their industries. This will have an impact on the level of competition that is increasingly competitive. This competition will motivate companies to continue to evaluate their business processes in order to compete with other competitors. The evaluation that can be done is one of them by conducting surveillance and observation in terms of productivity to achieve the targets set by the company.

PT Perkebunan Nusantara VIII Kebun Pasirmalang produces products in the form of black tea powder which is ready to be marketed to finished tea processing companies. In terms of production, tea will be processed every day due to tea products that must be handled directly. According to historical production data in Figure 1 in 2020, it can be seen that the achievement of tea processing results is unstable and tends to decrease compared to the expected target.

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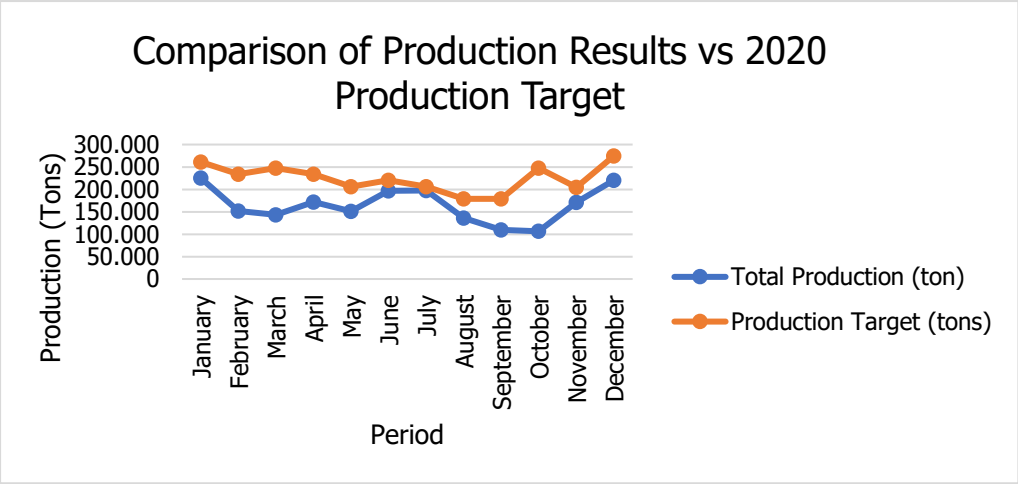

Figure 1. Graph of Production Results vs 2020 Black Tea Production Target

The concept of productivity is one indicator of the company's success in empowering its resources to produce targeted products. Productivity is an effort to always improve the quality of life by using the smallest possible resources. The implementation of a unidirectional and smooth production flow or the handling of several processes at once is very useful for improving work productivity, quality, production delivery time, inventory levels, and space utilization. Productivity is not the same as production but production, quality performance, and results are components of productivity efforts. Thus, productivity is a combination of effectiveness and efficient use of resources (Anthony, 2019).

Productivity measures are useful for improving resources in the short and long term. Because this productivity value can be used as a reference for setting strategic planning goals for future productivity levels. The planning will be more effective because it is based on facts and data (Komariah, 2019). There are four stages in the productivity cycle which consist of measuring, evaluating, planning and improving productivity. Productivity factors include three factors: efficiency, effectiveness and quality. Efficiency indicates the extent to which planned inputs are used compared to what has been done. Efficiency is a measure of the extent to which a goal is achieved. At the same time, quality indicates the extent to which requirements, specifications and consumer expectations are met (Permadi et al., 2015). In measuring productivity, the Objective Matrix (OMAX) method is often used. The method identifies what factors have a direct effect on increasing productivity in production. This method is used because of the ease and simplicity of data processing, so that the expected results will be researched and identified easily. Various previous studies on productivity measurement, one of which using the OMAX method, have proven to be able to determine the value of company performance with various input factors used. This is explained in one of the productivity analysis studies with the OMAX method on the production floor of a beverage bottle company. Where in this study, it can find out what resource usage causes low productivity, as well as what factors should be improved (Ramayanti, 2020).

The results of the productivity calculation will determine the highest and lowest achievements obtained at a certain time. Based on these results, an analysis will be carried out using the help of a Fishbone diagram (Ishikawa Diagram). Fishbone Diagram can systematize the causes of complicated accidents. With this method, we can analyze the factors that affect things the most, which is then followed by a deviation from the big reasons to find the middle reasons, minor causes and less reasons, and to detect and determine the main reasons. The analysis requires the use of logic and conformity to reality (Luo et al., 2018).

Based on the example of the explanation of research using OMAX above, it can be seen that measuring productivity can be the basis for companies to evaluate and make improvements. This research aims to 1) Determine the Performance Level and Productivity Index at PT Perkebunan Nusantara VIII in the black tea production process, 2) Analyze the causal factors that affect the low productivity of production at PT Perkebunan Nusantara VIII.

2. MATERIAL AND METHODS

This research was conducted through various stages including problem identification, criteria determination, productivity measurement with OMAX, and analysis of causal factors. The stages carried out are as follows:

2.1 Determination of Criteria

The first stage is to determine the criteria to be used as parameters according to the objectives to be achieved. Criteria are determined from field observations and brainstorming with production. The selected criteria are input resources that have a major influence and can be measured (Aziza and Patdono, 2019). The next thing to do is to collect data used for productivity measurement and historical data from PTPN Kebun Pasirmalang.

2.2 Productivity Measurement with OMAX

Productivity calculations must be done to find out how a company uses its resources optimally and effectively to achieve the desired production results. Productivity calculations are divided into three areas: partial productivity, total factor productivity, and total productivity. The calculation of productivity types is done according to considerations, according to the challenges and characteristics of the company. Many methods can be used to measure productivity, including the American Productivity Center method, PRISM method, POSPAC method, and OMAX method (Sajiwo & Hariastuti, 2021). These methods have their own computational focus. The American Productivity Center (APC) method focuses on the sales of a product compared to the costs incurred (Manullang, 2020). The POSPAC method focuses on productivity calculations that are only related to aspects of production, distribution, organization, labor, product, and capital. The PRISM method emphasizes an approach from the aspects of satisfaction and contribution, where overall performance is measured by displaying the importance of stakeholder perspectives, not making decisions (Hamdan Fauzan, Ari Zaqi Al-Faritsy). Finally, the OMAX Method then focuses on partial calculations that measure the productivity of each area of the company. This research calculates productivity partially, namely how optimally the company uses its resources, especially around its production line. The use of the OMAX method is based on relatively simple and easy-to-understand calculations, using available data, and being more flexible. The use of partial productivity with the aim of calculating the productivity of a particular input only for example, output/one of the inputs. The results of this measurement will show the level of efficiency and effectiveness of the use of raw material resources, labor, electrical energy use, and production output. The formula used is:

$$\text{Productivity Ratio: } \frac{Output\ in\ a\ certain\ unit}{Intput\ in\ a\ certain\ unit} \quad 1)$$

a. Productivity measurement according to Afianti et al., (2020) is continued by determining the standard performance and performance scale of each criterion. Where at this stage the scale consists of the target target value, standard performance value and the lowest target value. In these results, it will be known whether the company's performance value is below the standard or above the standard. The formula used is:

$$\text{Level Performance Score 10: } \mu + k\sigma \quad 2)$$

$$\text{Level Performance Score 3: } \frac{\sum Xi}{n} \quad 3)$$

$$\text{Level Performance Score 0: } \mu - k\sigma \quad 4)$$

Remarks:
μ = Average of each criterion measured
k = Constant
K: 1, if the confidence level (CL) is between 0% ≤ CL ≤ 68%.
K: 2, if the confidence level (CL) is between 68% ≤ CL ≤ 95%.
K: 3, if the confidence level (CL) is between 95% ≤ CL ≤ 99,7%.
σ = Standard Deviation
Xi= total ratio value of each criterion

n = sum of data

In each performance score, it is necessary to calculate the interpolation of each level with the formula :

Level interpolation 1 - 2: $\frac{0\ level-3\ level}{0-3}$ 5)

Level interpolation 4 - 9: $\frac{3\ level-10\ level}{3-10}$ 6)

b. Next, the determination of weights is used to determine the priority level of each input used. The weight calculation is carried out using the Pairwise Comparison method to several respondents
c. Furthermore, determining the level of performance is the score of each ratio in each period in the OMAX matrix table.
d. Determination of the performance level value based on the results of scores and weights. The performance level shows the total performance achievement of all criteria in a certain period.
e. Measurement of productivity index to show the increase or decrease during a certain period. The calculation is based on the formula:

Productivity Index (IP): $\frac{current\ performance\ indicator-previous\ period\ performance\ indicator}{previous\ period\ performance\ indicator}$ 7)

2.3 Analysis of Causal Factors

This stage analyzes the factors that cause low productivity using Ishikawa diagrams. The use of Ishikawa diagrams focuses on five factors including Methods, People, Machines, Materials, and Environment. According to Wiswandani & Suharsono (2020), the causes of problems that occur are often caused by five elements, namely, Man, Method, Machine, Material, and Environment. At this stage, discussion sessions and interviews will be conducted with heads in all sections of PTPN VIII such as the Head of Plantation, Head of Production, and Head of Packaging. Possible causes of low productivity will appear with the analysis conducted on the Ishikawa diagram. Therefore, it is expected to help the company analyze what factors are the improvements.

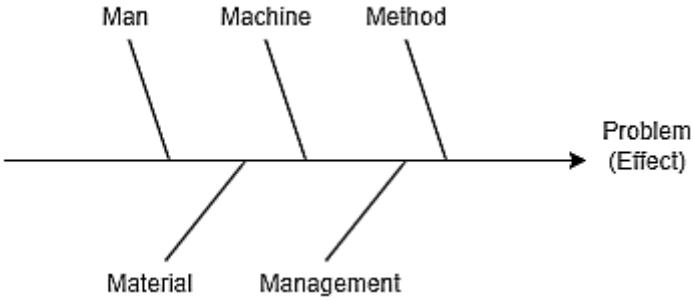

Figure 2. Ishikawa Diagram Model

3. RESULTS AND DISCUSSION

3.1 Identification of Productivity in the Production Process

Productivity calculation is done by calculating the ratio value first. Before that, the determination of criteria that become the source of input that will affect the productivity value of the company. Based on Sylviatuzzahroh et al (2022) the determination of criteria focuses on 1) Efficiency criteria, namely the use of resources owned by the company, 2) Effectiveness criteria based on accuracy and quality, 3) Inferential criteria in the form of criteria that indirectly affect productivity. Effectiveness criteria based on accuracy and quality, 3) Inferential criteria in the form of criteria that do not directly affect productivity.

The calculation of productivity focuses on three inputs that are the determining points of productivity achievement. These inputs are raw material usage, total electrical energy usage, and labor usage. Criteria are determined to find out what input resources have a big influence and

productivity calculations must be made. In addition, the criteria show a comparison that states the productive work of a work unit. The determination of these criteria must be a measurable factor (Aziza and Patdono, 2019). The results of this measurement will show the level of efficiency and effectiveness of the use of raw material resources, labor, electrical energy use, and production output. The raw material used is wet tea shoots with the output in the form of black tea powder. Because black tea powder is the expected output, so the more the amount of output, the productivity increases. Then the use of electrical energy resources in the production process, where the more its use shows the decreasing value of productivity. Furthermore, in the use of labor, how effective is the use of labor with the output produced. Below is the measurement formulation of each criterion regarding raw materials, labor, and the use of electrical energy according to table 1.

Table 1. Productivity Ratio of Each Criterion

Month	Raw Material Criteria Ratio	Electrical Energy Criteria Ratio	Labor Ratio
January	0.19485	1.45671	2813.31
February	0.15710	1.29367	1896.06
March	0.20481	1.40354	1793.89
April	0.18243	1.48240	2150.19
May	0.21060	1.45193	1478.58
June	0.21968	1.51179	1930.40
July	0.22578	1.87424	1865.58
August	0.22313	2.10025	1333.37
September	0.21418	1.47230	1128.05
October	0.21303	1.23096	1298.12
November	0.22489	1.53495	2140.03
December	0.22295	1.52189	2750.20

a. Raw Material Criteria Ratio

The ratio of raw material criteria is a comparison between production output in the form of black tea powder and raw materials for wet tea shoots. Because the greater the output produced, the higher the productivity value. So that the higher the ratio value indicates increasing productivity. This shows that the quality of wet tea buds is good. This ratio shows the highest value in November 2020, and the lowest in February 2020.

b. Electrical Energy Criteria Ratio

The ratio of electrical energy criteria is a comparison between production output in the form of black tea powder and the use of electrical energy. The higher the ratio value indicates increasing productivity. This shows that the more output produced with the least use of electrical energy shows a high level of efficiency. This ratio shows the highest value in August 2020, and the lowest in October 2020.

c. Labor Ratio

Ratio 3 is the ratio between production output in the form of black tea powder and the number of workers per month. The higher the ratio value, the higher the productivity. This shows that the more output produced with a certain amount of labor shows a high level of efficiency. This ratio shows the highest value in January 2020, and the lowest in September 2020.

3.2 Productivity Measurement Results

Productivity measurement is carried out in several stages, namely by calculating the performance scale by determining the value of BKA (Batas Kendali Atas) (level 10), BKB (Batas Kendali Bawah) (level 0), average (level 3), and interpolation value. The BKA value is the upper maximum limit as the highest ratio, which shows the optimal realistic value of the company's productivity that is possible to achieve. The average value is the middle limit as the standard ratio. While the BKB value is the lower minimum limit which shows the worst possible realistic value of the company's productivity (Sayyidah). The score level is divided into 3, namely in the position of Level 8 to level 10, meaning that performance has reached the target. In the position of Level 4 to level 7, it means that performance has not yet reached the target, but has approached the target to be achieved. While the same position or below the level 0 value means that the performance is really below the target, even below the standard (Supriyadi and Suryadiredja, 2020). In this study, the level of confidence in ratios 1, 2, and 3 is used, namely 90%, 84% and 71%, respectively. The results of the calculation of the boundary value from top to bottom will provide an assessment from level 0 to 10 illustrated in Table 2. The value will tell information that in which position each criterion ratio is used. The value of the performance scale used is illustrated in table 2.

Table 2. Performance Scale Value of Each Criterion

Level	Raw Material Criteria Ratio	Electrical Energy Criteria Ratio	Labor Ratio
10	0.2491	2.0036	2,950.60
9	0.2432	1.9357	2.,797.87
8	0.2373	1.8677	2,645.14
7	0.2314	1.7997	2,492.41
6	0.2255	1.7318	2,339.67
5	0.2196	1.6638	2,186.94
4	0.2137	1.5958	2,034.21
3	0.2078	1.5279	1,881.48
2	0.1940	1.3693	1,525.11
1	0.1803	1.2107	1,168.74
0	0.1665	1.0522	812,36

Source: Processed Data

The results of the calculation of the performance scale value in Table 2. are then applied in the calculation of productivity. Productivity calculations are carried out in each period from January to December during 2020. Each calculation will obtain a total productivity value based on the multiplication of scores with weights. The results obtained are listed in Table 3 as an example of calculations in January 2020.

Table 3. Calculation of Productivity with OMAX in January 2020

Raw Material Criteria Ratio	Electrical Energy Criteria Ratio	Labor Ratio	Ratio	Description
0.1948	1.4567	2,813.31	Performance	
0.2491	**2.0036**	**2,950.60**	**10**	Very good
0.2432	1.9357	2,797.87*	9	
0.2373	1.8677	2,645.14	8	Good
0.2314	1.7997	2,492.41	7	
0.2255	1.7318	2,339.67	6	
0.2196	1.6638	2,186.94	5	Medium
0.2137	1.5958	2,034.21	4	
0.2078	**1.5279***	**1,881.48**	**3**	
0.1940*	1.3693	1,525.11	2	Not Good
0.1803	1.2107	1,168.74	1	
0.1665	**1.0522**	**812.36**	**0**	Poor
2	3	9	SCORE	
32.4	34.3	33.3	Weight (%)	
64.8	102.9	299.7	Value	
	467		TOTAL	

*Position of the ratio value obtained for each input

In Table 3. shows the results of productivity in January 2020. The productivity value is seen from the value of each ratio which is said to be bad if it is below the performance standard value, namely level 3. This can be seen in the descriptive section, if the ratio value is equal to or less than the value at level 3, it can be categorized as not good or the output results are not effective. Based on the calculation, the performance value is obtained in one of the criteria, namely raw materials where the value is 0.1948. This value is in the position of level 2 performance which is still below the normal standard of level 3. The value electrical energy input ratio is 1.4567 at a performance score of 2 which is also below the normal standard. Meanwhile, the value of labor ratio is 2,813.31 at a performance score of 9. It can be seen that the two inputs used in January 2020 have a low achievement compared to the output produced. The labor input is at level 9, which is very high. This shows that the amount of labor used was effective in that month. These results are continued to assess productivity by multiplying the score, namely the position of the performance value multiplied by the weight. This weight has been done using the pairwise comparison method, which compares between various criteria using a matrix (Yusuf et al., 2020).

The calculation is done every month during 2020. The results will illustrate how the performance value in each input used, as well as the total value as productivity. This total productivity value will be compared between months to see whether the productivity results are decreasing or increasing. Therefore, based on the calculation in each month, the process productivity results shown in Figure 1 have been obtained. The results show a fluctuating curve where the highest achievement occurred in December 2020, while the lowest achievement occurred in February 2020. The calculation of the Productivity Index is done from the difference of the calculated period minus the previous period. Productivity Index calculation if there is a positive sign (+) or positive value indicates an increase in the company's productivity. Likewise, the minus value resulting from the productivity index before and after the calculation year shows a decrease in productivity (Sajiwo & Hariastuti, 2021).

For example, in figure 3 the February 2020 calculation is the difference between the February value (168.5) and the January 2020 month (467). The result obtained is -63.95. This negative result shows that productivity is far from good because it is not in accordance with the targets and outputs set by the company. Calculations are performed on all months during 2020.

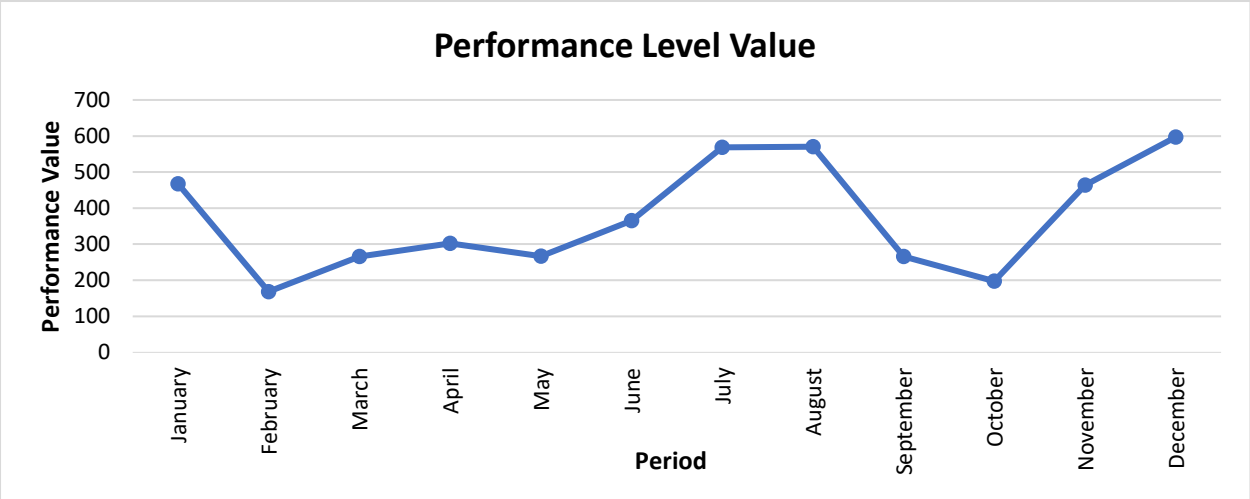

Figure 3. Performance Level Chart for the Period January - December 2020

Based on Table 4, seen in the January 2020 period which is the base month of calculation, so it is considered 0. Furthermore, in February 2020, it can be seen that productivity has decreased very drastically to reach -63.950%. In March, productivity experienced a significant increase to reach 57.685%. In April, productivity decreased to 13.587%, but the value is still positive so that productivity is still said to be good. Furthermore, in May, it decreased again to -11.63%. In June, productivity increased sharply to reach 36.783%. July again experienced a high increase to 55.894%. Then in August it decreased, but the productivity value was positive so it was still quite good. The value reached 0.352%. In September, it decreased very drastically to -53.426%. In October, it decreased again to -25.809%. In November, it increased drastically to 135.193%. The increase in productivity also occurred in December, but decreased compared to the previous month, namely 28.719%. Therefore, it can be seen that the highest productivity occurred in November 2020 with a productivity index value of 135.193%. This is obtained with scores in ratio 1, ratio 2, ratio 3 of 6, 3, and 5 respectively. In addition, the achievement value of November with the previous month is too far away, so it can be said that the productivity index has increased rapidly. Meanwhile, low productivity occurred in February 2020 with a value of -63.950%.

Based on research by Erdhianto and Basuki (2019), by looking at changes in the productivity index, the best and worst productivity can be seen. In February showed a very drastic decrease in productivity compared to other months. In this month the score obtained in the ratio 1 value is 0.1571 below the lowest target, so the score is 0. Then the ratio 2 value is 1.2937 with a score of 2 which is in the lower standard category. Then the value of ratio 3 with a value of 1,896.06 with a score of 3 is right at the standard set. These results show that the company did not effectively use the three inputs during February 2020 compared to other months. In addition, it could be caused by other factors that will be analyzed using a fishbone diagram.

Table 4. Recapitulation of Productivity Index

Period	Productivity Index (%)
January	0
February	-63.950
March	57.685
April	13.587
May	-11.630
June	36.783
July	55.894
August	0.352
September	-53.426
October	-25.809
November	135.193
December	28.719

3.3 Results of Analysis of Causal factors

The lowest productivity index value at PTPN VIII Kebun Pasirmalang occurred in February 2020 with a value of -63.950%. These results are still below the 0% value and show that the three inputs are still far from the set output target. Therefore, it is necessary to evaluate five elements including Machines, People, Methods, Materials and Environment. The analysis was carried out by conducting discussions with related parties, namely the Assistant Head, Head of Quality Control (QC), and Processing Foreman. Based on the discussions that have been carried out, the possible causes are depicted on the Ishikawa diagram, among others:

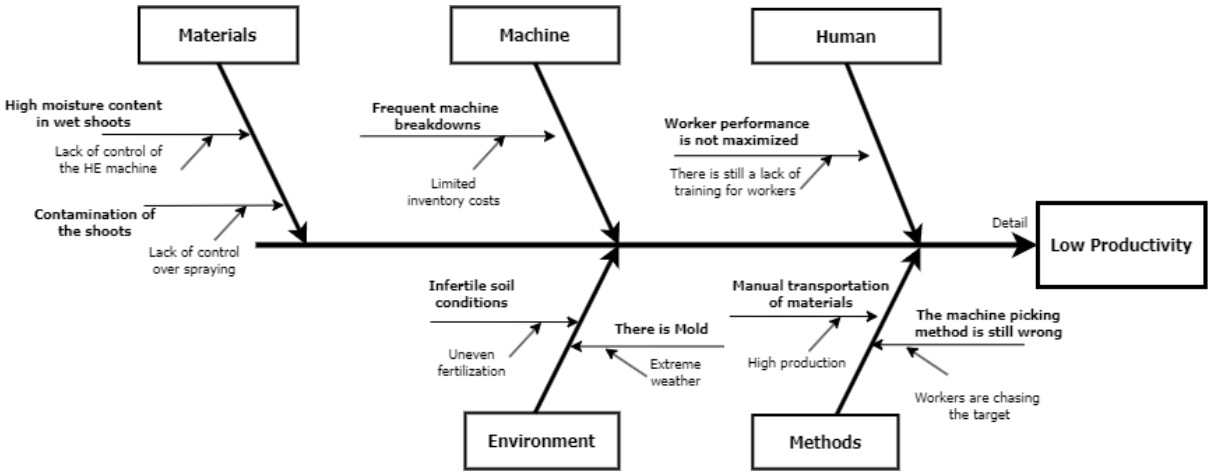

Figure 4. Ishikawa Diagram of Causes of Low Productivity

a) Method Factor

There is a chance that methods cause low productivity. The first is the manual transportation of materials. This is due to high production or overproduction which causes some areas in the Pasirmalang Tea factory to be unable to be passed by several machines. This resulted in some work having to be done manually.

The second is the method of picking tea shoots that is still inappropriate. This is due to workers who are chasing targets. The picking method referred to here is machine picking. Because workers are too focused on the target, many tea shoots that do not meet the standards are included in the production process. As a result, it will affect the quality of the tea powder produced.

b) Human Factors
The possible cause in this case is that the performance of workers is not optimal. This is because the company still lacks training for workers. The training here is intended so that workers have the same skills and knowledge in each production activity. In addition, there is still a lack of evaluation both before and after production activities are carried out. So that the production results obtained are not maximized.

c) Machine Factors
The cause of low productivity is the frequent occurrence of damage to the machine. This is due to the very limited cost of the company's inventory. Therefore, many machines that are in a state of disrepair are only repaired in a sober manner. So that this will result in the production process being hampered, frequent rework on products. This machine damage will also result in a dead machine and eventually not using the machine with the function as it should or it can be said that the transfer of production to another machine.

d) Material Factors
The next causal factor is the material which is the most important point in producing a quality. The most important raw material in the process of making black tea is tea shoots. In this case there are two causes that result in low productivity. The first is the high water content in wet tea buds. This is due to the lack of control of the Heat Exchanger (HE) machine. Usually this often happens during the tea bud withering process. If the moisture content in the tea buds is still high, this will result in a longer process. In addition, the quality of tea powder is not in accordance with the existing standards at Pasirmalang Tea Factory. The second cause is contamination of the tea buds. This contamination usually occurs while in the garden. This is due to the lack of control of spraying.

e) Environmental Factors
This factor can be caused by the external or internal environment. The cause occurs in the external environment, namely in the tea garden. The first cause is infertile soil conditions. This is due to the uneven fertilization process. Uneven fertilization can be caused by other things, such as limited quantity of fertilizer. The second cause is the presence of mold on tea plants. This is due to extreme weather especially during the rainy season. Because mold is definitely present in plants, so proper control must be carried out to overcome the presence of this fungus.

By looking at some of the problems that arise and result in productivity, several solutions can be considered and implemented. In the method section, the arrangement of products in the warehouse can be done by updating the layout. Furthermore, in the human part, training should be held or a reward program should be held to increase the enthusiasm of the workers. Furthermore, in the machine section, it is with routine maintenance on the machine, replacing unfit machines with new machines. Then in the material section, a controlling team should be formed at each work station in order to reduce the occurrence of the causes already mentioned. Finally, in the environment section, where the problem is in the tea shoots section, so the proposed solution is to carry out work evaluations by the garden foreman on a regular basis.

4. CONCLUSIONS

Based on what has been presented, the highest performance-based Productivity Index value in 2020 occurred in November 2020 with a productivity index value of 135.193%. While the lowest productivity index occurred in February 2020 with an IP value of -63.950%. Factors causing low productivity in February 2020 with the Ishikawa diagram include the method of manually transporting materials and the method of picking tea shoots that is still inappropriate. In the human factor is the performance of workers who are not maximized. The machine factor is the frequent occurrence of damage to the machine. Furthermore, the material factor is the highwater content of wet tea buds and contamination of tea buds. Finally, the environmental factor is caused by infertile soil conditions and the presence of mold on tea plants.

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