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The Effect of Drying Methods on The Quality of Dragon Fruit Skin Tea

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Abstract
As a co-product, dragon fruit peels still contain polyphenols that can be used as a tea product alternative, requiring an appropriate drying process. Therefore, it is necessary to find a suitable drying method to obtain high-quality dragon fruit peels as tea product ingredients. The aim of this research is to determine the quality of dragon fruit skin tea with different drying methods. This research used an experimental method by using sun drying against the oven as a drying method in the drying stages of the dragon fruit tea skin making process. The dried fruit peels were then characterized by their tannin, flavonoid, vitamin C, and water contents, as well as their hedonic test scores. The results showed that the qualitative results of tannins and flavonoids in dragon fruit peel tea were positive (+), and the vitamin C content of the peel tea was higher when produced in sun-dried (6.6 mg/100g). On the contrary, the water content of dragon fruit peel tea was higher (7%) by oven drying. Based on hedonic tests, the panelists preferred dragon fruit peel tea produced by the sun drying.

Keywords: *dragon fruit skin, drying, oven, tea*

1. INTRODUCTION

Dragon fruit is a fruit where only the flesh is consumed, and the skin is only thrown away as waste. Dragon fruit skin has advantages that have not been utilized properly. As much as 30-35% of a whole dragon fruit is the skin of the fruit (Nazzarudin et al., 2011). Raudhatul (2017) stated that dragon fruit skin is much more beneficial than the flesh because dragon fruit skin contains antioxidants that can ward off free radicals.

Substances contained in the red flesh of dragon fruit skin in 100 g of dragon fruit include calories 60 kcal, protein 0.53 g, carbohydrates 11.5 g, fiber 0.71 g, calcium 134.5 mg, phosphorus 87 mg, iron 0 .65 mg, vitamin C 9.4 mg, anthocyanins, antioxidants, phenols, flavonoids, proteins, fats, carbohydrates, and water content of 90% (Anzharni, 2016). Many people do not know the benefits of dragon fruit skin. Based on the content contained in dragon fruit skin, research was carried out to make dragon fruit skin tea as well as an innovative approach to utilize dragon fruit skin and further increase its added value.

The drying method is an important factor that affects the quality of the tea. If it's too high, it can damage some of the antioxidant compounds (Kusuma, 2019). Therefore, research was carried out on making dragon fruit peel tea using different drying methods to find out the best way.

2. MATERIAL AND METHODS

2.1 Tools and materials

The tools used were an oven (Yamato), hotplate (Thermo), measuring flask (Iwaki Asahi 100 ml), and volume pipette (Iwaki Asahi 25 ml). The ingredients used in making dragon fruit peel tea were rose-type red dragon fruit peel, which has been cut into small 1 cm pieces, as well as the ingredients used in the tannin test, flavonoid test, vitamin C test, and distilled water, iron (III) chloride solution ($FeCl_3$) 1% (Merck), 96% alcohol (Merck), concentrated HCL (Merck), Mg powder (Merck), 0.01 N iodine solution (Merck), 1% starch (Merck).

2.2 Samples preparation

Rose-type dragon fruit skins (300 g) were purchased in Tajau Pecah village, and they were cut into small pieces with the size of approximately 1 cm. The cutted fruit skin was then dried using an oven (15°C, 18 h) and sun drying (24 h) to see the differencein the tea content. According to Nasir (2020), the use of temperature and time variations has enabled the researcher to assess the differences in the quality of the leather samples in two different drying methods.

2.3 Chemical analysis

The dragon fruit peel tea was tested for tannin and flavonoid qualitatively. Vitamin C content was determined by the iodimetry, and water content was determined by the thermogravimetry.

2.4 Hedonic Test

The hedonic test was carried out using panelists, which tested for the tea's taste, color and aroma. The SNI calculation for Organoleptic and/or Sensory Testing Instructions 01-2346-2006 was used to calculate the average quality value interval for each panelist.

3. RESULTS AND DISCUSSION

Dragon fruit skin is dried using an oven at 50°C for 18 hours. The drying method using an oven has the advantage of a relatively short time required, and the heat provided is relatively constant. However, the method was quite expensive (Bambang, 2016). Meanwhile, sun drying for 24 hours has the advantage of being economical. However, the drying time depends on weather conditions. (Mukhti, 2016).

(a)

(b)

Figure 1 (a) Oven drying and (sun drying) processes of dragon fruit peels

When dragon fruit was dried using an oven, its skin had a drier and harder texture due to the higher temperature of the oven. This resulted in a lower water content and a redder color compared to drying in sun drying (Figure 1). Sun drying could fade the color of dragon fruit skin due to the presence of ultraviolet rays, which could break down the chemical bonds in the skin. The characteristics of dragon fruit tea are summarized in Table 1.

Table 1. Characteristics of Dragon Fruit Peel Tea

Method	Water content (%) Maks 8% (SNI 3945:2016)	Vitamin C (mg/100g)	Tannin Compounds	Flavonoid Compounds
Oven	7.0 ± 1.04	3.31	+	+
Sun drying	9.2 ± 0.58	6.60	+	+

3.1 Water content

Water content is a very important characteristic of food ingredients because it can affect the appearance, texture and taste of food ingredients. According to Bambang (2016), dried tea is hygroscopic so it is very susceptible to damp conditions. Likewise, dried dragon fruit peel tea has hygroscopic properties so their water content needs to be considered to maintain the quality of the tea.

The water content of dragon fruit skin tea dried using an oven, and sun drying has a water content of 7% and 9.2%, respectively. It is observed that dragon fruit skin contains the highest average water content when dried at high temperatures in sun drying. This is because the higher the drying temperature, the more water molecules will evaporate from the dried dragon fruit skin tea. The longer the drying time and the higher the drying temperature, the lower the water content of dragon fruit peel tea. This condition is also supported by the surface area of the dried dragon fruit skin which has a relatively equal skin surface area, making it easier for water to evaporate in the dragon fruit skin. A thin layer will reduce the distance between heat energy moving towards the center of the material so that the water will come out from the material. It was shown that the water content of dragon fruit skin produced by oven drying meets the dry tea quality requirements, (SNI 3945:2016 green tea) of a maximum of 8%.

3.2 Vitamin C content

Vitamin C is known by its chemical name from its main form, namely ascorbic acid. Vitamin C is classified as a water-soluble vitamin. Sources of vitamin C are mostly vegetables and fruits, especially fresh fruits. The average daily nutritional intake of around 30 to 100 mg of vitamin C is recommended for adults (Angelia, 2017).

The vitamin C content in dragon fruit skin is 9.4 mg. The vitamin C was detected by using the Iodimetry method (direct titration). Vitamin C reacts with iodine to produce dehydroascorbic acid, and iodine acts as an oxidizer using a starch indicator; during titration, it reacts with the starch indicator solution to form blue iod-amylum. The formation of a blue color indicates that the titration process has been completed because all the vitamin C has been added to iodine so that the volume of iodine needed during the titration is equivalent to the amount of vitamin C (Nurdin, 2015).

The vitamin C content of dragon fruit peel tea produced by oven drying and sun drying were 3.31 and 6.6 mg/100g, respectively. The difference in the vitamin C content of dragon fruit peel tea products was due to the different thickness positions of the fruit peel slices. During the drying process, which causes the heat received by each product to be different, resulting in differences in damage to vitamin C due to heating in each product. Therefore, the vitamin C levels of each product become unstable.

Judging from the test results for vitamin C content, the higher the drying temperature, the more vitamin C will be damaged because vitamin C is easily oxidized. High drying temperatures will accelerate vitamin C oxidation. This is in accordance with the research of Yanti, et al, (2012) that if the vitamin C content is small and then heated, the resulting vitamin C levels will be smaller. Temperature influences vitamin C resistance, in which vitamin C resistance decreases with increasing temperature. In the drying process, water removal is important, because ingredients (fruit) that contain water and are processed at high temperatures will destroy all the vitamin C.

3.3 Tannin Content

Tannins are a group of polyhydroxy phenols that can be distinguished from other phenols because of their ability to precipitate proteins. This compound has antioxidant activity to inhibit tumor growth (Anggraeni & Oktadoni, 2016). Identification of tannin content in dragon fruit peel tea with the addition of $FeCL_3$ is positive (+) for the presence of tannin by forming a black color. The addition of $FeCl_3$ is used to determine the presence of phenol groups in the sample. The presence of a phenol group in a sample can be detected by observing a greenish-black or blue ink. A positive result from the tannin test with FeCl3 suggests the presence of phenolic compounds, which may include tannin, a polyphenolic compound. Therefore, the presence of tannin may be indicated by the presence of a positive $FeCl_3$ tannin test and the simultaneous observation of a greenish-black or blue ink. The formation of a blackish green or inky blue color in the extract following $FeCl_3$ addition is because tannin will form a complex compound with $Fe_3{}^{+\text{ ions}}$ (Ergina, 2014). From the human sight, oven drying of dragon fruit skin tea produces more black color than those by sun drying, this is because some of the active plant compounds are damaged due to the influence of ultraviolet (UV) from sunlight.

3.4 Flavonoid Content

Flavonoids are found in all green plants, so they can be found in every plant extract. Flavonoids are polar compounds because they have a number of unsubstituted hydroxyl groups. Polar solvents such as ethanol, methanol, ethyl acetate, or a mixture of these solvents can be used to extract flavonoids from plant tissue. Dragon fruit peel tea, which was dried by both oven and sun drying, showed that the dragon fruit peel tea, which was initially red, changed to yellow, indicated that it positively contained flavonoids with the type of flavon compound (Table 2).

The flavonoid content test showed that the ethanol and water extract of red dragon fruit peel tea were yellow and pink, respectively, and it was positive for flavonoids (Lanisthi, 2015). Magnesium and hydrochloric acid react to form bubbles, which are H2 gas. At the same time, the concentrated Mg and HCL powders in this test had a function of reducing the benzopyrone nuclei contained in the flavonoid structure so that the colors become red, yellow, and orange.

According to Lilik (2013), if there is a color change from dark red to purple in the flavonoid test, then the extract contains flavonoids. Flavone compounds gave the red to orange color, the dark red color was given by flavanol or flavonoid compounds, and the green color was given by glycine or glycoside compounds.

3.5 Hedonic Test

The hedonic test is a test in organoleptic sensory analysis that is used to determine the magnitude of differences in quality by providing data from hedonic test results analyzed descriptively using the values given in accordance with SNI 01-2346-2006 Instructions for organoleptic testing and/or sensory assessment of certain properties of a product.

Table 2 Hedonic test results for dragon fruit peel tea

Drying Method	Color	Aroma	Flavor
Oven	6 (somewhat like)	6 (somewhat like)	4 (somewhat dislike)
Sun	7 (like)	6 (somewhat like)	4 (somewhat dislike)

The results of the hedonic test showed that the panelists had the highest level of preference for the color when dried in the sun, with a value of 7 (like). This was caused by the brown color of dragon fruit skin tea almost resembles the color of tea in general.

The aroma and color of dragon fruit skin tea dried in the oven and sun drying have the same favorability value, because it used the same type of red dragon fruit, and there weren't other mixed ingredients that affect the aroma and taste of the skin tea dragon fruit.

4. CONCLUSION

Dragon fruit peel tea produced by oven-drying and sun drying-drying contains positive tannins and flavonoids. The tea produced by sun drying contains 7%, which meets SNI No. 3945:2016. Vitamin C content in dragon fruit peel tea produced by sun-drying was highest (6.6 mg/100g). Dragon fruit peel tea produced by sun-drying exhibits an aroma, color, and texture better than those produced by oven drying.

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The Quality Analysis of Vermicelli From Corn *(Zea mays L)* and Potato *(Solanum tuberosum L)* Starch

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Abstract

Vermicelli was a food made from flour with a particular characteristic in the form of transparent thread and could be produced from corn and potato starch. It must appropriate the quality standards. The Objectives of the research are: (1) to determine the effect of formulation and drying time on the water content of vermicelli, (2) to determine the appropriate formulation of corn and potato starch, (3) to evaluate the quality of durability, (4) to determine the quality of the total protein content in vermicelli made from corn and potato starch. The experimental design of making vermicelli used the complete random design (CRD) method with 2 factors (composition of corn and potato starch) and drying time (120 and 180 minutes). The quality parameters of vermicelli are water content, sensory analysis, durability, and protein content. The results showed that the drying time has a significant effect on the water content of vermicelli. Still, the interaction of formulation and drying time factors did not significantly influence the water content of vermicelli. The overall preference for sensory analysis showed that the vermicelli formulation of 60:40 for corn and potato starch in 180 minutes of drying was the best formulation for Vermicelli-based corn and potato starch. The durability of this vermicelli was appropriate to quality standards (not easily crushed). The protein content was 1.53%, which is not appropriate to the quality standard of SNI 01-2975-2006 (minimum 4%). The novelty of the research was the best composition of materials to produce vermicelli from corn and potato starch and the drying time to produce it. Suggestions for further research could be to produce vermicelli with the composition of materials by adding nuts, eggs, or other ingredients to increase protein content and to analyze its quality.

Keywords: *corn starch, potato starch, quality analysis, vermicelli*

1. INTRODUCTION

Vermicelli was the one variant of noodles. Noodles were a popular food among the public. Noodles are generally made from wheat flour that contains (Julianti et al., 2018). Gluten is a protein found in whole grains. Wheat is an example of a grain that contains gluten (Lu et al., 2022). In the manufacture of noodles (Rara et al., 2020), gluten was served to make the dough elastic (Edun et al., 2019). Gluten (Tortoe et al., 2017) has elastic properties (Jatmiko and Estiasih, 2014) are caused by glutenin compounds (Edun et al., 2019) Not everyone can consume noodles that contain gluten (Zhang et al., 2022). People who have particular diseases such as celiac disease and Autism Spectrum Disorder (ASD) should not consume foods that contain gluten.

Celiac disease is an immune disease in which people cannot consume gluten because it damages their small intestines. People with this disease should avoid gluten for life (Rifa'i, 2013). At the same time, ASD is a disorder in a person that affects verbal and nonverbal abilities. ASD also affects a person's interaction patterns with the social environment (Irvan, 2017). With these conditions, it was necessary to find alternative noodles (Kumalasari et al., 2018) that did not contain gluten. Vermicelli was a gluten-free noodle solution.

Generally, vermicelli is made from rice flour (Hasrini and Hasanah, 2013). Vermicelli could be produced from other materials. Corn starch and potato starch (Julianti et al., 2017), could be used to produce vermicelli. The characteristic advantages of corn and potatoes would be utilized in the vermicelli process. Corn could be processed into starch because it contains 71.35% starch, 2.4% fiber, 4.72% fat, and 0.11% protein (Aini et al., 2016; Siwale et al., 2023) vermicelli produced from corn starch had a soft texture and low protein content. This soft texture caused vermicelli to break easily. The addition of potato starch was expected to be a solution to overcome the shortage.

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According to (Budiarti, 2016), potatoes could be processed into flour because they have carbohydrate content in starch. Potato flour has protein content and low fat (Panghal et al., 2018), as well as a low gelatinization temperature (Aini et al., 2016). Potato starch also had large starch granules as well as high viscosity levels. Another advantage of potato starch is that it contains vitamins B1 and B2, starch, ash, fiber, and essential amino acids used to increase energy (Feng et al., 2022). The use of potato starch covered the deficiencies found in corn starch to produce vermicelli. Vermicelli, with characteristics the same as wheat flour-based noodles, was obtained by experimenting with suitable formulations of corn and potato starch. Therefore, research is needed to determine the effect of formulation and drying time on the water content of vermicelli, determine the appropriate formulation of corn and potato, evaluate the quality of durability, and determine the quality analysis of the total protein content in vermicelli made from corn and potato starch.

2. MATERIAL AND METHODS

The materials of this research are corn and potato starch by added water to produce vermicelli. The materials used to laboratory analysis are filter paper, SeO_2, K_2SO_4, $CuSO_45H_2O$, H_3BO_3 2%, H_2SO_4, NaOH 30%, aqua dest, red methyl, HCl 0.01N, alcohol, and *bromocresol* green 0.1%. This research used analytical balance, Kjeldahl, grinder, drying oven, gas stove, pan, hot plate, desiccator, cup, knife, and porcelain cup.

This research began with making vermicelli using ingredients such as corn starch and potato starch. These two ingredients are added to water and mixed evenly. The resulting mixture will be steamed for 30 minutes. After steaming, it will continue with compression and forming. The vermicelli formed will be dried according to the desired research time. The procedure of making vermicelli can be seen in Figure 1.

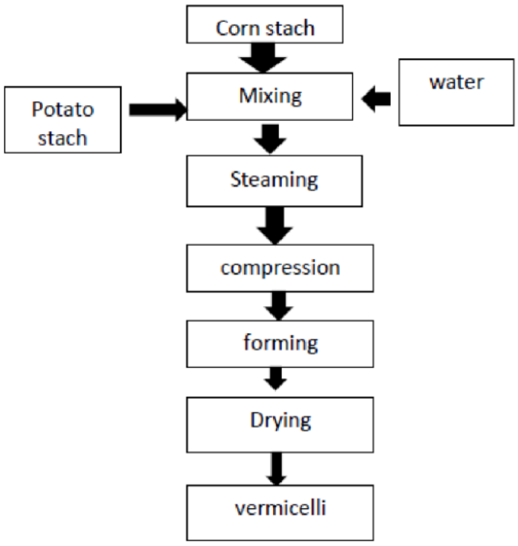

Figure 1. The Procedure for Making Vermicelli

The experimental design of making vermicelli used the complete random design (CRD) method with factorial analysis (2 factors) with two repetitions. The two factors of vermicelli formulation were the composition of corn and potato starch and drying time. The study used 10 combination samples with two repetitions so there were 20 combinations of treatments. All data were processed for analysis of variance on a statistical package SPSS version 25.0. Table 1 shows the design of the experiments in this study.

An experimental design was carried out to determine the effect of formulation and drying time on the water content of vermicelli. This water content is one of the quality parameters of vermicelli. Water content used the gravimetric method (AOAC). Determining the best vermicelli formulation for the composition of corn starch and potato starch to make vermicelli is based on the overall preference value sensory evaluation of vermicelli. The sensory evaluation was performed involving 25 semi-trained panelists. To figure out their preference for vermicelli, panelists were asked to score their preference of smell, color, taste, texture, and overall preference of vermicelli, from 1 to 5. Durability was measured as SNI 01-2975-2006. The vermicelli produced in the study was soaked at room temperature, stirred for 10 minutes, and showed that conditions were not crushed. The protein content of vermicelli was measured by the Kjeldahl method. The analysis of protein content and durability of vermicelli was carried out based on the best formulation.

Table 1. Design Experiment of Vermicelli Based on Corn and Potato Starch.

Time of Drying	Formulation				
	X1	X2	X3	X4	X5
T1	X1T1	X2T1	X3T1	X4T1	X5T1
T2	X1T2	X2T2	X3T2	X4T2	X5T2

T1 = 120 minutes
T2 = 180 minutes
X1 = 30 : 70
X2 = 40 : 60
X3 = 50 : 50
X4 = 60 : 40
X5 = 70 : 30

3. RESULTS AND DISCUSSION

3.1. Effect of formulation and drying time on water content

Based on Table 2, it can be seen that formulation factors do not significantly influence the water content of vermicelli. Meanwhile, the drying time factor has a significant effect on the water content of vermicelli. The interaction of formulation factors and time factors did not significantly influence the water content of vermicelli.

Table 2. ANOVA of Water Content

Source	Df	SS	MS	F Value	Sig.
Formulation	4	12.218	3.054	1.584	0.253
Drying time	1	10.976	10.976	5.690	0.038
Formulation * Drying Time	4	5.042	1.261	0.653	0.638
Error	10	19.289	1.929		

There were ten samples in the water content analysis of vermicelli. The results of the water content values for vermicelli using the gravimetric method can be seen in Table 3. The water content of vermicelli with a drying time of 180 minutes has a lower water content compared to vermicelli dried for 120 minutes. The Water content is the water component contained in a material. The percentage of water content in the material needs to be measured because if the water content capacity does not match the desired product standard, it will have the potential for microorganisms to grow(Prasetyo et al., 2019) . The water content of a material is influenced by the drying time and temperature. The longer the drying time and higher the drying temperature, the lower the water content of a material (Rosidin et al., 2012).

Table 3. The Results of Water Content Analysis

Formulation (%)	Time (minutes)	Water Content (%)
30: 70	120	8.049
	180	7.166
40: 60	120	10.573
	180	7.094
50: 50	120	8.633
	180	7.727
60: 40	120	8.282
	180	6.320
70: 30	120	9.456
	180	7.285

The drying time factor has a significant effect on the water content analysis of vermicelli. The results of the water content analysis based on the length of drying time can be seen in Table 3. It can be seen that the drying times of 120 minutes and 180 minutes are significantly different. The long drying time causes the water content of vermicelli to be different.

3.2. Sensory Analysis of Vermicelli

The sensory analysis (Rodrigues Júnior et al., 2016) was used to assess the level of consumer preference for smell, color, taste, texture, and the overall preference for vermicelli. Table 4 shows the results of the average score of sensory properties e.g. smell, color, taste, and texture. The highest score of the sensory analysis became an indicator of the panelist's preferred level.

Table 4 shows the 70:30 formulation of corn starch and potato starch at 120 minutes is the highest score (3.80). The smell that was most selected by panelists was the corn smell. The highest average score occurred at the concentration of 70% cornstarch and 30% potato starch with a drying time of 120 minutes. This showed that the less concentration of corn starch, the smell of vermicelli couldn't be smelled perfectly. The panelist's preference level will decrease along with the increase in flour or starch concentration because the distinctive smell of the flour or starch itself will be more pronounced (Biyumna et al., 2017).

Table 4. Sensory Analysis Score Of Smell, Color, Taste, and Texture

Formulation (%)	Time (minutes)	Sensory Properties			
		Smell	Color	Taste	Texture
30: 70	120	3.40	3.13	3.27	3.20
	180	3.20	3.33	3.20	3.80
40: 60	120	3.60	3.53	3.13	3.93
	180	3.33	3.13	3.47	3.93
50: 50	120	3.27	3.87	3.53	3.27
	180	3.60	3.47	3.40	3.67
60: 40	120	3.73	3.60	3.33	3.33
	180	3.47	3.93	3.60	3.83
70: 30	120	3.80	3.40	3.47	3.47
	180	3.73	3.73	3.53	3.67

Based on the color sensory analysis score in Table 4, it can be seen that the highest score of 3.93 is for vermicelli with a formulation of 60:40 and a drying time of 180 minutes, indicating that the panelists like the color of vermicelli. The highest score indicates the panelists' preference. In this condition, the color of vermicelli is yellow. The color of this vermicelli tends to be yellow because the formulation contains more corn starch. Corn influences the level of yellowness of the product (Xiang et al., 2019). The yellow color in vermicelli is due to the carotenoid content in corn, which is 6,4-11,3 μg/g. Carotenoid is one of the essential pigments that contribute red, yellow, and orange colors to corn. Some kinds of carotenoids include β-carotene, lycopene, lutein, α-carotene, γ-carotene, bixin, norbixin, capsanthin, and β-apo-8- carotene (Hu & Zhang, 2022; Lalujan et al., 2017).

Table 5. Overall Preference Sensory Test Score

Formulation (%)	Time (minutes)	Score
30:70	120	3.20
	180	3.67
40:60	120	3.73
	180	3.33
50:50	120	3.73
	180	3.87
60:40	120	3.73
	180	3.93
70:30	120	3.87
	180	3.39

The average score of taste sensory analysis showed vermicelli with a 60:40 formulation and 180 minutes drying time is 3.60. It is the highest score and most preferred by panelists. The preferred taste of vermicelli is the sweet taste of corn and potato starch. According to Yu & Moon (2021), the preferred taste of corn vermicelli is the sweet taste of corn.

Table 4 shows that the highest texture sensory test score is 3.93. The score of vermicelli with a formulation of 40:60 for all drying time (120 and 180 minutes). It indicates that the panelists like the texture of vermicelli. The vermicelli texture favored according to vermicelli research (Ismail et al., 2020) by panelists is chewy and not easily broken (Chen, 2020).

Table 5 shows the overall preference for sensory analysis. Vermicelli with a formulation of 60:40 and 180 minutes of drying time has the highest score (3.93). It becomes the most preferred choice of panelists and the best formula for Vermicelli-based corn and potato starch. It becomes the best formulation determined by using the overall preference sensory score (Nurdjanah et al., 2014).

3.3. Durability Test

A durability test was also conducted in this study. The indicator of this test is easily crushed by the product. The study used SNI 01-2975-2006 as the standard for vermicelli durability. This fact indicates that the vermicelli made in this study is already appropriate to the standard. The formulation's content of 60:40 and 180 minutes of drying time indicates the best vermicelli durability (not easily crushed). The content of amylose makes for good durability of vermicelli. Hydrogen (hydroxyl) bonds between amylose in starch produce insoluble crystals (Aini et al., 2016).

3.4. Protein Content of Vermicelli

The vermicelli protein analysis was based on the best formulation of vermicelli formulation of 60:40 and a drying time of 180 minutes. The analysis obtained a protein content of this vermicelli of 1.53%. According to SNI 01-2975-2006, vermicelli has a minimum protein content of 4%, so the vermicelli protein in this study is not appropriate to the standard. The low protein content of vermicelli is likely due to the raw material formulation being low in protein. The protein in corn starch is only 3.43% (Alam and Nurhaeni, 2008) and the protein content in potato starch ranges from 0.08% (Schirmer et al., 2013); (Shen et al., 2021) to 1.18% (Cruz et al., 2016) and is generally lower than that of cereal starch. Therefore, to increase the protein content of vermicelli, we must add ingredients that are high in protein, such as nuts, eggs, or other materials to fulfill SNI quality standards. According to Jumanah et al. (2017), a concentration of canna flour: green bean flour: and tapioca flour (30%: 35%: 35%) obtained a protein content of 9.83%. It can be seen that differences in the formulation can affect the total protein content of a product.

4. CONCLUSIONS

The conclusions of the research are (1). The drying time factor has a significant effect on the water content of vermicelli. A drying time of 180 minutes has a lower water content compared to vermicelli dried for 120 minutes. The interaction of formulation factors and time factors did not significantly influence the water content of vermicelli. (2). The overall preference for sensory analysis shows that vermicelli with a formulation of 60:40 for corn and potato starch in 180 minutes of drying time has the highest score (3.93). It becomes the most preferred choice of panelists and the best formulation for Vermicelli-based corn and potato starch. (3). The formulation's content of 60:40 and 180 minutes of drying time indicates the best vermicelli durability (not easily crushed). (4) The quality analysis obtained a protein content of this vermicelli of 1.53%, which is not appropriate to the SNI 01-2975-2006 standard (minimum 4%).

The novelty of the research is the best composition of materials to produce vermicelli from corn and potato starch and the drying time to produce it. Suggestions for further research could be to examine the composition of materials to produce vermicelli by adding nuts, eggs, or other ingredients to increase protein content.

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Design of Table and Chairs for Packaging Tempe Chips Work Station for Reducing the Risk of Occupational Diseases in Putra Tunggal Home Industry Wonosobo

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Abstract

Home Industry Putra Tunggal Wonosobo is a tempeh chip industry whose production process is manual, so it can have a negative impact on worker ergonomics. Preliminary research was conducted by interviewing pain complaints and assessing work posture using the OWAS method. The tempeh chips packaging workstation was the workstation that had the most pain complaints at 67.86% (19 of 28 body parts) and the highest OWAS score at 4, so this was at high risk of experiencing musculoskeletal disorders. The next study used the NBM questionnaire to analyze the level of pain due to work and RULA for work posture. CATIA software was used to design tables and chairs, as well as assess the posture of the design results using the RULA method. Worker performance will be compared before and after using tables and chairs based on the level of body pain due to work (NBM) and work posture (RULA). The research results showed a decrease in the risk of work-related diseases by 80 and 78 to 40 and 44 (from high to low-risk levels) as well as a decrease in the RULA score from 7 (dangerous posture) to 2 (good posture).

Keywords: *NBM, OWAS, posture, RULA.*

1. INTRODUCTION

The production process of most Home Industries in Indonesia still applies a labor-intensive system with minimal skills (Thorbecke, 2018) and is carried out manually (Manual Material Handling). This can result in workers being 62% more at risk of developing work-related musculoskeletal disorders (WMSDs) (Calzavara et al., 2017). Moving goods that are not supported by good facilities causes unhealthy body posture (Zhang et al., 2018). Therefore, it is necessary to apply knowledge of the design of work facilities that pay attention to human aspects as users, which is often called ergonomics.

Ergonomic work facility design requires anthropometric aspects. Anthropometry is the science of measurement that determines the physical geometry, mass properties, and strength capabilities of the human body and plays an important role in the design of household and industrial environments (Sutalaksana and Widyanti, 2016). The aim of designing ergonomic work facilities is to reduce complaints of pain during work and after work. The methods that can be used to assess working posture are the OWAS (Ovako Working Posture Analysis System) method as a preliminary assessment method and the RULA (Rapid Upper Limb Assessment) method as a follow-up assessment method. The use of the RULA method is due to the packaging workstation being static (not requiring whole-body movement). The NBM (Nordic Body Map) questionnaire is a questionnaire used to determine workers' complaints before and after work (Wahyudi et al., 2015).

Ergonomics research like this is very necessary in all industries, especially in MSME-based industries. This is because the average MSME production process is still manual with minimal work facilities (without paying attention to ergonomics). For example, research conducted by Zulkifli (2010) related to "Analysis of Cracker Making Workstations Based on the OWAS Method [Case Study: *Dua Saudara* Home Industry]". The results of the research show that of all the workstations there is a workstation that is the most uncomfortable, one of which is mixing workstation 1 with an OWAS score of 3 because the mixing process is still on the floor with a bucket tool. (back bent, both arms straight at the shoulders, and both legs bent). Therefore, at workstation 1 a table is provided to make the kneading process more comfortable and safe by improving the position of the back straighter, both arms under the shoulders, and both legs straight.

Putra Tunggal Home Industry is one of the home industries with a superior product in the form of tempe chips which is located in Wonosobo. The production process is carried out by 8 workers

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consisting of 5 workstations, namely workstations for slicing tempeh, making flour and spice dough, frying tempeh chips, packaging tempeh chips, and sealing packaging for tempeh chips. However, the production process is carried out manually with work facilities that are unergonomic, one of which is at the tempeh chips packaging workstation. This can be proven in preliminary research with the results of assessing the percentage of worker complaints based on NBM and the results of the OWAS assessment at other workstations such as the tempeh slicing workstation with an NBM value of 39.28% (11 out of 28 body parts) and a final OWAS value of 1 (normal work); a workstation for making chip dough with an NBM of 21.43% (6 out of 28 body parts) and a final OWAS score of 2 (rather heavy work); a chip frying workstation with an NBM value of 28.57% (8 out of 28 body parts) and a final OWAS score of 2 (rather heavy work); as well as the packaging sealing workstation with an NBM value of 7.14% (2 out of 28 body parts) and a final OWAS value of 1 (normal work), while the tempeh chips packaging workstation had an NBM value of 67.86% (19 out of 28 body parts) and a final OWAS value of 4 (very heavy work) which indicates that the musculoskeletal system has a very fatal risk (high risk) and requires improvement. Therefore, improvements are needed in the ergonomic aspects of the tempe chips packaging workstation. This aims to obtain a work facility design in the form of ergonomic tables and chairs at the tempeh chips packaging workstation which can reduce WMSDs in the form of pain after work.

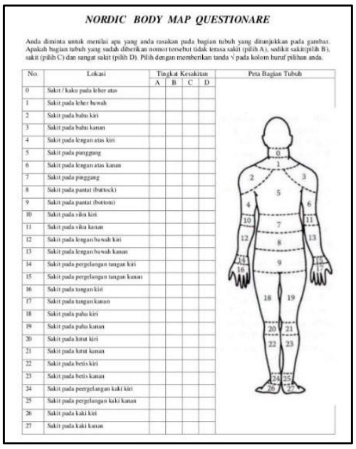
2. MATERIAL & METHODS

2.1. Material

The materials used in this research were tempeh chips and there were 8 workers (2 people slicing tempeh, 1 person making chip dough, 2 people frying chips, 2 people packing chips, and 1 person at the sealing workstation), the NBM questionnaire as a medium for assessing work-related pain, the OWAS questionnaire as a medium for assessing preliminary work posture, the RULA questionnaire as a medium for assessing advanced working posture, a notebook, smartphones as a medium for taking photos, and writing tools. Other materials used are the CATIA (Dassault Systemes, French) application as a design and simulation maker as well as wood and tools as the main materials for making table and chair work facilities.

2.2. Methods

The research method uses the Ovako Working Posture Analysis System (OWAS) method which is a method used to analyze and evaluate uncomfortable working postures and result in musculoskeletal injuries (Karhu et al., 1977). The parts of OWAS posture that are assessed are the back, arms, legs, and weight of the load when working (loads/use of force). Assessment of the level of work-related pain using the Nordic Body Map (NBM) method is a method that uses a questionnaire to determine the level of fatigue which is measured before and after carrying out work at each workstation, and is usually characterized by the appearance of disorders or complaints in the muscles and bones that occur. often called musculoskeletal disorders (Sutari et al., 2015). The questionnaire can be seen in Fig 1.


NORDIC BODY MAP QUESTIONARE

Anda diminta untuk menilai apa yang anda rasakan pada bagian tubuh yang ditunjukkan pada gambar. Apakah bagian tubuh yang sudah diberikan nomor tersebut tidak terasa sakit (pilih A), sedikit sakit(pilih B), sakit (pilih C) dan sangat sakit (pilih D). Pilih dengan memberikan tanda √ pada kolom huruf pilihan anda.

No.	Lokasi	Tingkat Kesakitan A	B	C	D	Peta Bagian Tubuh
0	Sakit / kaku pada leher atas					
1	Sakit pada leher bawah					
2	Sakit pada bahu kiri					
3	Sakit pada bahu kanan					
4	Sakit pada lengan atas kiri					
5	Sakit pada punggung					
6	Sakit pada lengan atas kanan					
7	Sakit pada pinggang					
8	Sakit pada pantat (buttock)					
9	Sakit pada pantat (bottom)					
10	Sakit pada siku kiri					
11	Sakit pada siku kanan					
12	Sakit pada lengan bawah kiri					
13	Sakit pada lengan bawah kanan					
14	Sakit pada pergelangan tangan kiri					
15	Sakit pada pergelangan tangan kanan					
16	Sakit pada tangan kiri					
17	Sakit pada tangan kanan					
18	Sakit pada paha kiri					
19	Sakit pada paha kanan					
20	Sakit pada lutut kiri					
21	Sakit pada lutut kanan					
22	Sakit pada betis kiri					
23	Sakit pada betis kanan					
24	Sakit pada peergelangan kaki kiri					
25	Sakit pada pergelangan kaki kanan					
26	Sakit pada kaki kiri					
27	Sakit pada kaki kanan					

Figure 1. Nordic Body Map Questionnaire
(Source: Dewi, 2020)

Based on Fig 1, the NBM questionnaire can be calculated by adding up the parts of the body that feel uncomfortable working multiplied by their respective scores (A for score 1, B for score 2, C for score 3, and D for score 4), then added together overall for all parts of the body. According to Dewi (2020), after the total score is obtained, it is then matched with the respective total scores, where a score of 28-49 has a low level of risk (no improvement has been made, a score of 50-70 has a medium level of risk (it is possible to make improvements at a later date, a score of 71-91 has a high-risk level (immediate action is required), and a score of 92-112 has a very high-risk level (repair is needed as soon as possible).

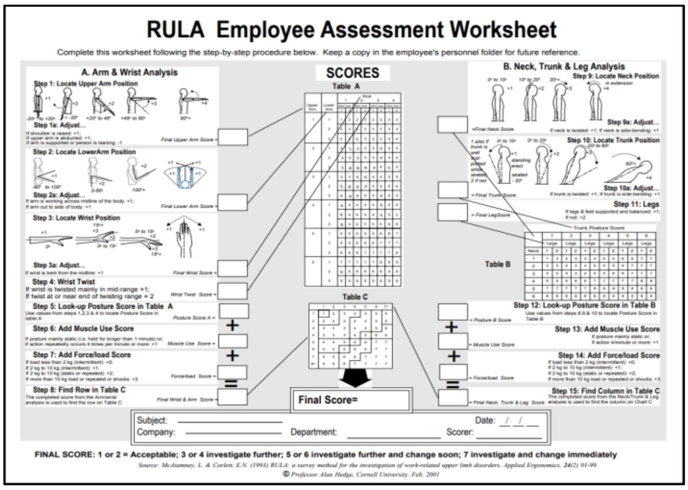


Figure 2. RULA Assessment Questionnaire *(Source: McAtamney dan Corlett, 1993)*

Rapid Upper Limb Assessment (RULA) is a method of ergonomic analysis and assessment of body posture when working with the use of the upper body (Tiogana and Hartono, 2020). Based on Fig 2, the final score obtained from table A and table B in the questionnaire, a final score can be obtained in table C which can be linked to risks and corrective actions. According to McAtamney and Corlett (1993), a score of 1-2 is still acceptable, a score of 3-4 may be corrected at a later date, a score of 5-6 can be corrected, and a score of 7 must be corrected as soon as possible. The advantages of the RULA method are the most accurate and specific analysis of upper body posture, easy calculations, and does not require special equipment to carry out.

Anthropometry is the science of measurement that determines the physical geometry, mass properties, and strength capabilities of the human body, and plays an important role in the design of household and industrial environments (Sutalaksana and Widyanti, 2016). This anthropometric measurement can be carried out using four dimensions of body part groups, namely anthropometry of the head, body, hands and feet. Anthropometric calculations can be adjusted to the percentile requirements, where the percentiles commonly used in this calculation are the 5^{th}, 50^{th} and 95^{th} percentiles. The determination of this percentile formula can be seen in Table 1.

Table 1. Normal Distribution and Calculation of Anthropometric Percentiles

Percentiles	**Calculation**
1	$\underline{X} - 2.325\ \sigma_x$
2.5	$\underline{X} - 1.960\ \sigma_x$
5	$\underline{X} - 1.645\ \sigma_x$
10	$\underline{X} - 1.280\ \sigma_x$
50	$\underline{X}$
90	$\underline{X} + 1.280\ \sigma_x$
95	$\underline{X} + 1.645\ \sigma_x$
97.5	$\underline{X} + 1.960\ \sigma_x$
99	$\underline{X} + 2.325\ \sigma_x$

(Source: Wignjosoebroto, 2000)

Based on Table 1, the percentiles that will be used are 5, 50, and 95. However, the 50th percentile is not used in this study because the results of the design can only be used comfortably for adults who have average body dimensions (people who have extreme bodies will feel uncomfortable) (Purnomo, 2013). The 5th percentile is used in the design because it can accommodate the type of work for the smallest people in the population who can use the design, while the 95th percentile is used to accommodate the type of work for the tallest and fattest user population. The use of these two percentiles can be applied to the design of tables and chairs as in Table 2.

Table 2. Specifications for the use of anthropometric data in making tables and chairs

Specifications	Body Limb Size	Percentiles
Table Width	Distance between the hand grip to the back (horizontal hand position)	5
Table Length	Shoulder Width (bideltoid) + 2 thigh thickness (allowance)	5
Table Height	Knee Crease Height (popliteal) + Elbow height in sitting position	95
Chair Width	Distance from the knee (popliteal) to the buttocks	95
Chair Length	Pelvic Width	95
Chair Height	Knee Fold Height (popliteal)	5

3. RESULTS AND DISCUSSION

3.1. OWAS and NBM

Work element 1 Work element 2 Work element 3

Figure 3. Initial Conditions of the Tempe Chips Packaging Workstation

Based on Fig 3, the OWAS assessment was used during preliminary research only because observation techniques are compatible with occupational health care, practical to use, oriented towards corrective action (not just problem identification), and proven to function as a safety tool at work in a company (Karhu et al, 1981). The results obtained at the tempe chips packaging workstation had a value of 4 which was categorized as very heavy work. This is because work element 1 of putting tempeh chips into 0.5 kg plastic packaging has a score of 4 (code 4 1 4 1), work element 2 of weighing packaged tempeh chips (0.5 kg) has a score of 4 (code 4 1 4 1), as well as work element 3 of placing and tidying up the packaged tempeh chips that will be sealed with a score of 4 (code 4 2 4 1). Packaging of tempe chips is done by sitting on a dingklik chair with dimensions of 30x25x20 cm and without a supporting base for the basin holding the frying tempe chips which causes the worker's back to bend (forward and to the side) and the knees to be too bent. This result makes the tempe chips packaging workstation have the highest OWAS score compared to other workstations, so improvements are needed as soon as possible.

The NBM questionnaire was used to assess chip packaging employees before and after work. However, the results that will be compared are the NBM value of workers after work because the NBM value before work is 28 which shows that the whole body is still normal. The results that will be compared are before using the table and chairs (initial conditions) and when using the table and chairs as in Table 3.

Table 3. NBM assessment results in initial conditions and using tables and chairs

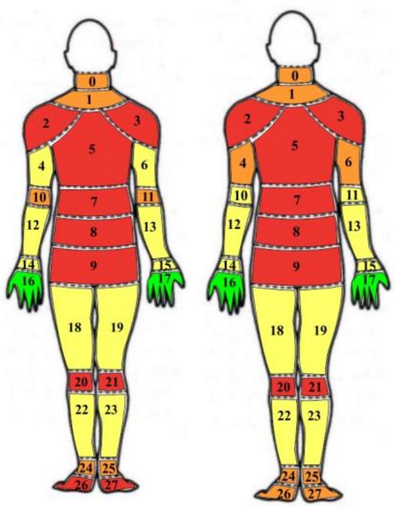
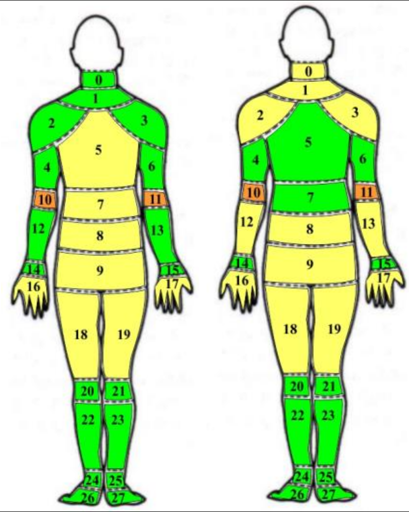
Initial Condition	Using a table and chair
	
Score of worker 1 (left)= 80 Score of worker 2 (right)= 78	Score of worker 1 (left)= 40 Score of worker 2 (right)= 44

Table 3 explains that when using packaging tables and chairs there is a decrease in work-related pain based on the NBM value for both workers. In the initial conditions, worker 1 and worker 2 respectively had NBM scores of 80 and 78, where this result indicates that the chip packaging workstation has a high level of risk so immediate corrective action is needed. However, when using packaging tables and chairs, there was a decrease in the NBM score. Worker 1 and worker 2 respectively had NBM scores of 40 and 44, where this result indicates that the chip packaging workstation has a low risk level so no corrective action has been found. These results indicate that the improvements made in the form of creating work facilities such as tables and chairs can reduce the level of risk of work-related illness from high risk to low risk.

3.2. RULA

The initial conditions of the tempeh chips packaging workstation with minimal facilities can be seen in Figure 4 and the results of the RULA assessment can be seen in Table 4.

Worker 1 Worker 2

Figure 4. Worker's position in initial conditions and the elevation angle

Table 4. RULA assessment in initial conditions

Assessment Indicators	RULA Score		Information
	Worker 1	Worker 2	
Group A			
Upper arm	4	4	Worker 1 experiences flexion at an angle of 70°, while worker 2 experiences flexion at an angle of 75°, and the upper arm is raised away from the body
Forearm	1	1	Worker 1 experiences flexion at an angle of 80°, while worker 2 experiences excessive flexion at an angle of 65°
Wrist	3	3	Worker 1 experiences extension at an angle of 31°, while worker 2 experiences extension at an angle of 25°
Wrist twist	1	1	Wrist rotation is within a rotation range of no more than 90°
Muscle Use Score	1	1	This posture is repeated more than 4 times in 1 minute
Load Score	0	0	Load < 2 kg
Group A Score	5	5	-
Group B			
Neck	3	3	Worker 1 experiences flexion at an angle of 20.5°, while worker 2 experiences flexion at an angle of 21°
Back	4	4	Worker 1 experiences flexion at an angle of 21°, while worker 2 experiences flexion at an angle of 32°, and his back tends to tilt to the side.
Legs	2	2	Legs are not balanced by bending the knees due to limited facilities (stool)
Muscle Use Score	1	1	This posture is repeated more than 4 times in 1 minute
Load Score	0	0	Load < 2 kg
Group B Score	7	7	-
Final Score	7	7	The work posture is less than natural so investigation and correction are needed as soon as possible

Based on Fig 4 and Table 4, the results of the RULA assessment at this packaging workstation received a score of 7 (less common work posture). This final score shows that this packaging workstation really has an unnatural working posture so investigation and repair are needed as soon as possible. It can be seen that the upper arm is flexed more than 45°, the lower arm is flexed more than 100° or less than 60°, the neck is flexed more than 20° or extended, the back is flexed more than 20°, and legs are similar to a squatting position. This is because the facility only uses seating mats in the form of chairs measuring 30x25x20 cm and there is no support for the basin holding the tempe chips frying which causes the upper and lower arms to be raised for long periods of time, the neck bends, the worker's back bends and the knees (feet) too bent. The RULA assessment results after using the packaging table and chair facilities have different RULA scores. This can be seen in Figure 5 for the working posture and Table 5 for the RULA assessment results.

Worker 1 Worker 2

Figure 5. The position of the worker using the table and chair and the elevation angle

Table 5. RULA assessment when using tables and chairs

Assessment Indicators	RULA Score		Information
	Worker 1	Worker 2	
Group A			
Upper arm	1	1	Worker 1 experiences flexion with an elevation angle of 40°, while worker 2 experiences flexion with an elevation angle of 40.5°, and his arm can rest on the table.
Forearm	1	1	Worker 1 experiences flexion with an elevation angle of 87°, while worker 2 experiences flexion with an elevation angle of 95°
Wrist	1	1	Worker 1 and worker 2 do not experience extension or flexion because both elevation angles are 0°.
Wrist twist	1	1	Wrist rotation is within a rotation range of no more than 90°
Muscle Use Score	1	1	This posture is repeated more than 4 times in 1 minute
Load Score	0	0	Load < 2 kg
Group A Score	2	2	-
Group B			
Neck	1	1	Worker 1 experiences flexion with an elevation angle of 8°, while worker 2 experiences flexion with an elevation angle of 9°
Back	1	1	Worker 1 and worker 2 do not experience flexion or extension because the elevation angle formed is 0°.
Legs	1	1	Leg posture is balanced with the help of a chair that suits the anthropometry (ergonomics)
Muscle Use Score	1	1	This posture is repeated more than 4 times in 1 minute
Load Score	0	0	Load < 2 kg
Group B Score	2	2	-
Final Score	2	2	The working posture is acceptable

Based on Table 5, the final RULA score before the repairs took place was from 7 (requires investigation and repair as soon as possible) to 2 (acceptable work posture). This can be seen in the upper arm which is not too raised because it can be leaned on the table (flexed less than 45°), the lower arm which can be leaned on the table, the wrist which is straight (not too bent/extended), the neck which is no longer bent forward (flexed less than 10°), the back is straighter (not flexed), and the legs are not too bent and can be easily moved forward or backward. These results indicate that using these work facilities can create conditions for good working posture naturally and can minimize the danger of WMSDs in packaging workers.

3.3. Design of Table and Chair

The design of the table and chairs is closely related to the anthropometric data of the two tempe chips packaging workers. This stage requires carrying out anthropometric calculations using the 5th, 50^{th,} and 95th percentiles, but the percentiles that will be applied are the 5th and 95th percentiles. The 5th percentile is used as a representation of the range of dimensions that accommodates the type of work for the smallest people in the population. Meanwhile, the 95th percentile represents a spatial dimension that can accommodate types of work for a large population (Purnomo, 2013). The basic requirements that need to be used to make tables and chairs include the length, height, and width of each facility which are adjusted to the anthropometric data used as in Table 6.

Table 6. Measurement and Calculation of Anthropometric Data

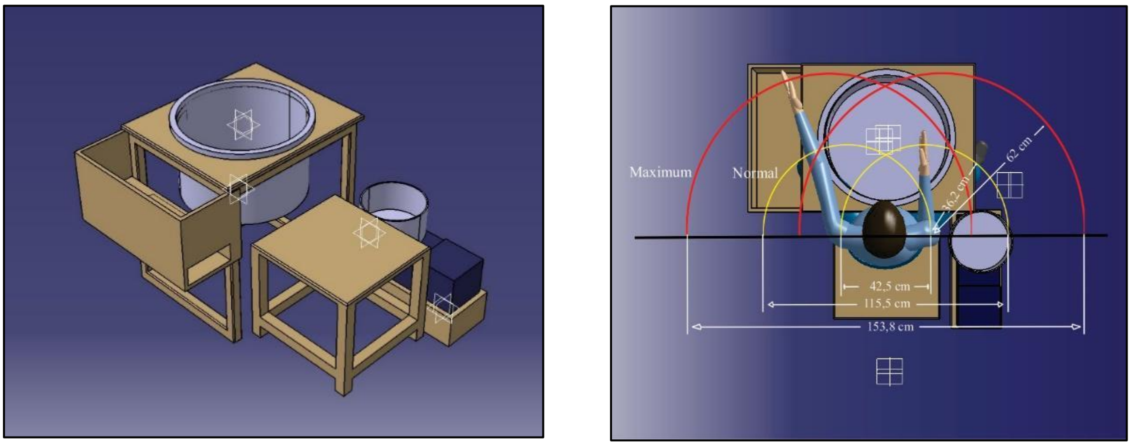
Specific Needs	**Part of Body**	**Dimensi of Worker**		**Percentile**	**Size Specifications**
		1	**2**		
Table Width	The distance between the hand (grip) to the back (horizontal hand position)	55	59	5	55.5
Table Length	Shoulder width (bideltoid) + 2 thigh thickness (allowance)	65.4	66	5	65
Table Height	Knee height (popliteal) + elbow height in sitting position	55	59.5	95	62.5
Chair Width	The distance from the knee (popliteal) to the buttocks	42.5	40	95	44.5
Chair Length	Pelvic width	38	32	95	42
Chair Height	Knee height (popliteal)	37	37.5	5	37

Table 6 explains that the percentiles used are adjusted to the dimensions, where table width, table length, and chair height use the 5th percentile (distance dimension) while table height, chair width, and chair length use the 95th percentile (space dimension) (Purnomo, 2013). This stage is rounded up to the nearest one with the aim of making the error smaller. This stage also requires modifications to suit existing tools such as basins, scales, and the size of the packaged chips. The specifications for these modifications are as in Table 7.

Table 7. Specifications of Modifications Made

Specific Needs	Parts Required	Sizes	Specifications Used	Remarks
Table Hole Diameter	Inner basin diameter	47	47	No handle on the basin
Length of Scale place	Length of Scale	46	50	Plus 2 cm for the 2 sides of the fence
Width of Scales place	Width of Scales	17	21	Plus 2 cm for 2 sides for the fence
Height of Scales place	Height of chairs - height of scales (total)	7	12	Plus allowance for 5 cm of scale to fit into place
Plastic Container Length	Plastic length	40	40	-
Width of Plastic Container	Plastic width	18	21	Plus 1.5 cm for the 2 sides of the fence
Height of Plastic Container	Height of Plastic Stack 2 pack	5	7	Plus 1.5 cm for the base
Shelf Length	Table width	55.5	52.5	Minus 1.5 cm for the 2 sides of the fence and a total distance of 1 cm from the edge of the tabletop
Shelf Width	Width of Packed Chips	18	21.5	Plus 1.5 cm for 1 fence and 2 cm allowance
Shelf height	It is half the length of the packaged chips	20	20	-
Shelf Height From Ground	Table Height-(Shelf Height+Plastic Container Height)	35.5	35.5	-
Distance between weighing place and chair	-	5	5	To the right of the chair
Distance between Shelf and Table	-	0	0	To the right of the table
Distance of Plastic Container to Table	-	0	0	To the right of the table

Based on the specifications for making packaging tables and chairs in Table 6 and Table 7, a design can be created using CATIA along with the work area as in Figure 6.



(a) Model Design (SE Isometric)

(b) Normal (Yellow) and Maximum (Red) Work Area

Figure 6. Table and Chair Design and Work Area

Fig 6 explains the design position of the packaging table and chair facilities, such as the position of the frying basin in the middle of the table with a hole, the scale to the right of the chair, and the temporary chip placement rack and its plastic packaging container to the left of the table. This placement is done to create more effective working habits. Figure 6 also explains the normal work area with a distance of 36.2 cm which makes it easier and easier for the work to be done, while the maximum work area is with a distance of 62 cm which makes the work done difficult and burdensome. The design in Figure 6 is then carried out with a work posture assessment (RULA) using the CATIA application as in Figure 7.

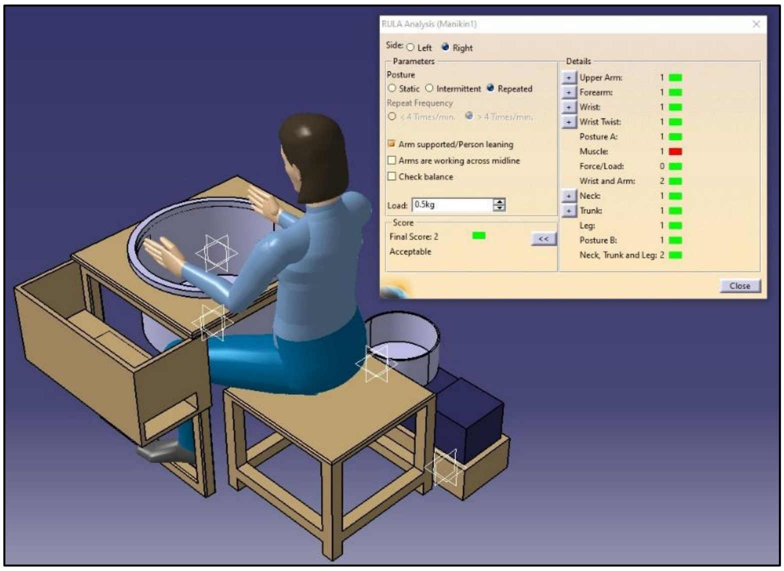


Figure 7. RULA Posture Assessment in the CATIA application

Based on Figure 7, explains that with a tempe chips load of 0.5 kg (score 0), the RULA score for the upper arm, forearm, wrist, wrist rotation, and muscle use is 1 so the RULA score for the upper limb is 2, while the RULA score for the neck, back and legs is 1 so the RULA score for the lower limbs is 2. Both of these body parts results can be obtained with a final RULA score of 2 on CATIA which indicates that the working posture is more comfortable and acceptable, so this design will be directly created as in Figure 8.

Desk and chair facilities from behind the side

Figure 8. Packaging table and chair facilities

Based on Fig 8, it can be seen that the work facilities for packaging tempe chips in the form of tables and chairs are made from sengon wood, totaling 4 wooden planks measuring 2 meters and 4 wooden poles measuring 3 meters. This work facility has been used by employees of the tempe chips packaging department during the 3-day trial period for data to be collected.

This research needs to increase the flexibility of the working facilities of tables and chairs for packaging tempeh chips so that these facilities can be used by anyone apart from the two packaging worker respondents with different anthropometric measurements. Increased flexibility by using table and chair heights that can be adjusted according to needs, for example by using a hydraulic system to raise and lower height levels.

4. CONCLUSION

This table and chair facility can reduce the level of risk of work-related illnesses (NBM score) from 80 and 78 to 40 and 44 (high risk to low risk) and also minimize mismatches in a working posture with RULA score of 7 to 2, so that working posture is better. Overall, the packaging table and chair facilities make workers work more safely and comfortably.

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Analysis of Factors Influencing Interest in Purchasing Porang Rice Using The Extended Theory of Planned Behavior (E-TPB)

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Abstract

Porang rice, as imitation rice made from porang tubers, can be used as a substitute for white rice because it contains low calories and high fiber. In Indonesia, the marketing of porang rice and related research is still limited. This research aims to determine the characteristics of respondents and the factors that influence interest in buying porang rice, as well as recommendations for marketing strategies based on the research results. Data were analyzed using descriptive statistics, chi-square test, and SEM-PLS. The sample used was selected using a non-probability sampling method using a purposive sampling technique. The number of respondents obtained was 112 respondents. The research results found that the knowledge and status of respondents who were on a calorie diet were the main characteristics of respondents regarding their interest in buying porang rice. Subjective norms and perceived behavioral control directly influence interest in buying porang rice. Product availability indirectly influences interest in buying porang rice through perceived behavioral control. Recommendations for manufacturers' marketing strategies include providing information about low calories and high fiber on their packaging and promotional media, expanding their partner network with retail stores that are frequently visited by the public, and maximizing sales using e-commerce.

Keywords: *marketing, porang rice, purchasing interest, theory of planned behavior*

1. INTRODUCTION

Obesity, or being overweight, is a problem for the world community, including in Indonesia. According to the Ministry of Health of the Republic of Indonesia (Kementerian Kesehatan RI) (2023), there has been a significant increase in obesity, from 10.5% in 2007 to 21.8% in 2018. Obesity is one of the factors causing the emergence of non-communicable diseases that cause other deaths, such as diabetes mellitus, heart disease, cancer, and hypertension. Efforts can be made to reduce the number of obese people in Indonesia by increasing their awareness of following a high-calorie diet.

The habit of consuming high-calorie foods increases the risk of obesity 12.4 times (Putri, 2022). Some high-calorie food products that are often consumed include fried foods, white rice, processed noodles, and sweetened or fizzy drinks. Among these foods, white rice is a staple food for Indonesian people. Many community members assume that they have eaten when they have consumed rice. Statistical data from the Central Statistics Agency (BPS) (2022) states that per capita rice consumption per week from 2019 to 2021 has continuously increased, namely from 1,313 tonnes to 1,451 tonnes. The carbohydrate content of white rice with high levels of consumption can increase obesity and the risk of diabetes mellitus in countries where white rice is consumed as a staple food (Bhavadharini et al., 2020). So, a calorie diet that replaces carbohydrates in white rice as a staple food with other products high in fiber and low in calories can also be implemented in Indonesia.

Artificial rice can be an alternative to white rice for staple foods because its texture and taste are almost similar. A nearly identical texture can provide an excellent response to food substitutes in consumers because texture dramatically influences the taste of food when chewed in their mouth (Setiawan et al., 2021). Apart from that, artificial rice diversifies rice to strengthen Indonesian food security.

Artificial rice can be an alternative to white rice or porang rice. Porang flour comes from processed porang tubers, which contain low fat, high fiber, and protein (Mahirdini and Afifah, 2016), so it can be used as a substitute for white rice. The main ingredient in porang flour is glucomannan,

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which has various benefits, such as reducing blood cholesterol obesity, treating chronic constipation, preventing and inhibiting cancer, and lowering blood glucose (Supriati, 2016; Setyono et al., 2021).

The glucomannan contained in porang rice helps reduce blood cholesterol, reduce obesity, treat chronic constipation, prevent and inhibit cancer, and lowering blood glucose (Supriati, 2016; Li et al., 2019; Setyono et al., 2021; Faizal et al., 2022). In the Fukumi brand of porang rice, it was found that the calories of porang rice per 100g were worth 70 kcal. Where the calorific value, when compared with white rice, red rice, and other analogous rice such as Smart rice, Gayong, Siger, Rasbi (sweet potato rice), and rasi (cassava rice), has the lowest value (Table 1).

Table 1. Calorie Value per 100g of rice

Types of Rice	Calorie (kcal)
White rice	180
Brown rice	149
Smart rice	350
Gayong rice	364
Siger rice	344
Rasbi (sweet potato rice)	394
Rasi (cassava rice)	350
Porang rice (Fukumi)*	70

Source: Indonesian Food Composition Table 2017 (Ministry of Health, 2018); *Sucofindo Laboratory Test Results (www.fukumi.co.id, 2021)

The porang rice industry in Indonesia has become known to the general public in recent years. The pioneer of the porang rice industry is PT. Ambitious Trading Company (PT. Ambico) and several industries have mass-produced and marketed porang rice, such as PT. Asia Prima Konjac (Fukumi) and CV. Bali Yuan Organic. Porang rice is produced by mixing several components as complementary ingredients, such as water and rice flour, starch, or shellfish flour, with each brand composition varying. This research focused on porang rice products with a composition of porang flour (48-50%), rice flour and water.

As a product that has only just become known to the public, the marketing of porang rice is still relatively limited. Porang rice is still not known throughout Indonesia. According to search data on Google Trend (2023), Indonesian people who are familiar with porang rice are predominantly from the islands of Java and Bali. Previous research was about the behavior of shirataki rice consumers (Case Study in Malang City) by Gillandtama et al, 2022. In this research, the respondents were only limited to Malang City so the results of the research only presented consumers in the Malang City area. There is another study with the same raw materials but the products used are different, namely interest in buying shiradek noodles by Divayana et al, 2022. Knowledge regarding the factors that influence the formation of interest in buying porang rice is necessary because it can help the porang rice industry prepare marketing strategies that align with consumer desires (Morwitz et al., 2007).

Research Purposes: 1) Describe consumer characteristics influencing interest in purchasing porang rice. 2) Analyze the factors from the Extended Theory of Planned Behavior (E-TPB) that influence consumer buying interest in porang rice. 3) Provide recommendation notes for marketing strategies based on objectives 1 and 2.

2. MATERIAL AND METHODS

2.1 Research Time and Sampling

This research was carried out in July - November 2023. The respondent sample was determined using purposive sampling, a technique with specific criteria adapted to research needs (Sugiyono, 2013). The requirements for respondents in the sample were Indonesian citizenship, having knowledge about porang rice, experiencing a decline in health (obesity, diabetes mellitus, hypertension, or stroke), being on a high-calorie diet, and/or having consumed porang rice and being willing to fill out a questionnaire. The minimum number of respondents is 100 (Lemeshow and David, 1997).

2.2 Data collection

The primary and secondary data used in this research are primary and secondary. Secondary data was collected from literature studies sourced from books and information from journals related to the topic of discussion. Primary data was collected using an online survey via a Google form questionnaire (tinyurl.com/KuesionerBerasPorang).

The questionnaire contains questions about respondent characteristics and variable indicators prepared in a research hypothesis scheme (Figure 1.) The scheme is prepared based on the TPB concept, namely attitudes towards behavior (SP), subjective norms (NS), and perceived behavior control (PC) variables which can influence the purchase intention (MB) variable (Ajzen, 2005), which was expanded with the addition of health awareness (KS) and product availability (KP) variables (Divayana et al., 2022). The respondents' answers were assessed using 4 Likert scales, namely 1=strongly disagree, 2=disagree, 3=agree, and 4=strongly agree.

Data was collected from the accounts of researchers and fellow researchers by distributing questionnaires using social media, including WhatsApp, Instagram, TikTok, and X/Twitter. Through this media, data was collected from 112 respondents who had filled out the questionnaire, with 66 respondents having ever consumed porang rice and 46 people who had never consumed porang rice. All respondents obtained good knowledge about porang rice.

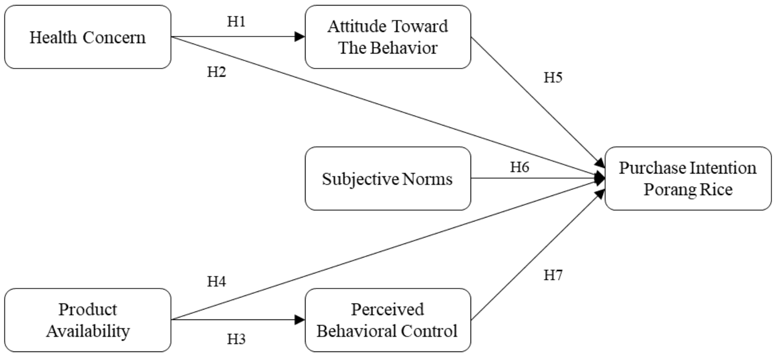

Figure 1. Research Hypothesis Scheme

2.3 Data Analysis

The collected data was then analyzed using descriptive statistics, cross-tabulation Chi-Square test analysis, and Partial least square Structural equation modeling (SEM-PLS) analysis. Descriptive statistics are used to describe the respondent's character. Cross-tabulation Chi-Square test analysis was used to see the significant relationship between respondent characteristics and interest in buying porang rice. SEM-PLS analysis is used to analyze factors influencing purchasing interest based on E-TPB.

2.4 Chi-Square Cross tabulation

Cross-tabulation analysis is a relatively simple analytical method that can explain the relationship between variables. The cross-tabulation analysis used Chi-Square statistical analysis to describe the significance level of the relationship between variables (Sugiyono, 2013). In this study, the cross-tabulation chi-square test was carried out with the help of SPSS 25 software. The two variables have a significant relationship when the Asymp Sig (2-sided) value is more than 0.05 (Priyono, 2008).

2.5 SEM-PLS

E-TPB variables (attitudes towards behavior, subjective norms, perceived behavioral control, health awareness, and product availability) on interest in buying porang rice were analyzed using SEM-PLS with SmartPLS 4.0 software. The benefit of using SmartPLS 4.0 software is its ability to analyze data in small amounts (112) and does not require normally distributed data in the data analysis process

(Supriadi, 2022). The data analysis process was carried out in two stages: evaluation of the measurement model and assessment of the structural model.

2.5.1 Third-Level Heading Evaluation of the Measurement Model/Outer Model

Measurement model evaluation is used to evaluate the validity and reliability of the data used for analysis. The assessment was carried out using three tests: convergent validity, discriminant validity, and reliability (Ghozali, 2006). The measurement model can be seen in Table 2.

Table 2. Measurement model evaluation (Ghozali, 2006)

Evaluation	Parameter
Reliability	Composite reliability value > 0.70
Convergent Validity	Loading factor value > 0.60 Average variance extracted (AVE) value > 0.50
Discriminant Validity	Fornell Larcker value: Square root AVE > correlation value between latent constructs Cross loading value: Correlation of indicators with their constructs > correlation between indicators and other constructs

2.5.2 Evaluation of the Structural Model/Inner Model

Structural model evaluation is used to analyze the relationships between variables. Evaluation is carried out by looking at the value of R^2 (*explained variance*) to measure the level of relationship between exogenous variables and endogenous variables. The Q^2 (*predictive relevance*) value is to see how well the model makes observations. The f^2 (effect size) value is used to know the variable's influence level at the structural level. The value of f^2 is equal to 0.02; 0.15; and 0.35 can be interpreted respectively that the latent variable predictor has a small, medium, and large influence structurally. The path coefficient value is used to see the level of influence between variables in one path, and the t-statistic test evaluates the hypothesis acceptance. The path coefficient value between -1 and 0 means that the exponential variable has a negative influence on the endogenous variable or has the opposite influence. A value between 0 and 1 means that the exogenous variable has a positive influence on the endogenous variable (Ghozali, 2006).

3. RESULTS AND DISCUSSION

3.1 Characteristics That Influence Interest in Buying Porang Rice

The relationship between respondent characteristics and interest in buying porang rice was analyzed using a cross-tabulation chi-square test using SPSS 25 software. The results of the analysis can be seen in Table 3. Based on these results, the respondents' knowledge and current condition are the characteristics that significantly influence their interest in buying porang rice, which is suitable for a calorie diet. Based on respondents' knowledge of porang rice, it was found that their knowledge of porang rice consistently influenced their interest in giving porang rice. Based on the health condition of the respondents, it was found that the condition of the respondents who were on a calorie diet significantly influenced their interest in buying porang rice. Meanwhile, the characteristics of respondents based on demographics were not significantly related to interest in buying porang rice. It is different from similar research conducted by Divayana et al. (2022) on Shirataki Instant Noodles, who found that demographics influenced purchasing interest through TPB variables, namely gender, income, and age, but did not influence overall.

Table 3. Cross-tabulation chi-square test results of respondent characteristics with buying interest

Respondent Characteristics		*Asymp Sig (2-sided)*		
		MB1	MB2	MB3
Sociodemographic	Gender	0.139	0.084	0.262
	Age	0.892	0.262	0.629
	Domicile	0.540	0.219	0.724
	Education	0.727	0.705	0.982
	Occupation	0.925	0.263	0.791
	Income	0.516	0.791	0.221
Health Status	Diabetes	0.062	0.076	0.145
	Hypercholesterol	0.945	0.815	0.510
	Coronary heart	0.645	0.267	0.755
	Obesity	0.422	0.506	0.718
	Chronic constipation	0.819	0.601	0.811
	Cancer	-	-	-
	Calorie diet	0.044**	0.544	0.245
Knowledge		0.872	0.387	0.036**

** Significance at α=5%

3.2 Factors of Interest in Buying Porang Rice Based on Extended Theory of Planned Behavior (E-TPB) Variables

The results of the measurement model evaluation show that the data used has a loading factor value for all variables > 0.60 and an AVE value > 0.50, so the data is convergently valid. The cross-loading value and Fornell Larcker value for all pairs of indicators are higher than the correlation value between other indicators, so the data is said to be discriminant valid. The composite reliability value obtained is > 0.70, so the data is reliable. The results of the R^2 test (Table 4) show that health awareness, product availability, attitudes towards behavior, subjective norms and perceived behavioral control can explain the purchase interest variable by 57.8%. The product availability variable can explain the perception of the behavior control variable by 36%. The health awareness variable can explain the attitude towards behavior variable by 43.1%. The Q^2 test results (Table 4) show that all endogenous variables (MB, PC, and SP) have a value of more than 0. The Q2 value explains that the model has good predictive relevance (Ghozali, 2006). So, the exogenous variables can be good at predicting endogenous variables.

Table 4. R^2 and Q^2 Values

Variable Exogen	Variable Endogen	R^2 Value	Q^2 Value
Health Awareness Product Availability Attitudes Towards Behavior Subjective Norms Perceived Behavioral Control	Purchase Interest	0.578	0.310
Product Availability	Perceived Behavioral Control	0.360	0.333
Health Awareness	Attitude Toward	0.431	0.404

The results of the f2 test (Table 5.) show that product availability and health awareness do not influence structural purchase intention. Subjective norms and attitudes towards behavior weakly influence purchase intention structurally. Product availability on perceived behavioral control, health awareness on attitudes towards behavior, and perceived behavioral control on purchase intention have a solid structural influence.

The t-statistic test (Table 6) shows that three hypotheses are rejected, namely H2, H4, and H5. So, based on the t-test, it can be said that health awareness influences attitudes toward behavior, product availability influences perceived behavioral control, and subjective norms and perceived behavioral control directly influence interest in buying porang rice. Meanwhile, health awareness, product availability, and attitudes toward behavior do not directly influence interest in buying porang rice. However, regarding the product availability variable, it can be said that it indirectly influences the interest in buying porang rice through a behavioral control process. These findings can be seen from the path that the variable product availability influences perceived behavioral control, then perceived behavioral control influences interest in buying porang rice (Figure 2.). This finding aligns with research from Lwin et al. (2020) and Divayana et al. (2022), which states that product availability indirectly influences purchase intention for functional foods through perceived behavioral control.

The path coefficient value (Table 4) (Figure 2) obtained is above 0 for all paths, meaning all paths have a positive relationship. A positive relationship means that every time the value of the exogenous variable increases, the value of the endogenous variable will also increase. Based on the path coefficient value, it was also found that the highest value was found in the behavioral control perception variable path, which influenced interest in buying porang rice with a value of 0.544. So, it can be concluded that perceived behavioral control influences the intention to purchase porang rice more than subjective norms. The perceived behavioral control variable path is also influenced by product availability with a path coefficient value of 0.600.

Based on the loading factor value (Figure 2), the indicator with the most influence on the latent variable can be found. The indicator with the most significant loading factor value means that the indicator is the factor that has the most impact on the formation of the latent variable. The product availability variable has the most significant loading factor value on the KP3 indicator (I can quickly get porang rice at my regular shop) of 0.805. It means that product availability in consumers' regular shops is an essential factor in the product availability variable that influences interest in buying porang rice. The behavioral control perception variable has the most significant loading factor value in the PC2 indicator (I am willing to purchase porang rice if the resources (time & costs) are available) of 0.849. That means that the availability of time and costs have a significant influence on controlling consumer behavior and interest in purchasing porang rice. The purchase interest variable has the most considerable loading factor value on the MB3 indicator (I am consistently interested in buying porang rice) of 0.915. The consistency of interest in purchasing porang rice is the most significant factor in forming interest in purchasing porang rice.

Table 5. value of effect size (f^2) dan *Path Coefficient*

Path	Value f^2	*Path Coefficient Value*
KP → PC	0.563	0.600
KP → MB	0.001	0.023
KS → SP	0.758	0.657
KS → MB	0.005	0.062
NS → MB	0.037	0.140
PC → MB	0.358	0.544
SP → MB	0.027	0.156

Table 6. Results of Bootstrapping Testing and Hypothesis Testing

Hypothesis	*t-statistics*	Acceptance of Hypothesis Testing
H1: KS SP	14.076	Accepted
H2: KS MB	0.750	Rejected *
H3: KP PC	9.306	Accepted
H4: KP MB	0.269	Rejected *
H5: SP MB	1.705	Rejected *
H6: NS MB	2.062	Accepted
H7: PC MB	5.289	Accepted

*Requirements for accepting the hypothesis are >1.96

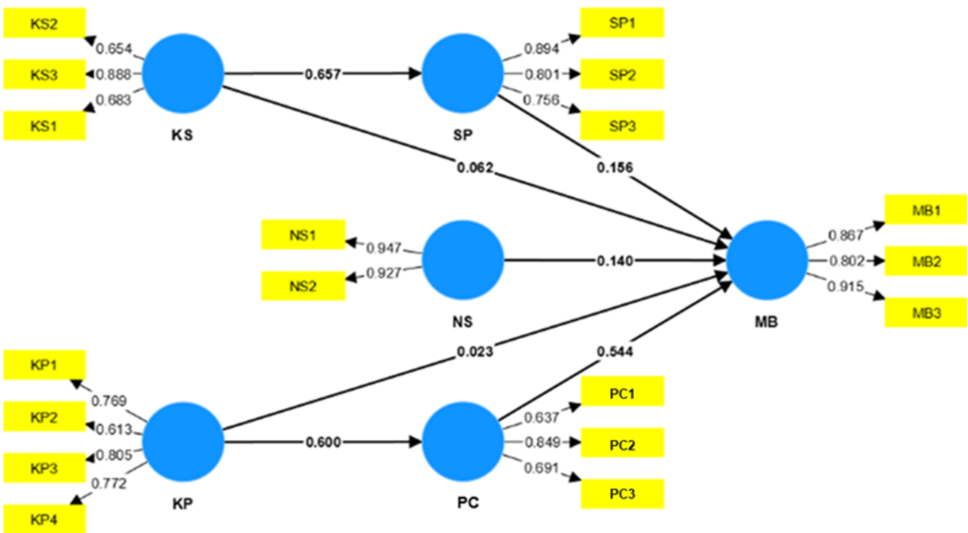

Figure 2. Final model analysis results

3.3 Recommendations For Marketing Strategy

The following recommendations can be considered to assist in developing a marketing strategy for porang rice. (1) Based on the relationship between respondent characteristics and interest in buying porang rice, it is known that the knowledge and status of respondents who are on a calorie diet have a significant relationship with interest in buying porang rice. Therefore, producers can add more information about the content and benefits of porang rice on the packaging or in product advertisements, such as adding information about claims of low calorie and high fiber content based on laboratory test results on the packaging. (2) Based on the variable analysis, the availability of porang rice products at consumers' regular shops is an important factor in buying interest in porang rice through perceived behavioral control. Therefore, producers can expand their partner network with retail stores that are frequently visited by the public, such as national minimarkets and supermarkets such as Alfamart, Indomaret, Superindo, and others or local ones such as Gading Mas, Mirota, and Pamela in Yogyakarta, Golden supermarkets and Dynasty supermarkets in Kediri, as well as local minimarkets and supermarkets in other areas. (3) Based on the behavioral control perception variable, the availability of respondents' resources such as time and costs are important factors, so business actors can pay attention to prices and easy access to purchasing porang rice. Therefore, producers can maximize sales using e-commerce because purchasing using e-commerce according to the public saves more time and costs than offline purchases.

4. CONCLUSIONS

The demographic characteristics of respondents do not have a significant relationship with interest in buying porang rice. Respondents' knowledge of porang rice and the status of respondents on a calorie diet have a substantial relationship with their interest in purchasing porang rice.

Based on the Extended Theory of Planned Behavior (E-TPB), subjective norms and perceived behavioral control directly influence interest in buying porang rice. The product availability variable indirectly influences the interest in buying porang rice through the perception and behavior control variable. The variable influencing the intention to purchase porang rice is perceived behavioral control with a t-statistic value of 5.227 > 1.96.

Recommendations for marketing strategies based on the results of this research provide information on the content and benefits of porang rice in packaging or in product advertisements, such as adding information about claims of low calorie and high fiber content based on laboratory test results on the packaging. Apart from that, producers can expand their partner network with retail stores frequently visited by the public, such as national and local minimarkets or supermarkets, and maximize sales using e-commerce.

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Application of Edible Coating from Konjac Flour added with Chitosan on the Quality of Red Chili

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Abstract

Red chilies have a relatively short shelf life and are highly perishable. Red chili is one type of vegetable with a water content (60 - 90 %) at the time of harvest and an increase in respiration rate. Therefore, it is necessary to pack a coating that can reduce and suppress respiration and transpiration rates to prevent vegetable damage. One potential way to reduce the damage to red chilies is by applying edible coatings. Edible coating is one technique that can be developed and applied to maintain quality and extend the shelf life of red chili. This study aims to determine the quality characteristics of red chili (Capsicum annuum L) before and after coating edible coating. In addition, to analyze the effect of Konjac flour concentration on the quality characteristics of red chili (Capsicum annuum L) with the addition of chitosan and to find out the best treatment for the application of edible coating with the basic ingredients of Konjac flour with the addition of chitosan. This study used a completely randomized design (CRD) and three replications. The treatment in this study was the storage time of coated red chilies edible coating for 1, 3, 6, and 9 days. The results showed that the storage time of coated red chilies edible coating affects the pH, water content, weight loss, respiration rate, and color. The analysis of the characteristics of red chilies showed that the coating done on red chilies can reduce and suppress the process of respiration rate.

Keywords: *edible coating, red chili, Konjac flour, chitosan*

1. INTRODUCTION

Red chili pepper (*Capsicum annum* L) is a leading commodity in the horticulture sub-sector, which is often used as a cooking spice. Red chili production increases every year in line with the increasing population and the development of industries that require red chili raw materials. The Central Statistics Agency states that the increase in red chili production volume from 2018 was 1,206,750 tons/year to 1,360,571 tons/year in 2021 (Badan Pusat Statistik, 2022). Red chilies have a relatively short shelf life and are easily damaged. Red chili is a type of vegetable that has a water content (60-90%) at harvest and undergoes a process of increasing respiration rate (Mikasari, 2016). Therefore, it is necessary to pack and coat vegetables that can reduce and suppress respiration and transpiration rates to prevent damage to vegetables. One of the potential ways to reduce the damage rate of red chilies is by applying edible coating. The edible coating acts as a barrier against gaseous moisture (O_2 and CO_2) as well as solutes by causing movement of the semipermeable membrane around the fruit, thus inhibiting the rate of respiration, water loss, and oxidation processes (Nawab et al., 2017).

The edible coating uses safe ingredients such as Konjac flour and chitosan. Konjac flour has the property of forming a selectively permeable membrane to CO_2 and O_2 which causes the respiration of fruits and vegetables to be reduced (Amalia et al., 2020). Chitosan compared with beeswax or paraffin, chitosan in chili coating is considered very good because it has the potential as an antimicrobial agent containing the enzyme lysozyme and clusters amino polysaccharides, which can inhibit the growth of microbes (Rohim et al., 2015). The purpose of this research is to determine the quality characteristics of red chili (*Capsicum annum* L) before and after edible coating Konjac flour with the addition of chitosan and determine the best application treatment edible coating with the basic ingredients of Konjac flour with the addition of chitosan.

2. MATERIAL AND METHODS

2.1 Tool and Material

Some types of equipment were used in this research; namely, analytical scales (sartorius), measuring cups, measuring pipettes, dropper pipettes, blender, pH meter, beaker glass, aluminum foil,

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stirrer, spatula, hot plate, magnetic stirrer (Medine scientific), tongs, aluminum pan, scissors, latex gloves, label paper, filter cloth, color reader, 50 ml glass bottle, aluminum cup, desiccator, and oven.

This study used several materials as the main ingredients, namely Konjac flour (Ikarie) and shrimp chitosan (Phy Edumedia). The additional materials used to implement this study were red chili (*Capsicum annum* L). At the same time, the chemicals used in the study namely distilled water, glycerol, benomyl fungicide (Masalgin), water, 0.1N HCL, phenolphthalein, and 0.1N NaOH.

2.2 Research Design

The research design used a laboratory experimental method with a completely randomized design (CRD) which aimed to determine the quality of fresh red chilies during storage. The proportions of Konjac flour and chitosan in five different formulas are distributed into each composition with a total weight of 5 grams, which is presented in Table 1.

Table 1. Design Experimental

Formula	Konjac Flour (%)	Chitosan (%)
F0	0	0
F1	100	0
F2	75	25
F3	50	50
F4	25	75
F5	0	100

2.3 Research Stages

The first stage of research is the identification of problems and objectives. The second stage is the study of literature. The third stage is antifungal immersion (masalgin) 2 grams/liter, and edible coating on red chilies. The fourth stage was testing the observation parameters to determine the best treatment by testing pH, water content, weight loss, color, and respiration rate on days 1^{st}, 3^{rd}, $6^{th,}$ and 9^{th}.

A. Making Edible Coating

Making process of edible coating starts from weighing each material according to the treatment ,adding 500 ml of distilled water, then homogenizing using a temperature of 60 ^{o}C with a magnetic stirrer for ±10 minutes at 140 rpm (Murni et al., 2013). The homogeneous chitosan solution was added to each Konjac flour according to the treatment, then heated and stirred at 60 ^{o}C for ±10 minutes at 140 rpm. Then, 2 ml of glycerol was added as a plasticizer. Respective application of edible coating on red chili by dipping method, then dried dan stored at room temperature (25^{o}C - 27^{o}C) by hanging. Then observations were made on days 1, 3, 6, and 9.

B. Application Edible Coating

The application process of edible coating starts with choosing the type of red chili that is in a fresh state. Then, washing is done to clean and remove the dirt that sticks. Then, dip antifungal (masalgin) with 2 g/L before the coating process. The red chilies were drained and dried at room temperature for 10 minutes. The dried chilies are then coated with an edible coating made from Konjac flour and chitosan using the immersion method. Observations were made on days 1, 3, 6, and 9, and then data were collected using observation parameters, namely pH test, water content, weight loss, color, and respiration rate.

2.4 Observation Parameters

A. Test pH

Measurement of the degree of acidity (pH) uses a pH meter (Sidabalok, 2021).

B. Test Water Content

Testing the water content was carried out using the gravimetric method (AOAC, 2012). Calculation of the value of water using the following equation.

$$\text{Water content} = \frac{Weight\ of\ the\ water\ evaporated}{Initial\ water\ weight} \text{ x } 100\ \% \quad (1)$$

$$\text{Water content} = \frac{b-c}{c-a} \text{ x } 100\ \%$$

C. Weight Loss Test

Measurement of weight loss was carried out by weighing the red chili sample first before treating it as the initial weight. The final weight was weighed on the n-day during storage (Marwina et al, 2016).

$$\%\ \text{Weight loss} = \frac{initial\ weight - final\ weight}{Initial\ weight} \text{ x } 100\% \quad (2)$$

D. Color Test

Testing the color of red chili using color reader tools. The values shown on the color reader are L* (brightness-dark), a* (red-green) and b* (yellow-blue) (Gunal et al., 2008).

E. Respiration Rate Test

Testing the respiration rate using the titration method with modifications to the ripening stage (Amalia et al., 2020).

$$\text{Respiration rate} = \frac{(t\ sample - t\ blangko)\ x\ N\ HCl}{Weight\ sample/\ time(hour)} \quad (3)$$

2.5 Data Analysis

The data obtained were analyzed statistically using ANOVA with the posthoc Duncan's New Multiple Range Test (DNMRT) at 5% significance level. Research results continued to determine the best treatment of edible coating by using multiple attributes, namely based on certain criteria from the results of the analysis of water content, weight loss, and respiration rate.

3. RESULTS AND DISCUSSION

3.1 pH Value

The pH test was carried out as one of the chemical parameter tests with the aim of knowing the acidity level of red chilies. The results of the initial pH test on red chili before it was carried out edible coating, namely 6. Post Harvest processing using the method of edible coating Konjac flour and chitosan are expected to be able to maintain the quality characteristics of red chili, one of which is the level of acidity. It could happen because changes in fruit pH occur due to an increase or decrease in H ions inside the fruit. The results of the red chili pH test can be seen in Figure 1.

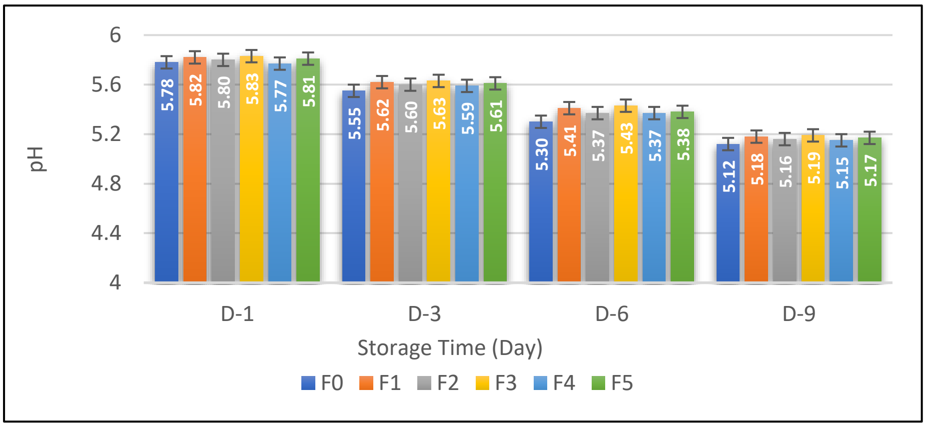

Figure 1. pH Value changes during storage

Based on Figure 1, the results showed that red chili decreased from day 1 to day 9 in all treatments. In the F0 treatment, the lowest decrease was 5.78 to 5.12, while the treatment that experienced the highest decrease occurred in the F3 treatment, which was 5.83 to 5.19. In storage conditions at room temperature, what matters is time. It caused a decrease in pH, but not significantly. On the 9^{th} day, F0 without treatment experienced the lowest decrease, while the coated red chili edible coating was higher due to plating edible coating. This reduces substrate contact with microorganisms. Sulistyaningrum's research (2018), the longer curly chili is stored, the pH decreases, and the effect of packaging or without packaging. The decrease in pH was due to the degradation of carbohydrate compounds into organic acids during storage (Sidabalok, 2021). The increased acid content causes the pH to decrease. Therefore, the longer the storage, the more metabolic reactions occur due to the activity of microorganisms that break down sucrose into organic acids.

3.2 Water Content Test Results

Physiological activities can cause disturbances in plant materials, including evaporation or transpiration, breathing or respiration, and physiological changes. It can affect several content factors contained in food ingredients so proper storage treatment is needed so that they can be preserved. One of the important factors contained in food ingredients is the water content. The water content contained in foodstuffs can be in the form of intracellular and or extracellular components as a solvent medium in various products. Red chili before edible coating has a moisture content of 90%. The process of handling fresh vegetables is necessary for humidity control so that loss of moisture content and damage during storage can be avoided.

Post Harvest processing using the method of edible coating Konjac flour and chitosan are expected to be able to maintain the quality characteristics of red chili, one of which is water content. Edible Coating produced with Konjac flour can produce Edible Coating which has strong adhesive power; based on the adhesive properties of Konjac flour, it is better when compared to other adhesives such as corn and rice, so it can function to provide a selective barrier against the movement of gases, water vapor and dissolved materials, as well as protection against mechanical damage so that the decrease in the moisture content of the ingredients can be suppressed (Amalia et al., 2020). Moisture content is done by calculating the amount of water content contained in a material using the drying method with an oven during storage time can be seen in the diagram of the results of the research on water content presented in Figure 2.

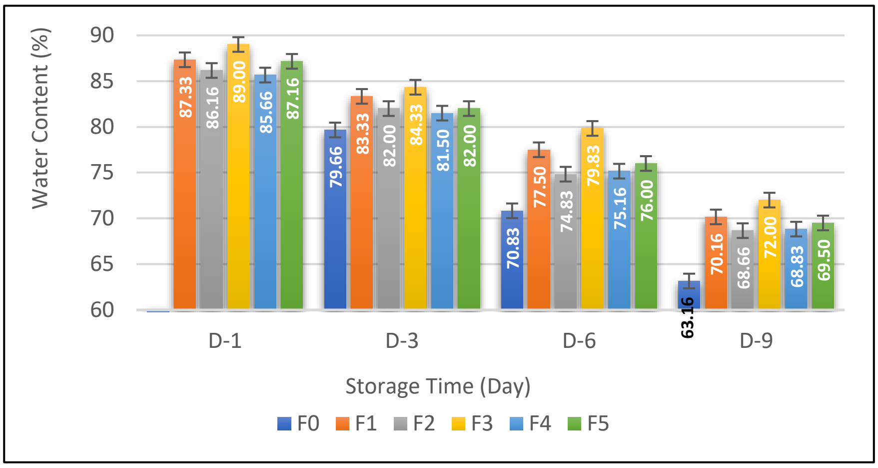

Figure 2. Water Level Test Results

Based on Figure 2, it was found that red chili experienced a decrease in water content from day 1 to day 9. The highest shrinkage occurred in the F0 treatment of 85.16% to 63.16%, while red chili with edible coating Konjac flour and chitosan, which experienced the lowest shrinkage, occurred in the F3 treatment of 89.00% to 72.00%. Changes in red chili water content are affected by storage time. In storage conditions at room temperature, the moisture content decreased with each treatment, which affected time. On the 9th day of storage showed the most significant decrease. According to Sembara (2021), the longer the storage life, the lower the water content in chilies coated with an edible coating made from taro starch on day 1 of 87.90% and day 6 of 75.17%. It could happen because the storage age increases the metabolic rate, and increases the loss of water in chilies, so they dry quickly and wrinkle. The coating method, edible Konjac flour, and chitosan function to provide a selective barrier against the movement of gases, water vapor, and dissolved materials, as well as protection against mechanical damage so that the decrease in the moisture content of the ingredients can be suppressed. Red chilies that are not treated do not have a barrier layer which can prevent water evaporation, so that the water content continues to decrease during storage. Edible coating with Konjac flour can inhibit the evaporation of water from inside the material. This inhibitory property is related to the hydrophilic nature of the polysaccharides (Murni et al., 2015). Application of edible coating Konjac flour can prevent dehydration, fat oxidation, and browning on the surface and reduce respiration rate (Amalia et al., 2020).

Chitosan with high concentration produces an edible coating which is thicker and able to inhibit the interaction between oxygen and fruit tissue so that the rate of respiration can be suppressed (Sitorus et al., 2014). The chilies used had a water content value on the first day 85.16 and on the 9th day 63.16, where the water content decreased by 25%, the decrease in water content was caused by reduced humidity and increased respiration rate due to the influence of chili storage time. According to Rukhana (2017), the water content in foodstuffs changes according to the environment and this is very closely related to the shelf life of food ingredients. Certain relationships exist between water activity, temperature, and nutrients. The water content values for all treatments in this study met the quality requirements based on Mikasari's research (2016), which ranged (60 - 90%).

3.3 Weight Loss Test

Horticultural products such as red chilies can make weight loss an indicator of a decrease in the quality of agricultural products. The initial weight of good, fresh red chilies before edible coating of 15g to 30g. Weight loss is one of the parameters that can be used to see the quality of the fruit after it is harvested. This is because after being harvested, the fruit still carries out physiological activities such as respiration and transpiration. The rates of respiration and transpiration that occur in red chili are not inhibited by any barrier substance. The increased weight loss during storage is caused by transpiration or the release of water in the fruit in the form of vapor through the surface of the fruit skin. In addition, the process of respiration also occurs, namely oxygen (O_2), which is absorbed by the fruit to decompose complex compounds into simple molecules such as carbon dioxide, energy, and water vapor (Al Suhendra et al., 2019).

The result showed that the fruit experienced changes in appearance and texture, such as softening, withering, and shrinking of the fruit (Vázquez et al., 2016). Post Harvest processing using the method of edible coating Konjac flour and chitosan are expected to be able to maintain the quality characteristics of red chili, one of which is weight loss. It could happen due to the coating method edible coating Konjac flour and chitosan function to provide a selective barrier against the transfer of gases, water vapor, and dissolved materials, and chitosan functions as a barrier so that water, gas, and energy produced in the fruit do not come out so that weight loss can be suppressed. The results of the research on red chili weight loss can be seen in the diagram presented in Figure 3.

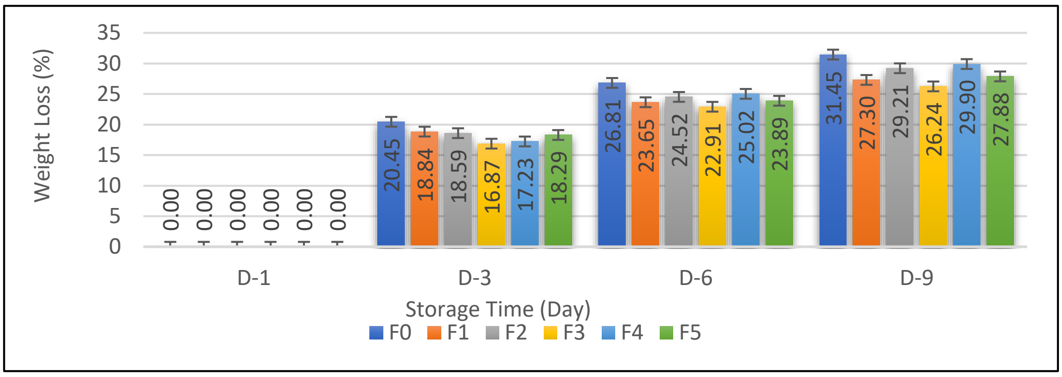

Figure 3. Weight Loss Test Results

Figure 3 shows data that chilies experience a weight loss process during the weight loss process. The highest shrinkage occurred in the F0 treatment of 20.45% to 31.41%, while red chili with edible coating Konjac flour and chitosan which experienced the lowest shrinkage occurred in the F3 treatment of 16.87% to 26.24%. This shows that the Edible Coating treatment can maintain the weight of the chilies. Red chilies that experienced the highest reduction in air content were found in F0 (without treatment). According to Susilowati et al. (2017), the higher the concentration of chitosan, the higher the thickness of the layer so that the pores of the fruit become closed, resulting in the respiration and transpiration processes being suppressed. The application of Edible Coating porang flour can prevent dehydration, fat oxidation, and browning on the surface and reduce the respiration rate by controlling the composition of CO2 and O2 gases in the atmosphere (Amalia et al., 2020). The reduction in the weight of red chilies occurs due to the loss of air and volatile components during processing and transpiration during the storage period (Marlina et al., 2014).

Red chilies have a high water content so losing air will result in a decrease in fruit weight. Based on the results of testing the water content and weight loss of red chilies during storage, the higher the reduction in water content, the higher the weight loss. The results of the correlation test between weight change and moisture content showed a value of -0.839. This result indicates that the correlation between these two components is inversely proportional. The correlation test results show that the relationship between weight loss and moisture content is very strong (0.839). The data show that an increase in weight loss will be accompanied by a decrease in moisture content. According to Kusumiyati et al. (2018) the longer the fruit is stored, the higher the weight loss of the fruit will be, besides that visually the fruit will become wrinkled. Loss of fruit weight during storage is caused by loss of air, which can reduce quality and cause damage. This air loss is caused by some of the air in the tissue experiencing evaporation or transpiration (Susilowati et al., 2017).

3.4 Respiration Rate Test

The decline in the quality of chili is caused by the respiration process which continues even though it has been harvested. The respiration process depends on the storage temperature, where the higher the storage temperature, the faster the respiration process takes place (Maftoonazad and Ramaswamy, 2019). Respiration is a process of absorption of oxygen (O_2) and release of carbon dioxide (CO_2) and the energy used to maintain metabolic reactions (Rahayu et al., 2021). Therefore, it is necessary to pack and coat vegetables which can reduce and suppress respiration and transpiration rates to prevent damage to vegetables (Nurlatifah et al., 2017). Post Harvest processing using the method of edible coating Konjac flour and chitosan are expected to be able to maintain the quality characteristics of red chili, one of which is respiration rate. It could happen due to the coating method edible coating Konjac flour and chitosan function to provide a selective barrier against the transfer of gases, water vapor, and dissolved materials, and chitosan functions as a barrier so that water, gas, and energy produced in the fruit do not come out so that weight loss can be suppressed. The results of the research on the respiration rate of red chilies can be seen in the diagram presented in Figure 4.

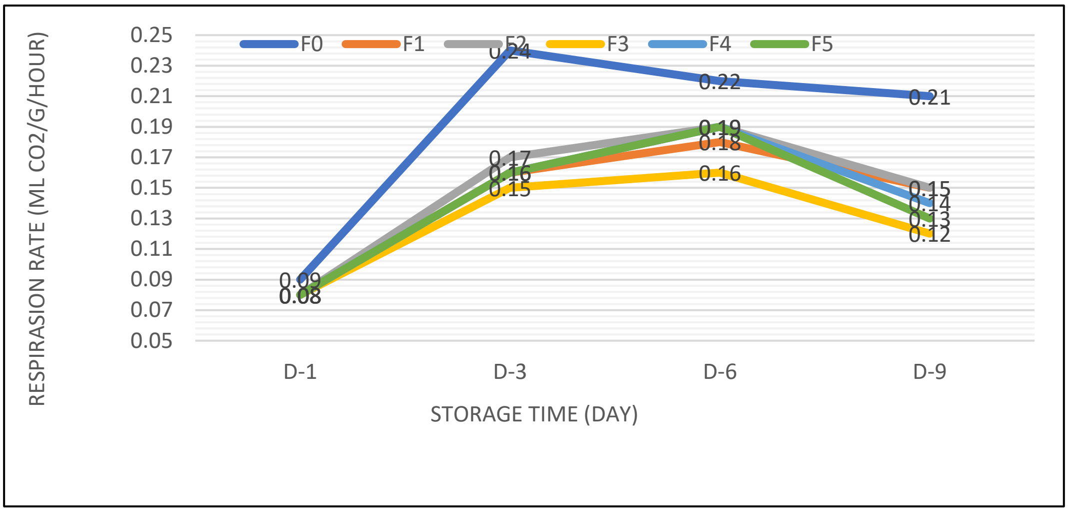

Figure 4. Respiration Rate Test Results

Based on Figure 4, the results of the respiration rate of red chilies during the room temperature storage process begin with an increase in respiration rate and then a decrease in respiration rate. Red chili is a climacteric fruit that has a climacteric pattern. The climacteric pattern is characterized by an increase in respiration rate, an increase in ethylene production, and physical and chemical changes in the fruit until finally it reaches a climacteric peak (Rahayu et al., 2021). F0 without treatment showed an increase in respiration rate from day 0 to day 3 and a decreased respiration rate from day 6 to day 9. Coated red chilies edible coating experiences a slower and lower climax peak on the 6th day, then declines on the 9th day. Treatment coating in this study is suspected to delay fruit ripening by modifying CO_2, O_2 and ethylene in fruit. Edible coating is able to reduce the amount of O_2 for respiration activity and limit the diffusion of CO_2 off the network. CO_2 internal in high fruit can also be delayed (Moalemiyan et al., 2012).

Edible coating with Konjac flour can inhibit the evaporation of water from inside the material. This inhibitory property is related to the hydrophilic nature of the polysaccharides (Murni et al., 2015). Application edible coating Konjac flour can prevent dehydration, fat oxidation and browning on the surface and reduce respiration rate by controlling the composition of CO_2 and O_2 in the atmosphere (Amalia et al., 2020). Making process edible coating Konjac flour with a heating temperature of 60°C and the stirring time t=30 minutes for Konjac flour there is still an increase in viscosity. Glucomannan molecule chains at 75°C - 90°C, there is a change in the physical properties of the Konjac flour solution so that at this heating temperature, the final viscosity value is lower when compared to heating at 60°C. Higher viscosity values lead to better solution stability, which is characterized by a more stable material because the movement of particles tends to be difficult the more viscous a material is. The result showed that the application of edible coating could inhibit the rate of respiration, the inhibition of the rate of respiration is due to edible coating on the surface of the fruit covering the lenticels and cuticles.

Konjac flour is a hydrophilic compound so the film matrix breaks easily because it binds to water components in the environment, while the formulation of the addition of chitosan as a hydrophobic component in edible coating polysaccharides is known to be able to increase the gas barrier so that it can significantly reduce the respiration rate of fruit (Velickova et al., 2013). It caused F3 to experience the lowest respiration rate.

3.5 Color Test

Color is an important component in determining the quality or degree of acceptance of a food ingredient. Determining the quality of a material, one of which is the color factor which is considered visually. Color changes in large red chilies can be done by calculating the values of L, a, and b. The value of L indicates the brightness level of dark and light colors, the value of an indicates the chromatic color level of red and green, and the value of b indicates the chromatic color level of yellow and blue.

3.5.1 Value of L*

In general, fruits and vegetables experienced a decrease in quality, one of which is the color brightness level during postharvest. Post Harvest processing innovation using the method of edible coating Konjac flour and chitosan are expected to be able to maintain the quality characteristics of large red chilies, one of which is the brightness level of large red chilies. The results of measuring the brightness of the red chili color are expressed in the form of the Value of L* obtained from using a color reader. Color L test results on good and fresh red chilies before edible coating is 71.00 to 75.00. Color L shows the difference in brightness between dark and light colors. The higher the Value of L*, the brighter the captured color, while the lower the L* value, the darker the captured color. The L*value is between 0 and 100. The Value of L* is the result of research in Figure 5.

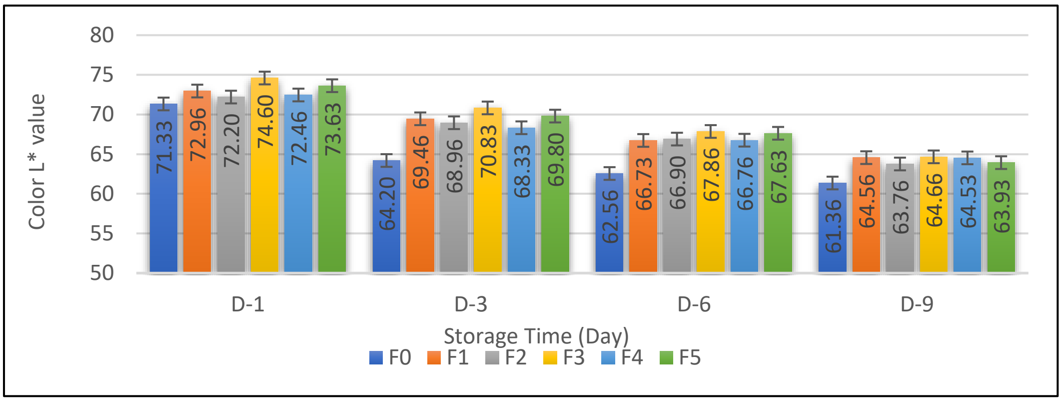

Figure 5. Red Chili Value of L* Color Test Results

Based on Figure 5, the color value of L*red chili decreased from day 0 to day 9. The F0 treatment experienced the lowest brightness level of 61.36. The cause of the decrease in the value of the brightness level is damage to the carotenoid pigments contained in red chilies. Pratiwi (2019), the decrease in brightness level is caused by the nature of β-carotene contained in chili experiencing oxidation and also β-carotene which is sensitive to light because light affects the oxidation of β-carotene resulting in carotenoid damage which accelerates the color change of red chilies to dark.

Vegetables in storage still carry out physiological activities, namely the process of respiration. Mutia et al. (2014), during the respiration process, an enzymatic process occurs, which causes the overhaul of complex compounds to form energy with the end result in the form of water and carbon dioxide, which are released into the air, resulting in a decrease in weight during storage. Lamona (2015), the color change of red chilies during storage is caused by the gradual oxidation of carotene and xanthophyll pigments due to contact with free air.

Discoloration of fruits and vegetables can occur along with a decrease in quality due to metabolic processes that affect the physical appearance of the product during storage. When fruits and vegetables are stored at low temperatures or room temperature, the product changes color because the product tries to balance the chemical and water content due to a lack of O_2 so that there is a change in the chemical process, namely fermentation, which causes the product to release water in its body so that light reflects due to the presence of a layer of water on the surface of fruits and vegetables. The result showed that the fruit experienced changes in appearance and texture, such as softening, withering and shrinking of the fruit (Vázquez et al., 2016). The color change in chilies is also caused by rot caused by the fungus species *Colletotrichum sp*. The fruit rot in red chilies is presented in Figure 6.

Figure 6. Anthracnose Fruit Rot on Red Chili

Chili fruit that has anthracnose disease has signs of small round brown spots on the fruit. The spots will widen, and if the quantity increases, they will connect with other spots and form large, non-round spots. If the spots are complete, they will make the fruit too dry out and shrivel to a dark brownish color (Inaya et al., 2022). It could happen in line with the results of a study which showed that F0, F2, and F4 experienced anthracnose disease in red chilies at first showing symptoms of round black dots on the skin of the fruit, then the black area widened with almost 50% of the fruit surface turning black and in that area the fruit looks soft because of rot. If at a high level of severity, the symptoms are experienced, namely, the whole fruit turns brown or even black in color with the whole fruit drying and wrinkled (wrinkled). The development of this species of fungus in infecting chilies is strongly influenced by environmental aspects such as pH, temperature, and humidity.

3.5.2 Value of a*

The color Value of a* indicates the value of the red and green chromatic differences. , The color test result value of a* on good and fresh red chilies before edible coating is 5 to 6. If the color a*value increases, then the color tends to be red, and if the value of a* decreases, then the color tends to be green. The result showed that the color of red chili and its influence on edible coating Konjac flour and chitosan are found in Figure 6.

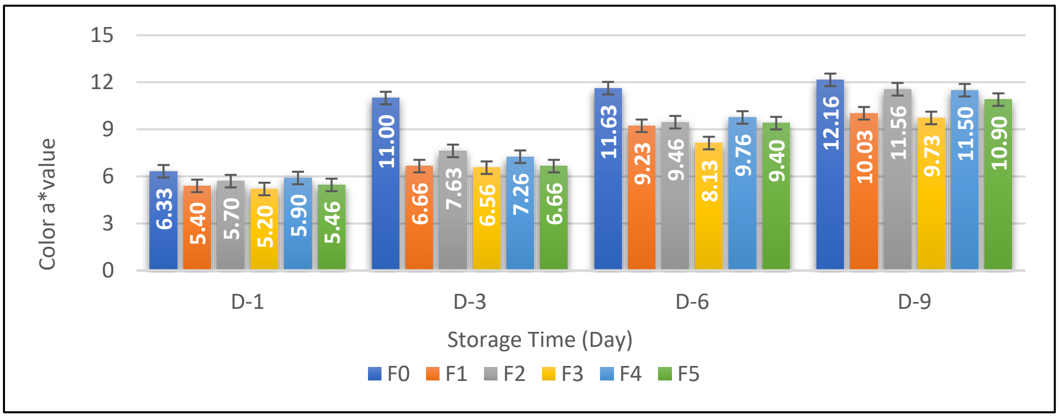

Figure 7. Color Test Results Value of a* Red Chili

Based on Figure 6, it was found that red chili experienced an increase in color value of a* from day 1 to day 9. The color value of a*, which experienced the highest increase, was in the F0 treatment of 12.16. F0 has the highest value, this is because the chili has undergone decay so that the color tends to be red. The red color change is caused by the degradation of carotenoids in red chilies. Jonathan (2011), color changes occur due to carotenoid degradation in chilies. Pigments in chili include β-carotene, lutein, and capsanthin, which are types of provitamin A. Edible coating Konjac flour and chitosan are able to suppress the rate of respiration, which causes the acceleration of the red color in chilies.

3.5.3 Value of b*

Color b shows yellow and blue chromatic colors, if color b increases, then the color is close to yellow, and if the value decreases, then the color is close to blue. The results of the b color test on good and fresh red chilies before being edible coating, namely 3 to 4. The results of the measurement of the color value of b* of red chili with edible coating Conjac flour and chitosan in Figure 8.

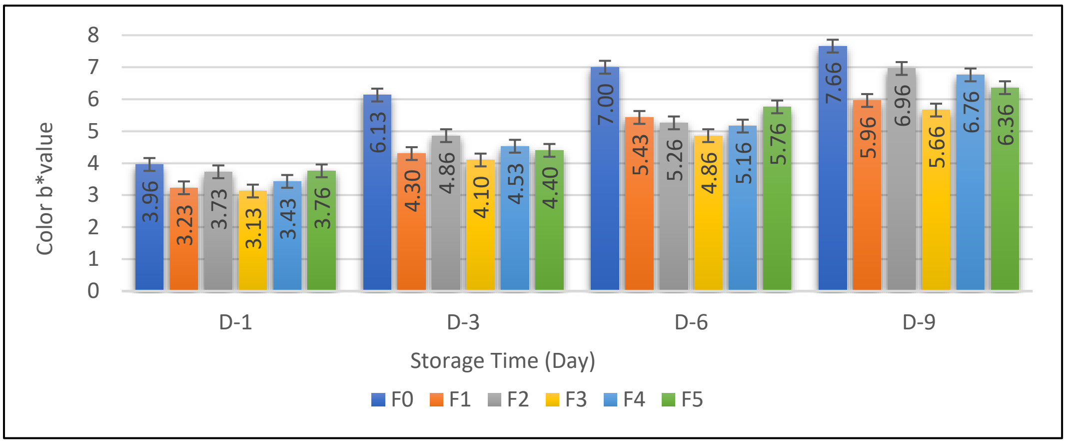

Figure 8. Color Test Results value of b* Red Chili

Based on Figure 4.7, the results show that the color b*value of red chili has increased from day 1 to day 9. The highest increase in b*value color was found in the F0 treatment of 7.66. The yellow-red discoloration is due to the decomposition of carotenoid pigments. Jonathan (2011), the yellow color of chili is caused by browning maillard non-enzymatic, formation of brown pigment, and decomposition of carotenoid pigments.

4. CONCLUSIONS

Based on the results of the research, it can be concluded that Edible Coating produced from Konjac flour and chitosan is effective for development because it can produce low air content, low weight loss, and low respiration rate, which indicates a longer shelf life of red chilies. The best treatment was obtained in the F3 treatment with the results of a slower and lower climax respiration rate on day 6. In addition, on the last day of storage, (day 9), pH was 5.19, air content was 72.00%, weight loss was 26.24 %, color L 64.66, color a 9.73, and color b 5.66.

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