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February, 9th 2023**Professor Dr. Son Radu****Chief Editor****Food Research**foodresearch.my@outlook.com

Dear Sir/Madam,

I/We wish to submit a new manuscript entitled “*Physico-chemical properties of lemongrass and Malang apple powder drinks*” for consideration by the Food Research

I/We confirm that this work is original and has not been published elsewhere nor is it currently under consideration for publication elsewhere.

In this paper, I/we report on the investigate the effect of coating type and drying temperature on the quality of lemongrass and Malang apple powder drinks.

Based on the result in this research I/we report on the result showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C and antioxidants. There was an interaction between the coating type and drying time which affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/ml, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC50 content of 1.29, and a water activity of 0.50.

I/we think that our manuscript fits well to the scope of the journal of Food Research and is of great interest to readers in the aera of Food Science, Food Technology,

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Thank you for your consideration of this manuscript.

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Physical and Chemical Properties of Lemongrass and Malang Apple Powder Drinks

Abstract

The human body's immunity can be increased through food and drink. Beverage products generally have a short shelf life, so they need to be made into powder drinks. Currently popular drinks come from spices containing antioxidants that can boost the body's immunity. To maintain the antioxidant compounds that exist during drying, it is necessary to have a coating material. This study aims to investigate the effect of coating type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The study used a Completely Randomized Design (CRD) with two factors and two replications. The first factor was the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). Data were analyzed using ANAVA test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C and antioxidants. There was an interaction between the coating type and drying time which affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/ml, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of 1.29, and a water activity of 0.50.

Keywords: apples, dextrin, powder drinks, drying, lemongrass.

Introduction

The ongoing COVID-19 pandemic has forced people to maintain their health through increasing their body's immunity. Body immunity can be improved through foods and drinks. Beverage products generally have a short shelf life, so they need to be made into powder drinks. Powder drinks are a processed food product in powder form, easily dissolved in water, practical in serving and have a relatively long shelf life. In addition, powder drinks are easy to carry and ship (Tangkeallo *et al.*, 2014). It causes powder drinks to be liked by the public. One of the ingredients that can increase the body's immunity is spices. Spices are known to contain antioxidant compounds. Antioxidant compounds are able to capture free radicals so that they can improve the body's immunity (Cakmakci *et al.*, 2015). One of the spices that contain antioxidants and is popular today is lemongrass or often called "*serai*". Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*, *eugenol*, *dipentene*, *citral* (Wibisono, 2011). These compounds act as anticancer and antioxidants, stabilize blood pressure, treat constipation, help the digestive system, tighten the body after childbirth (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). Apart from lemongrass, a food ingredient that can improve the body's immunity and has a good taste is Malang apples. Malang apples are a famous fruit typical of Malang city. Malang apples that are small in size have low economic value because they are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019), Malang apples contain lots of vitamins such as vitamins A, B, C, minerals, fiber, and flavonoid compounds, one of which is quercetin. Vitamin C and quercetin act as antioxidants, antivirals and anti-inflammatories that protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free radicals and change or reduce free radicals (Suparni *et al.*, 2012).

There are limitations in using lemongrass and Malang apples for drinks. Those materials are difficult to carry and do not last long. To overcome this, powder drinks made from a mixture of lemongrass and Malang apples are made. In the making of lemongrass and Malang apple powder drinks as functional drinks, there is a critical point during the drying process (Naibaho *et al.*, 2015). It is because the active ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures and for a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the amount of antioxidants present, it is necessary to find the right drying temperature. In addition to maintaining the existing volatile compounds, it is necessary to have a coating material. The commonly used coating material is gum arabic because this

material has the ability to form good emulsions and films. Gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the highest volatile components compared to modified starch (Santoso et al., 2013). According to Harahap et al. (2021), maltodextrin can disperse quickly, has a high solubility, forms low hygroscopic properties, has low browning properties, is able to inhibit crystallization and has strong binding power. Meanwhile, dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity (Asia et al., 2012). Based on the description above, this study aimed at investigating the effect of coating type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The quality of the powder drinks was determined based on physical tests in the form of bulk density, dissolution time, and stability test. These tests were required to determine packaging and consumer acceptance. In addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity, water activity, and vitamin C. These tests would indirectly determine the shelf life and ability of the product to increase body immunity. This research has yielded products that can increase body immunity, are easy to carry, and have a relatively long shelf life.

Material and Method

Material

The materials used in the study were lemongrass, Malang apples, Maltodextrin, Dextrin, Gum Arabic, water, and ant sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a "Mitzui" blender, cutting boards, measuring cups, knives, "WTC Binder 78532" blower ovens, baking sheets, spoons and "Matrix ESJ210-4B" scales, volumetric flasks, erlenmeyer, burettes, measuring cups, measuring pipettes, suction ball, funnel pipette, beaker glass, filter paper, burette, stative, Siever 60 mesh, and spectrophotometer "UV2100 Spectrophotometer".

The Process of Making Lemongrass and Malang Apple Powder Drinks

The process of making powder drinks was a modification of the research of Susanti et al. (2014). The process of making powder drinks consisted of two stages, namely the making of fruit pulp and the drying process.

Making Fruit Pulp

The making of fruit pulp began with sorting and washing the lemongrass and Malang apples, followed by cutting the lemongrass and Malang apples and then crushing them with a blender for 5 minutes at speed number 2. After that, the pulp was added with water in a ratio of 1:1. Furthermore, the coating materials (maltodextrin, dextrin, and gum arabic) were added separately as much as 5% w/w fruit pulp separately. The pulp was stirred until homogeneous.

Drying

The already homogeneous fruit pulp, each was placed on a 60x40x2 cm baking sheet as much as 250 ml and dried with a blower oven at a predetermined temperature (40°C, 45°C, and 50°C) separately for 18 hours. The dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3 minutes at speed number 2. Then, ant sugar was added as much as 10% w/w of the dry powder. After that, the powder was sieved using a 60-mesh sieve. Lemongrass powder drinks were packaged in aluminum foil zip lock with a size of 7 x 13 cm.

Analysis Procedure of Bulk Density (Budijanto et al., 2011)

The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring cup containing the powder sample was tapped 30 times until there were no more cavities when the powder sample was adjusted to 10 mL. The measuring cup containing the powder sample was then weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its volume (10 mL).

Analysis Procedure of Dissolution Time Testing (Pentury et al., 2013)

A total of 5 g of the test sample was weighed then dissolved in 50 mL of warm water and stirred 20 times until homogeneous. How long it took the sample to dissolve in water was recorded.

Analysis Procedure of Stability Testing (Nisa et al., 2017)

A total of 5 g of powder was weighed and brewed in 50 mL of water then put into a 10 mL measuring cup and kept for 24 hours. Afterwards, the suspension or solution was measured for the volume of the precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

Analysis Procedure of Water Content by Oven Drying Method (AOAC, 2006)

An empty cup was dried in the oven for 15 minutes and cooled in a desiccator (10 minutes for an aluminum cup and 20 minutes for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2-3 g then it was put in a dry cup. After that, it was put in the oven at 105°C for 6 hours. Next, the cup containing the sample was cooled in a desiccator, then weighed. Drying was repeated until a constant weight was obtained. Water content was calculated based on the loss of weight, namely the difference between the initial weight of the sample before drying and the final weight after drying.

Analysis Procedure of Ash Content by Muffle Furnace Method (AOAC, 2006)

A porcelain cup was dried in the oven for 15 minutes and then cooled in a desiccator and weighed. The sample was weighed as much as 3 g in a cup that had been dried and then it was burned in a smoke chamber until it no longer emitted smoke. Next, ashing was carried out using an electric furnace at a temperature of 400-600°C for 4-6 hours until white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

Analysis Procedure of Antioxidant Content Testing (Amanah et al., 2015)

A total of 1 mL of DPPH solution (10 mg/L) was added to 50 µL of sample solution and then added methanol p.a up to 5 mL, then incubated for 30 minutes at 37°C. The absorbance was measured at a wavelength of 513 nm. The antioxidant activity of the sample was determined by the magnitude of the DPPH radical uptake inhibition by calculating the percentage of DPPH uptake inhibition.

Analysis Procedure of IC₅₀ Antioxidant Activity Testing (Tristantini et al., 2016)

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. Analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 ml of sample in 100 ml of methanol PA. Furthermore, dilution was carried out using methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was prepared by dissolving 5

mg of solid DPPH in 100 ml of methanol PA. Then a comparison solution was prepared, namely a control solution containing 2 ml of methanol PA and 1 ml of 50 ppm DPPH solution. For the test sample, 2 ml of sample solution and 2 ml of DPPH solution were prepared. Then, the solution was kept for 30 minutes. All samples, extract samples that had been kept, were tested for measuring the absorbance values using a Uv-vis spectrophotometer at a wavelength of 517 nm.

Analysis Procedure of Water Activity Testing (Susanto, 2009)

The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated by adding $\text{BaCl}_2 \cdot 2\text{H}_2\text{O}$. It was then closed and kept for 3 minutes until the number on the scale became 0.9. The aw-meter was opened and the sample was inserted. The tool was then closed and waited until the aw scale was read. The temperature scale and the correction factor were observed. When the temperature scale was above 20°C , then the aw scale reading was added as much as the excess of the temperature multiplied by a correction factor of 0.002° , as well as for temperatures below 20°C .

Analysis Procedure of Vitamin C Testing (AOAC, 1995)

Vitamin C analysis was performed by iodimetric method. The crushed sample was weighed as much as 5 g. It was put into a 100 ml measuring flask. Distilled water was then added up to the line mark. The sample was shaken until homogeneous. The solution was filtered and the filtrate was pipetted as much as 25 mL and put into an erlenmeyer. Then a few drops of starch indicator were added, then titrated rapidly using 0.01 N iodine solution until a blue color appeared.

Statistical Analysis

The data obtained were analyzed using analysis of variance (ANOVA). When the data showed that there was a significant effect, then the Duncan Multiple Range Test was carried out. The testing was done using SPSS 16.0 Statistics Software. The significant level was set at $\alpha = 0.05$.

Results and Discussion

Bulk Density of Lemongrass and Malang Apple Powder Drinks

The bulk density value indicates void space, namely the number of empty cavities between the material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2007). The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The higher the drying temperature causes the bulk density value to decrease. It is because the higher the drying temperature causes more water in the material to be evaporated so that the resulting water content is lower, causing the weight of the powder to become lighter. It is in line with Andriyani *et al.* (2015) who state that as the drying temperature increases, the bulk density decreases. The bulk density is influenced by the type of material, water content, shape and size of the material. The smaller the bulk density, the more porous the product is (Widowati *et al.*, 2010).

Of the three types of coating used, gum arabic has the lowest bulk density compared to other coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan *et al.*, 2013). Meanwhile dextrin has the characteristic of quickly dispersing, has high solubility, is able to form films, has hygroscopic properties, is able to form body, has characteristic of low browning, is able to inhibit crystallization, and has strong binding power (Purbasari, 2019). The dextrin film layer has a higher proportion of solids than gum arabic, because the DE value of dextrin is lower than gum arabic, therefore the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*, 2010). Maltodextrin is a coating material

that has a high level of solubility, this is due to the nature of maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has the ability to absorb water) so that the water in the material is more retained and difficult to evaporate (Yuliwati et al., 2015).

According to Setiawati et al. (2014), the amount of bulk density of a material affects the space needed for that material. The greater the bulk density (particles), the smaller the space needed, and vice versa. The smaller the size of the molecule, the more easily the product will be compressed; with smaller gaps between molecules, the greater the bulk density (Stranzinger et al., 2017). The treatment using gum arabic with a drying temperature of 50°C resulted in the lowest bulk density value of 0.52. According to Palijama et al. (2020), foodstuffs that have a high bulk density indicate that the product is more compact (non-voluminous), meaning that in the same certain volume, the product is available in more weight. According to Widowati et al. (2010), a material is considered 'bulk' if the bulk density is small, meaning that light weight requires a large space; the smaller the bulk density, the more porous the product is. Sadeghi et al. (2010) state that the higher sphericity of the corn kernels results in a more regular arrangement of the kernels so that the cavities between the kernels were smaller, resulting in a higher bulk density.

Dissolution Time

Dissolution time in water is a time that shows all beverage powder dissolves in water perfectly. The testing of dissolution time is carried out to determine the speed of solubility of the drinks when it will be consumed. The higher the solubility value of the powder product, the better the product is; it is because the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang et al., 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 seconds (Table 2). The results show that, the higher the drying temperature, the faster the dissolution time (Table 2). It is because the powder produced is drier. The higher the drying temperature, the more water evaporated on the powder drinks so that the water content is lower. The lower the water content, the more hygroscopic so that the dissolution time is faster (Paramita et al., 2015 and Sakdiyah et al., 2019).

The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin has a faster dissolution time compared to other types of coating (Table 2). It is because when powder drinks are dissolved in water, especially warm water, the hydroxyl groups contained in the coating material will interact with the water so that the solubility of the powder can increase (Yuliwati et al., 2015). Dextrin has a dextrose equivalent (DE) value of 3–5 and has the ability to form layers (Tyanjani et al., 2015). With the addition of dextrin, the solubility of powder drinks increases. It is because dextrin is easily soluble in water. It is in accordance with Nurhidayah et al. (2014), who state that dextrin is easily soluble in water, disperse more quickly, is not viscous and is more stable than starch.

According to Wulansari et al. (2012), Dextrose Equivalent (DE) of maltodextrin is 3-20. The higher the DE value, the higher the monosaccharide content, causing the binding power to be greater. Thus, the use of maltodextrin causes a higher water content compared to dextrin. Maltodextrin is a filler that has a high level of solubility; it is due to the characteristic of maltodextrin that is soluble in water (Hofman et al., 2021). Gum arabic has a longer dissolution time than maltodextrin and dextrin. However, according to Herawati (2018), gum arabic has the advantage of having high solubility in water, making it better as a coating material in making powder drinks. The DE value of gum arabic is 6 (Soottitantawat et al., 2006). According to Hofman et al. (2016) the factor that affects the level of solubility in water is the DE value; the higher the DE value, the better the solubility level.

Stability

Beverage products will be stable if the particles acting as the dispersed phase can be retained without changing for a long time or without experiencing grouping with each other (Anjani et al., 2011). The stability testing is expressed in (%) which shows the percentage of stability of the powder drinks made. The stability of lemongrass and Malang apple powder drinks obtained an average of 63.89% to 93.33% (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The higher the drying temperature, the lower the powder water content. It causes the product to absorb water more easily so that the product becomes more stable when rehydrated. It is in line with Kryzhska et al. (2020) who state that high water content in powder products would seriously disrupt product stability and would cause the product to agglomerate when stored. The high water content in a product can cause damage due to the activity of microorganisms.

The type of coating also affects the stability value. Of the three types of coating used, dextrin has the most stable results compared to other types of coating. Dextrins can wrap or encapsulate the active ingredient particles from oxidation reactions during storage thereby increasing product stability (Septevani et al., 2013). Dextrin has a stronger ability to bind water because it is a group of polysaccharides that has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu et al., 2012). The addition of maltodextrin can increase the stability of the drink which can reduce the precipitate formed (Paramita et al., 2015). Maltodextrin has a high solubility so that the product does not precipitate too much (Prमितasari et al., 2011). Gum arabic has a more complex molecular structure than dextrin and contains starch in it, so gum arabic is more hygroscopic (Sutardi et al., 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren et al., 2012). According to Anggraini et al. (2016), the presence of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin treatment with a drying temperature of 50°C is the coating material with the highest stability value of 93.33%.

Water Content

The average water content of lemongrass and Malang apple powder drinks ranged from 2.06% to 2.57% (Table 4). In the manufacturing process, powder drinks are made by drying separately at 40°C, 45°C and 50°C for 18 hours. The results show that the higher the drying temperature, the lower the water content of the powder. Drying causes the water content in the lemongrass and Malang apple powder to evaporate. The higher the temperature produces powder with lower water content. According to Wiyono (2011), the drying temperature factor is important to note because it can remove the water content quickly when the material is dried at high temperatures. The increase of the heating temperature tends to reduce the water content. The decrease in the amount of water is due to the higher heating temperature. Thus, there are more water molecules that evaporate from the dried raw materials so that the water content obtained is lower.

The type of coating has a relatively similar effect on the value of the water content. Of the three types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari et al. (2012), dextrin is hygroscopic, that is, it easily absorbs water; but when it is dried, the absorbed water is released. The water content absorbed by the presence of coating material will evaporate more easily than the water content in the material tissue so that the evaporation process of water in powder drinks becomes easier (Paramita et al., 2015). Maltodextrin has a low molecular weight and a simple structure, so that water is easily evaporated during the drying process (Prमितasari et al., 2011). Meanwhile, gum arabic is hygroscopic so that the water in the material is more retained and difficult to evaporate. Gum arabic has a high molecular weight and a complex molecular structure and contains a large amount of starch (Sutardi et al., 2010). Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50°C dextrin and it was in accordance with SNI number 01-4320-1996 in which the water content of powder drinks was a maximum of 3% (BSN, 1996). It shows that powder

drink products meet the requirements of SNI number 01-4320-1996 and have a small possibility of being contaminated with microorganisms.

Ash Content

According to Leggli et al. (2011), ash content testing is carried out to determine the amount of minerals in a food. Ash is composed of various types of minerals with varying composition depending on the type and source in food (Andarwulan et al., 2011). Based on Table 5, the mean value of the ash content of the results of the study was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher the ash content. The increase in ash content is thought to be related to the higher drying temperature. It causes more water in the material to evaporate, so that the water content is lower. It causes the percentage of mineral content in the material to increase. The results of the study are in line with Shadri et al. (2018).

Dextrin coating is a polysaccharide group which has a simpler chemical structure than gum arabic. Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu et al., 2012). Meanwhile gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren et al., 2012). According to Sediaoetama (2010), ash content describes the amount of minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin coating with a drying temperature of 45°C. In general, the ash content of the product was still within the limits of SNI 01-4320-1996 regarding the quality requirements for powder drinks, namely a maximum of 1.5% (BSN, 1996). Malang apple has a fairly high nutritional content, especially vitamins and minerals such as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2, and vitamin C (Wahyuningtyas et al., 2017). Lemongrass contains several minerals such as vitamin A, vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri et al., 2018).

Vitamin C

The results of the vitamin C test are presented in Table 6, showing an average value of vitamin C between 53.15 mg/100g to 72.69 mg/100g. The vitamin C content tend to decrease with increasing drying temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C and is easily degraded, especially by heat (Parfiyanti et al., 2016). It shows that the drying process at high temperature can reduce the vitamin C content found in powder drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid which plays a role in inhibiting excessive oxidation reactions (Susanti et al., 2014).

The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin produces the highest content of vitamin C compared to other types of coating. It is because dextrin can protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the more dextrin is added, the more vitamin C content in the product is maintained. Dextrin has the characteristic of protecting vitamin C and compounds that are sensitive to heat or oxidation because the molecules of dextrin are stable to heat and oxidation, so that the vitamin C content can be maintained. In addition, according to Aretzy et al. (2018), maltodextrin can protect volatile compounds and protect compounds that are sensitive to oxidation. According to Alfonsius (2015), the addition of gum arabic in the processing process can protect important compounds such as vitamins due to extreme temperatures, since gum arabic has the ability to form a body as a coating and has a strong bond to the compounds coated. The highest content of vitamin C was produced in powder drinks dried at 40°C with dextrin coating (72.68 mg/100 g) and the lowest was produced at 50°C with gum arabic coating (53.15 mg/100 g). The vitamin C content of mix fruit powder drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and tween 80 dried at 50°C produces the vitamin C content

between 425 mg/100g – 550 mg/100g, which is higher than lemongrass and Malang apple powder drinks (Minah, et al, 2021).

Water Activity

Table 7 shows the mean value of water activity (a_w) of lemongrass and Malang apple powder drinks, namely 0.44 to 0.50. The a_w value of lemongrass and Malang apple powder drinks is lower than the a_w value for the bacterial growth requirement, namely 0.90. The a_w value for yeast growth is 0.80-0.90, and the a_w value for mold growth is 0.60-0.70. The a_w value is relatively decreased with increasing drying temperature. In the drying process, the free water in the material will evaporate. The higher temperature causes more water to evaporate. The lower the water content, the lower the water activity (Martins et al., 2019). According to Adri et al. (2013), the composition of water in foodstuffs such as free water and bound water can affect the rate or duration of food drying. The relatively small a_w value does not allow the growth of bacteria, molds and yeasts in the product. Lemongrass extract shows great potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella yphimurium* and *Staphylococcus aureus*; this indicates the possibility of using medicinal plants as natural antibacterial agents (Ibrahim et al., 2013). According to Parfiyanti et al. (2016), the purpose of drying is to reduce water content so that it is not easy for mold and bacteria to grow, eliminate the activity of enzymes that can decompose the active substance content and facilitate further processing so that it can be more compact, durable and easy to store.

The use of various coatings in this study relatively produces the same a_w value. The use of maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray drying can protect protein, calcium, lactose powder (Martins et al., 2019). The lowest water activity value of lemongrass and Malang apple powder drinks was obtained for products with gum arabic coating at drying temperature of 45°C (0.44).

The Percent Inhibition of Antioxidant Content

Percent inhibition shows the radical scavenging activity possessed by antioxidant compounds. One of the plants that has potential as an antioxidant is lemongrass (Wibisono, 2011) and apple (Yudhianto et al., 2013). Based on the antioxidant test in Table 8, the average inhibition value was 37.45% to 60.13%. Based on Table 8 it is also known that drying temperature affects antioxidant content. The higher the drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant activity in the lemongrass and Malang apple powder drinks is thought to be related to the damage to the antioxidant compounds due to high temperatures. According to Patras et al. (2010), antioxidant compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat. Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna et al. (2013) that antioxidant bioactive components have heat-resistant characteristics, so if the sample is extracted in hot conditions it will reduce the value of its antioxidant activity. The results of the research by Widiastuti et al. (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content in lemongrass is due to the large amount of phenolic compounds it contains. The high content of phenolic compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential oil in lemongrass stems is very high with an effective inhibition of 89% and 89.63%, whereas in lemongrass leaves it is slightly lower with antioxidant and antidiabetic activities ranging from 78.89% and 79.26% respectively (Mirghani, et al., 2012).

The use of dextrin coating with a drying temperature of 40°C produced the highest inhibition value compared to maltodextrin and gum arabic (Table 8). Goncalves et al. (2015) explains that dextrin is composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the oxidation process can be prevented. Dextrin has the characteristic of protecting volatile compounds and compounds that are

sensitive to heat or oxidation. Gum arabic can improve and maintain the stability of the compounds being coated. Gum arabic is also a type of coating that is resistant to heat (Dauqan et al., 2013). Meanwhile, maltodextrin can protect volatile compounds and protect compounds that are sensitive to oxidation (Aretzy et al., 2018). The maltodextrin coating has high oxidation resistance and can reduce the viscosity of the emulsion; combined with other coatings that have better emulsifying properties, it causes the antioxidant compounds in the microencapsulants to be well covered and protected (Purnomo et al., 2014). According to Godwin et al. (2014), lemongrass contains natural antioxidants and anti-inflammatories which can prevent free radicals in the human body. Antioxidants in lemongrass are able to inhibit the release of arachidonic acid by the mechanism of inhibiting kinase protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants which are very good for skin health. The very high antioxidant content is also the reason for the high consumption of apples by the public as an effort to prevent diseases and other dysfunctions of body health.

Antioxidant Content with Inhibition Concentration Value of 50% (IC₅₀)

The IC₅₀ value is the concentration of the antioxidant source to neutralize 50% of the radical compounds. The lower the IC₅₀ value, the better the antioxidant activity of the sample. IC₅₀ antioxidant content are determined from the 3 best samples based on the highest inhibition percentage, namely on lemongrass and Malang apple powders which are coated with dextrin with drying temperatures of 40°C, 45°C and 50°C. According to Phongpaichit et al. (2007), IC₅₀ value < 10 ppm indicates a very strong activity. IC₅₀ 10-50 ppm indicates a strong activity, IC₅₀ > 50-100 ppm indicates moderate activity, and IC₅₀ > 100-250 ppm indicates a weak activity. The results showed that the IC₅₀ value in the lemongrass and Malang apple powder drinks was 0.9 ppm to 1.47 ppm (Table 9), which indicated a very strong activity. The results of research by Andriyani et al., (2015) show that the IC₅₀ value of temulawak and red ginger powder functional drinks made using the spray drying method has the highest or strongest average value of 0.62 ppm at 4% maltodextrin concentration and the lowest or weakest value of 1.00 ppm at 0% maltodextrin concentration.

Conclusion

The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the type of coating and the drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was determined based on the antioxidant content and high stability. The fast dissolution time was found in lemongrass and Malang apple powder that was dried at 45°C with dextrin coating. The best lemongrass and Malang apple powder drinks had the following characteristics: a solubility of 0.96 seconds, a bulk density of 0.58 gr/ml, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, a percent antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 ppm, and a water activity 0.50.

Table 1. The mean value of bulk density for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.58 ^a	0.63 ^{bcd}	0.64 ^{bcd}	0.62 ± 0.03
45°C	0.67 ^{ab}	0.58 ^{abc}	0.64 ^{bcd}	0.63 ± 0.05
50°C	0.58 ^{abc}	0.67 ^{cd}	0.52 ^a	0.59 ± 0.08

Mean ± SD	0.61 ± 0.05	0.63 ± 0.05	0.60 ± 0.60
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Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

Table 2. The mean value of dissolution time for lemongrass and Malang apple powder drinks (second)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.06 ^{bc}	1.11 ^{ab}	1.29 ^d	1.15 ± 0.12 ^c
45°C	1.04 ^{abc}	0.96 ^a	1.05 ^{abc}	1.02 ± 0.05 ^b
50°C	1.07 ^{bc}	1.01 ^{cd}	1.17 ^e	1.08 ± 0.08 ^a
Mean ± SD	1.05 ± 0.01 ^a	1.03 ± 0.08 ^a	1.17 ± 0.12 ^b	

Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

Table 3. The mean value of stability for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	65.30 ^{ab}	87.32 ^e	63.89 ^a	72.17 ± 13.14 ^c
45°C	73.01 ^d	89.19 ^e	69.69 ^c	77.30 ± 10.43 ^b
50°C	78.74 ^d	93.33 ^f	80.19 ^e	84.09 ± 8.03 ^a
Mean ± SD	72.35 ± 6.74 ^a	89.95 ± 3.07 ^a	71.26 ± 8.26 ^b	

Table 4. The mean value of water content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	2.57	2.51	2.54	2.54 ± 0.03 ^c
45°C	2.39	2.38	2.31	2.36 ± 0.04 ^b
50°C	2.07	2.16	2.06	2.10 ± 0.05 ^a
Mean ± SD	2.34 ± 0.25	2.35 ± 0.18	2.30 ± 0.24	

Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

Table 5. The mean value of ash content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.17 ^{ab}	1.46 ^e	1.06 ^a	1.23 ± 0.21 ^a
45°C	1.26 ^{bcd}	1.21 ^{abc}	1.24 ^{bcd}	1.23 ± 0.02 ^a
50°C	1.26 ^{bcd}	1.37 ^{cde}	1.38 ^{de}	1.33 ± 0.07 ^b
Mean ± SD	1.23 ± 0.05 ^a	1.34 ± 0.13 ^b	1.23 ± 0.16 ^a	

Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

Table 6. The mean value of vitamin C content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	68.11 ^d	72.69 ^e	61.95 ^e	67.58 ± 5.39 ^c
45°C	63.36 ^e	70.22 ^{de}	58.26 ^b	63.95 ± 6.01 ^b
50°C	54.91 ^a	63.36 ^e	53.15 ^a	57.14 ± 5.46 ^a
Mean ± SD	62.13 ± 6.69 ^a	68.76 ± 4.83 ^b	57.79 ± 4.42 ^c	

Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

Table 7. The mean value of water activity for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.48	0.48	0.51	0.49 ± 0.02
45°C	0.51	0.50	0.44	0.49 ± 0.04
50°C	0.49	0.46	0.46	0.47 ± 0.02
Mean ± SD	0.49 ± 0.02	0.48 ± 0.02	0.47 ± 0.03	

Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

Table 8. The mean value of antioxidant content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	56.96 ^f	60.13 ^b	53.66 ^g	56.92 ± 3.24 ^c
45°C	45.73 ^c	50.97 ^e	48.17 ^d	48.29 ± 2.62 ^b
50°C	37.45 ^a	43.98 ^b	37.53 ^a	39.65 ± 3.75 ^a
Mean ± stdev	46.71 ± 9.79 ^a	51.69 ± 8.10 ^b	46.45 ± 8.20 ^a	

Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powder drinks (%) on the best product

Drying Temperature	Coating Type
	Dekstrin
40°C	0.9 ± 0.01
45°C	1.279 ± 0.08
50°C	1.47 ± 0.01



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Physical and Chemical Characteristics of Lemongrass and Malang Apple Powder

Drinks

Abstract

The human body's immunity can be increased through food and drink. Beverage products generally have a short shelf life, so they need to be made into powder drinks. Currently popular drinks come from spices containing antioxidants that can boost the body's immunity. To maintain the antioxidant compounds that exist during drying, it is necessary to have a coating material. This study aims to investigate the effect of coating type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The study used a Completely Randomized Design (CRD) with two factors and two replications. The first factor was the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). Data were analyzed using ANAVA test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C and antioxidants. There was an interaction between the coating type and drying time which affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/ml, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of 1.29, and a water activity of 0.50.

Keywords: apples, dextrin, powder drinks, drying, lemongrass.

Introduction

The ongoing COVID-19 pandemic has forced people to maintain their health through increasing their body's immunity. Body immunity can be improved through foods and drinks. Beverage products generally have a short shelf life, so they need to be made into powder drinks. Powder drinks are a processed food product in powder form, easily dissolved in water, practical in serving and have a relatively long shelf life. In addition, powder drinks are easy to carry and ship (Tangkeallo *et al.*, 2014). It causes powder drinks to be liked by the public. One of the ingredients that can increase the body's immunity is spices. Spices are known to contain antioxidant compounds. Antioxidant compounds are able to capture free radicals so that they can improve the body's immunity (Cakmakci *et al.*, 2015). One of the spices that contain antioxidants and is popular today is lemongrass or often called "serai". Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*, *eugenol*, *dipentene*, *citral* (Wibisono, 2011). These compounds act as anticancer and antioxidants, stabilize blood pressure, treat constipation, help the digestive system, tighten the body after childbirth (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). Apart from lemongrass, a food ingredient that can improve the body's immunity and has a good taste is Malang apples. Malang apples are a famous fruit typical of Malang city. Malang apples that are small in size have low economic value because they are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019), Malang apples contain lots of vitamins such as vitamins A, B, C, minerals, fiber, and flavonoid compounds, one of which is quercetin. Vitamin C and quercetin act as antioxidants, antivirals and anti-inflammatories that protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free radicals and change or reduce free radicals (Suparni *et al.*, 2012).

There are limitations in using lemongrass and Malang apples for drinks. Those materials are difficult to carry and do not last long. To overcome this, powder drinks made from a mixture of lemongrass and Malang apples are made. In the making of lemongrass and Malang apple powder drinks as functional drinks, there is a critical point during the drying process (Naibaho *et al.*, 2015). It is because the active ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures and for a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the amount of antioxidants present,

it is necessary to find the right drying temperature. In addition to maintaining the existing volatile compounds, it is necessary to have a coating material. The commonly used coating material is gum arabic because this material has the ability to form good emulsions and films. Gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the highest volatile components compared to modified starch (Santoso et al., 2013). According to Harahap et al. (2021), maltodextrin can disperse quickly, has a high solubility, forms low hygroscopic properties, has low browning properties, is able to inhibit crystallization and has strong binding power. Meanwhile, dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity (Asia et al., 2012). Based on the description above, this study aimed at investigating the effect of coating type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The quality of the powder drinks was determined based on physical tests in the form of bulk density, dissolution time, and stability test. These tests were required to determine packaging and consumer acceptance. In addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity, water activity, and vitamin C. These tests would indirectly determine the shelf life and ability of the product to increase body immunity. This research has yielded products that can increase body immunity, are easy to carry, and have a relatively long shelf life.

Material and Method

Material

The materials used in the study were lemongrass, Malang apples, Maltodextrin, Dextrin, Gum Arabic, water, and ant sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a “Mitzui” blender, cutting boards, measuring cups, knives, “WTC Binder 78532” blower ovens, baking sheets, spoons and “Matrix ESJ210-4B” scales, volumetric flasks, erlenmeyer, burettes, measuring cups, measuring pipettes, suction ball, funnel pipette, beaker glass, filter paper, burette, stative, Siever 60 mesh, and spectrophotometer "UV2100 Spectrophotometer".

The Process of Making Lemongrass and Malang Apple Powder Drinks

The process of making powder drinks was a modification of the research of Susanti et al. (2014). The process of making powder drinks consisted of two stages, namely the making of fruit pulp and the drying process.

Making Fruit Pulp

The making of fruit pulp began with sorting and washing the lemongrass and Malang apples, followed by cutting the lemongrass and Malang apples and then crushing them with a blender for 5 minutes at speed number 2. After that, the pulp was added with water in a ratio of 1:1. Furthermore, the coating materials (maltodextrin, dextrin, and gum arabic) were added separately as much as 5% w/w fruit pulp separately. The pulp was stirred until homogeneous.

Drying

The already homogeneous fruit pulp, each was placed on a 60x40x2 cm baking sheet as much as 250 ml and dried with a blower oven at a predetermined temperature (40°C, 45°C, and 50°C) separately for 18 hours. The dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3 minutes at speed number 2. Then, ant sugar was added as much as 10% w/w of the dry powder. After that, the powder was sieved using a 60-mesh sieve. Lemongrass powder drinks were packaged in aluminum foil zip lock with a size of 7 x 13 cm.

Analysis Procedure of Bulk Density (Budijanto et al., 2011)

The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring cup containing the powder sample was tapped 30 times until there were no more cavities when the powder sample was adjusted to 10 mL. The measuring cup containing the powder sample was then weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its volume (10 mL).

Analysis Procedure of Dissolution Time Testing (Pentury et al., 2013)

A total of 5 g of the test sample was weighed then dissolved in 50 mL of warm water and stirred 20 times until homogeneous. How long it took the sample to dissolve in water was recorded.

Analysis Procedure of Stability Testing (Nisa et al., 2017)

A total of 5 g of powder was weighed and brewed in 50 mL of water then put into a 10 mL measuring cup and kept for 24 hours. Afterwards, the suspension or solution was measured for the volume of the precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

Analysis Procedure of Water Content by Oven Drying Method (AOAC, 2006)

An empty cup was dried in the oven for 15 minutes and cooled in a desiccator (10 minutes for an aluminum cup and 20 minutes for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2.2 g then it was put in a dry cup. After that, it was put in the oven at 105°C for 6 hours. Next, the cup containing the sample was cooled in a desiccator, then weighed. Drying was repeated until a constant weight was obtained. Water content was calculated based on the loss of weight, namely the difference between the initial weight of the sample before drying and the final weight after drying.

Analysis Procedure of Ash Content by Muffle Furnace Method (AOAC, 2006)

A porcelain cup was dried in the oven for 15 minutes and then cooled in a desiccator and weighed. The sample was weighed as much as 3 g in a cup that had been dried and then it was burned in a smoke chamber until it no longer emitted smoke. Next, ashing was carried out using an electric furnace at a temperature of 400-600°C for 4-6 hours until white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

Analysis Procedure of Antioxidant Content Testing (Amanah et al., 2015)

A total of 1 mL of DPPH solution (10 mg/L) was added to 50 µL of sample solution and then added methanol up to 5 mL, then incubated for 30 minutes at 37°C. The absorbance was measured at a wavelength of 513 nm. The antioxidant activity of the sample was determined by the magnitude of the DPPH radical uptake inhibition by calculating the percentage of DPPH uptake inhibition.

Analysis Procedure of IC₅₀ Antioxidant Activity Testing (Tristantini et al., 2016)

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. Analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 ml of sample in 100 ml of methanol PA. Furthermore, dilution was carried out using methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each sample. The next

step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was prepared by dissolving 5 mg of solid DPPH in 100 ml of methanol PA. Then a comparison solution was prepared, namely a control solution containing 2 ml of methanol PA and 1 ml of 50 ppm DPPH solution. For the test sample, 2 ml of sample solution and 2 ml of DPPH solution were prepared. Then, the solution was kept for 30 minutes. All samples, extract samples that had been kept, were tested for measuring the absorbance values using a Uv-vis spectrophotometer at a wavelength of 517 nm.

Analysis Procedure of Water Activity Testing (Susanto, 2009)

The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated by adding BaCl₂.2H₂O. It was then closed and kept for 3 minutes until the number on the scale became 0.9. The aw-meter was opened and the sample was inserted. The tool was then closed and waited until the aw scale was read. The temperature scale and the correction factor were observed. When the temperature scale was above 20°C, then the aw scale reading was added as much as the excess of the temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.

Analysis Procedure of Vitamin C Testing (AOAC, 1995)

Vitamin C analysis was performed by iodimetric method. The crushed sample was weighed as much as 5 g. It was put into a 100 ml measuring flask. Distilled water was then added up to the line mark. The sample was shaken until homogeneous. The solution was filtered and the filtrate was pipetted as much as 25 mL and put into an erlenmeyer. Then a few drops of starch indicator were added, then titrated rapidly using 0.01 N iodine solution until a blue color appeared.

Statistical Analysis

The data obtained were analyzed using analysis of variance (ANOVA). When the data showed that there was a significant effect, then the Duncan Multiple Range Test was carried out. The testing was done using SPSS 16.0 Statistics Software. The significant level was set at $\alpha = 0.05$.

Results and Discussion

Bulk Density of Lemongrass and Malang Apple Powder Drinks

The bulk density value indicates void space, namely the number of empty cavities between the material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2007). The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The higher the drying temperature causes the bulk density value to decrease. It is because the higher the drying temperature causes more water in the material to be evaporated so that the resulting water content is lower, causing the weight of the powder to become lighter. It is in line with Andriyani *et al.* (2015) who state that as the drying temperature increases, the bulk density decreases. The bulk density is influenced by the type of material, water content, shape and size of the material. The smaller the bulk density, the more porous the product is (Widowati *et al.*, 2010).

Of the three types of coating used, gum arabic has the lowest bulk density compared to other coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan *et al.*, 2013). Meanwhile dextrin has the characteristic of quickly dispersing, has high solubility, is able to form films, has hygroscopic properties, is able to form body, has characteristic of low browning, is able to inhibit crystallization, and has strong binding power (Purbasari, 2019). The dextrin film layer has a higher proportion of solids than gum arabic, because the DE value of dextrin is lower than gum arabic, therefore the drying process using dextrin is

faster and the particle size is smaller than gum arabic (Sutardi et al., 2010). Maltodextrin is a coating material that has a high level of solubility, this is due to the nature of maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has the ability to absorb water) so that the water in the material is more retained and difficult to evaporate (Yuliwati et al., 2015).

According to Setiawati et al. (2014), the amount of bulk density of a material affects the space needed for that material. The greater the bulk density (particles), the smaller the space needed, and vice versa. The smaller the size of the molecule, the more easily the product will be compressed; with smaller gaps between molecules, the greater the bulk density (Stranzinger et al., 2017). The treatment using gum arabic with a drying temperature of 50°C resulted in the lowest bulk density value of 0.52. According to Palijama et al. (2020), foodstuffs that have a high bulk density indicate that the product is more compact (non-voluminous), meaning that in the same certain volume, the product is available in more weight. According to Widowati et al. (2010), a material is considered 'bulk' if the bulk density is small, meaning that light weight requires a large space; the smaller the bulk density, the more porous the product is. Sadeghi et al. (2010) state that the higher sphericity of the corn kernels results in a more regular arrangement of the kernels so that the cavities between the kernels were smaller, resulting in a higher bulk density.

Dissolution Time

Dissolution time in water is a time that shows all beverage powder dissolves in water perfectly. The testing of dissolution time is carried out to determine the speed of solubility of the drinks when it will be consumed. The higher the solubility value of the powder product, the better the product is; it is because the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang et al., 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 seconds (Table 2). The results show that, the higher the drying temperature, the faster the dissolution time (Table 2). It is because the powder produced is drier. The higher the drying temperature, the more water evaporated on the powder drinks so that the water content is lower. The lower the water content, the more hygroscopic so that the dissolution time is faster (Paramita et al., 2015 and Sakdiyah et al., 2019).

The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin has a faster dissolution time compared to other types of coating (Table 2). It is because when powder drinks are dissolved in water, especially warm water, the hydroxyl groups contained in the coating material will interact with the water so that the solubility of the powder can increase (Yuliwati et al., 2015). Dextrin has a dextrose equivalent (DE) value of 3–5 and has the ability to form layers (Tyanjani et al., 2015). With the addition of dextrin, the solubility of powder drinks increases. It is because dextrin is easily soluble in water. It is in accordance with Nurhidayah et al. (2014), who state that dextrin is easily soluble in water, disperse more quickly, is not viscous and is more stable than starch.

According to Wulansari et al. (2012), Dextrose Equivalent (DE) of maltodextrin is 3-20. The higher the DE value, the higher the monosaccharide content, causing the binding power to be greater. Thus, the use of maltodextrin causes a higher water content compared to dextrin. Maltodextrin is a filler that has a high level of solubility; it is due to the characteristic of maltodextrin that is soluble in water (Hofman et al., 2021). Gum arabic has a longer dissolution time than maltodextrin and dextrin. However, according to Herawati (2018), gum arabic has the advantage of having high solubility in water, making it better as a coating material in making powder drinks. The DE value of gum arabic is 6 (Soottitantawat et al., 2006). According to Hofman et al. (2016) the factor that affects the level of solubility in water is the DE value; the higher the DE value, the better the solubility level.

Stability

Beverage products will be stable if the particles acting as the dispersed phase can be retained without changing for a long time or without experiencing grouping with each other (Anjani et al., 2011). The stability testing is expressed in (%) which shows the percentage of stability of the powder drinks made. The stability of lemongrass and Malang apple powder drinks obtained an average of 63.89% to 93.33% (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The higher the drying temperature, the lower the powder water content. It causes the product to absorb water more easily so that the product becomes more stable when rehydrated. It is in line with Kryzhska et al. (2020) who state that high water content in powder products would seriously disrupt product stability and would cause the product to agglomerate when stored. The high water content in a product can cause damage due to the activity of microorganisms.

The type of coating also affects the stability value. Of the three types of coating used, dextrin has the most stable results compared to other types of coating. Dextrins can wrap or encapsulate the active ingredient particles from oxidation reactions during storage thereby increasing product stability (Septovani et al., 2013). Dextrin has a stronger ability to bind water because it is a group of polysaccharides that has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu et al., 2012). The addition of maltodextrin can increase the stability of the drink which can reduce the precipitate formed (Paramita et al., 2015). Maltodextrin has a high solubility so that the product does not precipitate too much (Prमितasari et al., 2011). Gum arabic has a more complex molecular structure than dextrin and contains starch in it, so gum arabic is more hygroscopic (Sutardi et al., 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren et al., 2012). According to Anggraini et al. (2016), the presence of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin treatment with a drying temperature of 50°C is the coating material with the highest stability value of 93.33%.

Water Content

The average water content of lemongrass and Malang apple powder drinks ranged from 2.06% to 2.57% (Table 4). In the manufacturing process, powder drinks are made by drying separately at 40°C, 45°C and 50°C for 18 hours. The results show that the higher the drying temperature, the lower the water content of the powder. Drying causes the water content in the lemongrass and Malang apple powder to evaporate. The higher the temperature produces powder with lower water content. According to Wiyono (2011), the drying temperature factor is important to note because it can remove the water content quickly when the material is dried at high temperatures. The increase of the heating temperature tends to reduce the water content. The decrease in the amount of water is due to the higher heating temperature. Thus, there are more water molecules that evaporate from the dried raw materials so that the water content obtained is lower.

The type of coating has a relatively similar effect on the value of the water content. Of the three types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari et al. (2012), dextrin is hygroscopic, that is, it easily absorbs water; but when it is dried, the absorbed water is released. The water content absorbed by the presence of coating material will evaporate more easily than the water content in the material tissue so that the evaporation process of water in powder drinks becomes easier (Paramita et al., 2015). Maltodextrin has a low molecular weight and a simple structure, so that water is easily evaporated during the drying process (Prमितasari et al., 2011). Meanwhile, gum arabic is hygroscopic so that the water in the material is more retained and difficult to evaporate. Gum arabic has a high molecular weight and a complex molecular structure and contains a large amount of starch (Sutardi et al., 2010). Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50°C dextrin and it was in accordance with SNI number 01-4320-1996 in which the water content of powder drinks was a maximum of 3% (BSN, 1996). It shows that powder

drink products meet the requirements of SNI number 01-4320-1996 and have a small possibility of being contaminated with microorganisms.

Ash Content

According to Leggli et al. (2011), ash content testing is carried out to determine the amount of minerals in a food. Ash is composed of various types of minerals with varying composition depending on the type and source in food (Andarwulan et al., 2011). Based on Table 5, the mean value of the ash content of the results of the study was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher the ash content. The increase in ash content is thought to be related to the higher drying temperature. It causes more water in the material to evaporate so that the water content is lower. It causes the percentage of mineral content in the material to increase. The results of the study are in line with Shadri et al. (2018).

Dextrin coating is a polysaccharide group which has a simpler chemical structure than gum arabic. Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu et al., 2012). Meanwhile gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren et al., 2012). According to Sediaoetama (2010), ash content describes the amount of minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin coating with a drying temperature of 45°C. In general, the ash content of the product was still within the limits of SNI 01-4320-1996 regarding the quality requirements for powder drinks, namely a maximum of 1.5% (BSN, 1996). Malang apple has a fairly high nutritional content, especially vitamins and minerals such as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2, and vitamin C (Wahyuningtyas et al., 2017). Lemongrass contains several minerals such as vitamin A, vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri et al., 2018).

Vitamin C

The results of the vitamin C test are presented in Table 6, showing an average value of vitamin C between 53.15 mg/100g to 72.69 mg/100g. The vitamin C content tend to decrease with increasing drying temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C and is easily degraded, especially by heat (Parfiyanti et al., 2016). It shows that the drying process at high temperature can reduce the vitamin C content found in powder drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid which plays a role in inhibiting excessive oxidation reactions (Susanti et al., 2014).

The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin produces the highest content of vitamin C compared to other types of coating. It is because dextrin can protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the more dextrin is added, the more vitamin C content in the product is maintained. Dextrin has the characteristic of protecting vitamin C and compounds that are sensitive to heat or oxidation because the molecules of dextrin are stable to heat and oxidation, so that the vitamin C content can be maintained. In addition, according to Aretzy et al. (2018), maltodextrin can protect volatile compounds and protect compounds that are sensitive to oxidation. According to Alfonsius (2015), the addition of gum arabic in the processing process can protect important compounds such as vitamins due to extreme temperatures, since gum arabic has the ability to form a body as a coating and has a strong bond to the compounds coated. The highest content of vitamin C was produced in powder drinks dried at 40°C with dextrin coating (72.68 mg/100 g) and the lowest was produced at 50°C with gum arabic coating (53.15 mg/100 g). The vitamin C content of mix fruit powder drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and tween 80 dried at 50°C produces the vitamin C content

between 425 mg/100g – 550 mg/100g, which is higher than lemongrass and Malang apple powder drinks (Minah, et al, 2021).

Water Activity

Table 7 shows the mean value of water activity (aw) of lemongrass and Malang apple powder drinks, namely 0.44 to 0.50. The aw value of lemongrass and Malang apple powder drinks is lower than the aw value for the bacterial growth requirement, namely 0.90. The aw value for yeast growth is 0.80-0.90, and the aw value for mold growth is 0.60-0.70. The aw value is relatively decreased with increasing drying temperature. In the drying process, the free water in the material will evaporate. The higher temperature causes more water to evaporate. The lower the water content, the lower the water activity (Martins et al., 2019). According to Adri et al. (2013), the composition of water in foodstuffs such as free water and bound water can affect the rate or duration of food drying. The relatively small aw value does not allow the growth of bacteria, molds and yeasts in the product. Lemongrass extract shows great potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella yphimurium* and *Staphylococcus aureus*; this indicates the possibility of using medicinal plants as natural antibacterial agents (Ibrahim et al., 2013). According to Parfiyanti et al. (2016), the purpose of drying is to reduce water content so that it is not easy for mold and bacteria to grow, eliminate the activity of enzymes that can decompose the active substance content and facilitate further processing so that it can be more compact, durable and easy to store.

The use of various coatings in this study relatively produces the same aw value. The use of maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray drying can protect protein, calcium, lactose powder (Martins et al., 2019). The lowest water activity value of lemongrass and Malang apple powder drinks was obtained for products with gum arabic coating at drying temperature of 45°C (0.44).

The Percent Inhibition of Antioxidant Content

Percent inhibition shows the radical scavenging activity possessed by antioxidant compounds. One of the plants that has potential as an antioxidant is lemongrass (Wibisono, 2011) and apple (Yudhianto et al., 2013). Based on the antioxidant test in Table 8, the average inhibition value was 37.45% to 60.13%. Based on Table 8 it is also known that drying temperature affects antioxidant content. The higher the drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant activity in the lemongrass and Malang apple powder drinks is thought to be related to the damage to the antioxidant compounds due to high temperatures. According to Patras et al. (2010), antioxidant compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat. Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna et al. (2013) that antioxidant bioactive components have heat-resistant characteristics, so if the sample is extracted in hot conditions it will reduce the value of its antioxidant activity. The results of the research by Widiastuti et al. (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content in lemongrass is due to the large amount of phenolic compounds it contains. The high content of phenolic compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential oil in lemongrass stems is very high with an effective inhibition of 89% and 89.63%, whereas in lemongrass leaves it is slightly lower with antioxidant and antidiabetic activities ranging from 78.89% and 79.26% respectively (Mirghani, et al., 2012).

The use of dextrin coating with a drying temperature of 40°C produced the highest inhibition value compared to maltodextrin and gum arabic (Table 8). Goncalves et al. (2015) explains that dextrin is composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the oxidation process can be prevented. Dextrin has the characteristic of protecting volatile compounds and compounds that are

sensitive to heat or oxidation. Gum arabic can improve and maintain the stability of the compounds being coated. Gum arabic is also a type of coating that is resistant to heat (Dauqan et al., 2013). Meanwhile, maltodextrin can protect volatile compounds and protect compounds that are sensitive to oxidation (Aretzy et al., 2018). The maltodextrin coating has high oxidation resistance and can reduce the viscosity of the emulsion; combined with other coatings that have better emulsifying properties, it causes the antioxidant compounds in the microencapsulants to be well covered and protected (Purnomo et al., 2014). According to Godwin et al. (2014), lemongrass contains natural antioxidants and anti-inflammatories which can prevent free radicals in the human body. Antioxidants in lemongrass are able to inhibit the release of arachidonic acid by the mechanism of inhibiting kinase protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants which are very good for skin health. The very high antioxidant content is also the reason for the high consumption of apples by the public as an effort to prevent diseases and other dysfunctions of body health.

Antioxidant Content with Inhibition Concentration Value of 50% (IC₅₀)

The IC₅₀ value is the concentration of the antioxidant source to neutralize 50% of the radical compounds. The lower the IC₅₀ value, the better the antioxidant activity of the sample. IC₅₀ antioxidant content are determined from the 3 best samples based on the highest inhibition percentage, namely on lemongrass and Malang apple powders which are coated with dextrin with drying temperatures of 40°C, 45°C and 50°C. According to Phongpaichit et al. (2007), IC₅₀ value < 10 ppm indicates a very strong activity. IC₅₀ 10-50 ppm indicates a strong activity, IC₅₀ > 50-100 ppm indicates moderate activity, and IC₅₀ > 100-250 ppm indicates a weak activity. The results showed that the IC₅₀ value in the lemongrass and Malang apple powder drinks was 0.9 ppm to 1.47 ppm (Table 9), which indicated a very strong activity. The results of research by Andriyani et al., (2015) show that the IC₅₀ value of temulawak and red ginger powder functional drinks made using the spray drying method has the highest or strongest average value of 0.62 ppm at 4% maltodextrin concentration and the lowest or weakest value of 1.00 ppm at 0% maltodextrin concentration.

Conclusion

The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the type of coating and the drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was determined based on the antioxidant content and high stability. The fast dissolution time was found in lemongrass and Malang apple powder that was dried at 45°C with dextrin coating. The best lemongrass and Malang apple powder drinks had the following characteristics: a solubility of 0.96 seconds, a bulk density of 0.58 gr/ml, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, a percent antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 ppm, and a water activity 0.50.

Table 1. The mean value of bulk density for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.58 ^a	0.63 ^{bcd}	0.64 ^{bcd}	0.62 ± 0.03
45°C	0.67 ^{ab}	0.58 ^{abc}	0.64 ^{bcd}	0.63 ± 0.05
50°C	0.58 ^{abc}	0.67 ^{cd}	0.52 ^a	0.59 ± 0.08

Mean ± SD	0.61 ± 0.05	0.63 ± 0.05	0.60 ± 0.60
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Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

Table 2. The mean value of dissolution time for lemongrass and Malang apple powder drinks (second)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.06 ^{bc}	1.11 ^{ab}	1.29 ^d	1.15 ± 0.12 ^c
45°C	1.04 ^{abc}	0.96 ^a	1.05 ^{abc}	1.02 ± 0.05 ^b
50°C	1.07 ^{bc}	1.01 ^{cd}	1.17 ^e	1.08 ± 0.08 ^a
Mean ± SD	1.05 ± 0.01 ^a	1.03 ± 0.08 ^a	1.17 ± 0.12 ^b	

Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

Table 3. The mean value of stability for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	65.30 ^{ab}	87.32 ^e	63.89 ^a	72.17 ± 13.14 ^c
45°C	73.01 ^d	89.19 ^e	69.69 ^c	77.30 ± 10.43 ^b
50°C	78.74 ^d	93.33 ^f	80.19 ^e	84.09 ± 8.03 ^a
Mean ± SD	72.35 ± 6.74 ^a	89.95 ± 3.07 ^a	71.26 ± 8.26 ^b	

Table 4. The mean value of water content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	2.57	2.51	2.54	2.54 ± 0.03 ^c
45°C	2.39	2.38	2.31	2.36 ± 0.04 ^b
50°C	2.07	2.16	2.06	2.10 ± 0.05 ^a
Mean ± SD	2.34 ± 0.25	2.35 ± 0.18	2.30 ± 0.24	

Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

Table 5. The mean value of ash content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.17 ^{ab}	1.46 ^e	1.06 ^a	1.23 ± 0.21 ^a
45°C	1.26 ^{bcd}	1.21 ^{abc}	1.24 ^{bcd}	1.23 ± 0.02 ^a
50°C	1.26 ^{bcd}	1.37 ^{cde}	1.38 ^{de}	1.33 ± 0.07 ^b
Mean ± SD	1.23 ± 0.05 ^a	1.34 ± 0.13 ^b	1.23 ± 0.16 ^a	

Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

Table 6. The mean value of vitamin C content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	68.11 ^d	72.69 ^e	61.95 ^c	67.58 ± 5.39 ^c
45°C	63.36 ^c	70.22 ^{de}	58.26 ^b	63.95 ± 6.01 ^b
50°C	54.91 ^a	63.36 ^c	53.15 ^a	57.14 ± 5.46 ^a
Mean ± SD	62.13 ± 6.69 ^a	68.76 ± 4.83 ^b	57.79 ± 4.42 ^c	

Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

Table 7. The mean value of water activity for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean \pm SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.48	0.48	0.51	0.49 \pm 0.02
45°C	0.51	0.50	0.44	0.49 \pm 0.04
50°C	0.49	0.46	0.46	0.47 \pm 0.02
Mean \pm SD	0.49 \pm 0.02	0.48 \pm 0.02	0.47 \pm 0.03	

Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

Table 8. The mean value of antioxidant content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean \pm SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	56.96 ^f	60.13 ^h	53.66 ^g	56.92 \pm 3.24 ^c
45°C	45.73 ^c	50.97 ^e	48.17 ^d	48.29 \pm 2.62 ^b
50°C	37.45 ^a	43.98 ^b	37.53 ^a	39.65 \pm 3.75 ^a
Mean \pm stdev	46.71 \pm 9.79 ^a	51.69 \pm 8.10 ^b	46.45 \pm 8.20 ^a	

Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powder drinks (%) on the best product

Drying Temperature	Coating Type
	Dekstrin
40°C	0.9 \pm 0.01
45°C	1.279 \pm 0.08
50°C	1.47 \pm 0.01

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Dear Sir/Madam,

I/We wish to submit a new manuscript entitled "***Physico-chemical properties of lemongrass and Malang apple powder drinks***" for consideration by the Food Research

I/We confirm that this work is original and has not been published elsewhere nor is it currently under consideration for publication elsewhere.

In this paper, I/we report on the investigate the effect of coating type and drying temperature on the quality of lemongrass and Malang apple powder drinks.

Based on the result in this research I/we report on the result showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C and antioxidants. There was an interaction between the coating

type and drying time which affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/ml, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC50 content of 1.29, and a water activity of 0.50.

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Sincerely,



Dede Saputra

Physico-chemical properties of lemongrass and Malang apple powder drinks

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Abstract

The immunity of the human body can be enhanced by food and beverages. Beverage products generally have a short shelf life, so they need to be made into powder drinks. Currently popular drinks come from spices containing antioxidants that can boost the body's immunity. To maintain the antioxidant compounds that exist during drying, it is necessary to have a coating material. This study aims to investigate the effect of coating type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The study used a Completely Randomized Design (CRD) with two factors and two replications. The first factor was the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). Data were analyzed using ANAVA test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C and antioxidants. There was an interaction between the coating type and drying time which affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of 1.29, and a water activity of 0.50.

Keywords: Apples, Dextrin, Powder Drinks, Drying, Lemongrass

1. Introduction

36 A brief literature review and previous relevant work with references. The ongoing COVID-19 pandemic
37 has forced people to maintain their health through increasing their body's immunity. Body immunity can
38 be improved through foods and drinks. Beverage products generally have a short shelf life, so they need
39 to be made into powder drinks. Powder drinks are a processed food product in powder form, easily
40 dissolved in water, practical in serving and have a relatively long shelf life. In addition, powder drinks are
41 easy to carry and ship (Tangkeallo *et al.*, 2014). It causes powder drinks to be liked by the public. One of
42 the ingredients that can increase the body's immunity is spices. Spices are known to contain antioxidant
43 compounds. Antioxidants are able to capture free radicals to enhance the immunity of the body.
44 (Cakmakci *et al.*, 2015). One of the spices that contain antioxidants and is popular today is lemongrass or
45 often called "serai". Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*,
46 *eugenol*, *dipentene*, *citral* (Wibisono, 2011). These compounds act as anticancer and antioxidants, stabilize
47 blood pressure, treat constipation, help the digestive system, tighten the body after childbirth
48 (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). Apart from lemongrass, a food ingredient
49 that can improve the body's immunity and has a good taste is Malang apples. Malang apples are a famous
50 fruit typical of Malang city. Malang apples that are small in size have low economic value because they
51 are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019),
52 Malang apples contain lots of vitamins such as vitamins A, B, C, minerals, fiber, and flavonoid compounds,
53 one of which is quercetin. Vitamin C and quercetin act as antioxidants, antivirals and anti-inflammatories
54 that protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free
55 radicals and change or reduce free radicals (Suparni *et al.*, 2012).

56 There are limitations in using lemongrass and Malang apples for drinks. Those materials are difficult
57 to carry and do not last long. To overcome this, powder drinks made from a mixture of lemongrass and
58 Malang apples are made. In the making of lemongrass and Malang apple powder drinks as functional
59 drinks, there is a critical point during the drying process (Naibaho *et al.*, 2015). It is because the active
60 ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures and for
61 a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the
62 amount of antioxidants, present, it is necessary to find the right drying temperature. In addition to
63 maintaining the existing volatile compounds, it is necessary to have a coating material. The commonly
64 used coating material is gum arabic because this material has the ability to form good emulsions and films.
65 Gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the
66 highest volatile components compared to modified starch (Santoso *et al.*, 2013). According to Harahap *et al.*
67 (2021), maltodextrin can disperse quickly, has a high solubility, forms low hygroscopic properties, has
68 low browning properties, is able to inhibit crystallization and has strong binding power. Meanwhile,
69 dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity
70 (Asia *et al.*, 2012). Based on the description above, this study aimed at investigating the effect of coating
71 type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The quality
72 of the powder drinks was determined based on physical tests in the form of bulk density, dissolution time,
73 and stability test. These tests were required to determine packaging and consumer acceptance. In
74 addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity,
75 water activity, and vitamin C. These tests would indirectly determine the shelf life and ability of the
76 product to increase body immunity. This research has yielded products that can increase body immunity,
77 are easy to carry, and have a relatively long shelf life.

79 **2. Materials and methods**

80 *2.1 Material*

81 The materials used in the study were lemongrass, Malang apples, Maltodextrin, Dextrin, Gum Arabic,
82 water, and ant sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N
83 NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a “Mitzui”
84 blender, cutting boards, measuring cups, knives, “WTC Binder 78532” blower ovens, baking sheets,
85 spoons and “Matrix ESJ210-4B” scales, volumetric flasks, erlenmeyer, burettes, measuring cups,
86 measuring pipettes, suction ball, funnel pipette, beaker glass, filter paper, burette, stative, Siever 60 mesh,
87 and spectrophotometer "UV2100 Spectrophotometer".
88

89 *2.2 The process of making lemongrass and malang apple powder drinks*

90 The process of making powder drinks was a modification of the research of Susanti *et al.* (2014). The
91 process of making powder drinks consisted of two stages, that is, the making of fruit pulp and the drying
92 process.

93 *2.3 Making fruit pulp*

94 The making of fruit pulp began with sorting and washing the lemongrass and Malang apples, followed
95 by cutting the lemongrass and Malang apples and then crushing them with a blender for 5 mins at speed
96 number 2. After that, the pulp was added with water in a ratio of 1:1. Furthermore, the coating materials
97 (maltodextrin, dextrin, and gum Arabic) were added separately as much as 5% w/w fruit pulp separately.
98 The pulp was stirred until homogeneous.
99

100 *2.4 Drying*

101 The already homogeneous fruit pulp, each was placed on a 60x40x2 cm baking sheet as much as 250
102 mL and dried with a blower oven at a predetermined temperature (40°C, 45°C, and 50°C) separately for
103 18 hrs . The dried sheets of lemongrass and Malang apples were then crushed separately with a blender
104 for 3 mins at speed number 2. Then, ant sugar was added as much as 10% w/w of the dry powder. After
105 that, the powder was sieved using a 60-mesh sieve. Lemongrass powder drinks were packaged in
106 aluminum foil zip lock with a size of 7 X 13 cm.
107

108 *2.5 Analysis procedure of bulk density*

109 The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring
110 cup containing the powder sample was tapped 30 times until there were no more cavities when the
111 powder sample was adjusted to 10 mL. The measuring cup containing the powder sample was then
112 weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its
113 volume (10 mL).
114

115 *2.6 Analysis procedure of dissolution time testing*

116 A total of 5 g of the test sample was weighed then dissolved in 50 mL of warm water and stirred 20
117 times until homogeneous. How long it took the sample to dissolve in water was recorded.
118

119 *2.7 Analysis procedure of stability testing*

120 A total of 5 g of powder was weighed and brewed in 50 mL of water then put into a 10 mL measuring
121 cup and kept for 24 hrs. Afterwards, the suspension or solution was measured for the volume of the
122 precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

123

124 *2.8 Analysis procedure of water content by oven drying method*

125 An empty cup was dried in the oven for 15 mins and cooled in a desiccator (10 mins for an aluminum
126 cup and 20 mins for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2-3
127 g then it was put in a dry cup. After that, it was put in the oven at 105°C for 6 hrs . Next, the cup containing
128 the sample was cooled in a desiccator, then weighed. Drying was repeated until a constant weight was
129 obtained. Water content was calculated based on the loss of weight, namely the difference between the
130 initial weight of the sample before drying and the final weight after drying.

131

132 *2.9 Analysis procedure of ash content by muffle furnace method*

133 A porcelain cup was dried in the oven for 15 mins and then cooled in a desiccator and weighed. The
134 sample was weighed as much as 3 g in a cup that had been dried and then it was burned in a smoke
135 chamber until it no longer emitted smoke. Next, ashing was carried out using an electric furnace at a
136 temperature of 400-600°C for 4-6 hrs until white ash was formed and had a constant weight. The ash
137 formed in the cup was cooled in a desiccator and then weighed.

138

139 *2.10 Analysis procedure of antioxidant content testing*

140 A total of 1 mL of DPPH solution (10 mg/L) was added to 50 µL of sample solution and then added
141 methanol pro analyzed up to 5 mL, then incubated for 30 mins at 37°C. The absorbance was measured at
142 a wavelength of 513 nm. The antioxidant activity of the sample was determined by the magnitude of the
143 DPPH radical uptake inhibition by calculating the percentage of DPPH uptake inhibition.

144

145 *2.10 Analysis procedure of IC₅₀ antioxidant activity testing*

146 Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging
147 activity) of DPPH. Analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl)
148 method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample.
149 A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made
150 by dissolving 0.01 mL of sample in 100 mL of methanol PA. Furthermore, dilution was carried out using
151 methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each
152 sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was
153 prepared by dissolving 5 mg of solid DPPH in 100 mL of methanol PA. Then a comparison solution was
154 prepared, namely a control solution containing 2 mL of methanol PA and 1 mL of 50 ppm DPPH solution.
155 For the test sample, 2 mL of sample solution and 2 mL of DPPH solution were prepared. Then, the solution
156 was kept for 30 mins . All samples, extract samples that had been kept, were tested for measuring the
157 absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

158

159 *2.12 Analysis procedure of water activity testing*

160 The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated
161 by adding BaCl₂.2H₂O. It was then closed and kept for 3 mins until the number on the scale became 0.9.
162 The aw-meter was opened and the sample was inserted. The tool was then closed and waited until the
163 aw scale was read. The temperature scale and the correction factor were observed. When the
164 temperature scale was above 20°C, then the aw scale reading was added as much as the excess of the
165 temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.

166

167 2.13 Analysis procedure of vitamin C testing

168 Vitamin C analysis was performed by iodometric method. The crushed sample was weighed as much
169 as 5 g. It was put into a 100 mL measuring flask. Distilled water was then added up to the line mark. The
170 sample was shaken until homogeneous. The solution was filtered and the filtrate was pipetted as much
171 as 25 mL and put into an erlenmeyer. Then a few drops of starch indicator were added, then titrated
172 rapidly using 0.01 N iodine solution until a blue color appeared.

173 2.14 Statistical analysis

174 The data obtained were analyzed using analysis of variance (ANOVA). When the data showed that
175 there was a significant effect, then the Duncan Multiple Range Test was carried out. The testing was done
176 using IBM SPSS Statistics 29 software. The significant level was set at $\alpha = 0.05$.

178 3. Results and discussion

179 3.1 Bulk density of lemongrass and malang apple powder drinks

180 The bulk density value indicates void space, namely the number of empty cavities between the
181 material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2007).
182 The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The higher the drying
183 temperature causes the bulk density value to decrease. It is because the higher the drying temperature
184 causes more water in the material to be evaporated so that the resulting water content is lower, causing
185 the weight of the powder to become lighter. It is in line with Andriyani *et al.* (2015) who state that as the
186 drying temperature increases, the bulk density decreases. The bulk density is influenced by the type of
187 material, water content, shape and size of the material. The smaller the bulk density, the more porous
188 the product is (Widowati *et al.*, 2010).

190 Of the three types of coating used, gum arabic has the lowest bulk density compared to other
191 coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and
192 hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan
193 *et al.*, 2013). Meanwhile dextrin has the characteristic of quickly dispersing, has high solubility, is able to
194 form films, has hygroscopic properties, is able to form body, has characteristic of low browning, is able to
195 inhibit crystallization, and has strong binding power (Purbasari, 2019). The dextrin film layer has a higher
196 proportion of solids than gum arabic, because the DE value of dextrin is lower than gum arabic, therefore
197 the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*,
198 2010). Maltodextrin is a coating material that has a high level of solubility, this is due to the nature of
199 maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has
200 the ability to absorb water) so that the water in the material is more retained and difficult to evaporate
201 (Yuliwati *et al.*, 2015).

202 According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space
203 needed for that material. The greater the bulk density (particles), the smaller the space needed, and vice
204 versa. The smaller the size of the molecule, the more easily the product will be compressed; with smaller
205 gaps between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum
206 arabic with a drying temperature of 50°C resulted in the lowest bulk density value of 0.52. According to
207 Palijama *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact
208 (non-voluminous), meaning that in the same certain volume, the product is available in more weight.
209 According to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small, meaning
210 that light weight requires a large space; the smaller the bulk density, the more porous the product is.

211 Sadeghi *et al.* (2010) state that the higher sphericity of the corn kernels results in a more regular
212 arrangement of the kernels so that the cavities between the kernels were smaller, resulting in a higher
213 bulk density.

214

215 3.2 Dissolution Time

216 Dissolution time in water is a time that shows all beverage powder dissolves in water perfectly. The
217 testing of dissolution time is carried out to determine the speed of solubility of the drinks when it will be
218 consumed. The higher the solubility value of the powder product, the better the product is; it is because
219 the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang
220 *et al.*, 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 seconds
221 (Table 2). The results show that, the higher the drying temperature, the faster the dissolution time (Table
222 2). It is because the powder produced is drier. The higher the drying temperature, the more water
223 evaporated on the powder drinks so that the water content is lower. The lower the water content, the
224 more hygroscopic so that the dissolution time is faster (Paramita *et al.*, 2015 and Sakdiyah *et al.*, 2019).

225 The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin
226 has a faster dissolution time compared to other types of coating (Table 2). It is because when powder
227 drinks are dissolved in water, especially warm water, the hydroxyl groups contained in the coating
228 material will interact with the water so that the solubility of the powder can increase (Yuliwaty *et al.*,
229 2015). Dextrin has a dextrose equivalent (DE) value of 3–5 and has the ability to form layers (Tyanjani *et al.*,
230 *et al.*, 2015). With the addition of dextrin, the solubility of powder drinks increases. It is because dextrin is
231 easily soluble in water. It is in accordance with Nurhidayah *et al.* (2014), who state that dextrin is easily
232 soluble in water, disperse more quickly, is not viscous and is more stable than starch.

233 According to Wulansari *et al.* (2012), Dextrose Equivalent (DE) of maltodextrin is 3-20. The higher
234 the DE value, the higher the monosaccharide content, causing the binding power to be greater. Thus, the
235 use of maltodextrin causes a higher water content compared to dextrin. Maltodextrin is a filler that has a
236 high level of solubility; it is due to the characteristic of maltodextrin that is soluble in water (Hofman *et al.*
237 *et al.*, 2021). Gum arabic has a longer dissolution time than maltodextrin and dextrin. However, according
238 to Herawati (2018), gum arabic has the advantage of having high solubility in water, making it better as a
239 coating material in making powder drinks. The DE value of gum arabic is 6 (Soottitantawat *et al.*, 2006).
240 According to Hofman *et al.* (2016) the factor that affects the level of solubility in water is the DE value;
241 the higher the DE value, the better the solubility level.

242

243 3.3 Stability

244 Beverage products will be stable if the particles acting as the dispersed phase can be retained
245 without changing for a long time or without experiencing grouping with each other (Anjani *et al.*, 2011).
246 The stability testing is expressed in (%) which shows the percentage of stability of the powder drinks made.
247 The stability of lemongrass and Malang apple powder drinks obtained an average of 63.89% to 93.33%
248 (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The
249 higher the drying temperature, the lower the powder water content. It causes the product to absorb water
250 more easily so that the product becomes more stable when rehydrated. It is in line with Kryzhska *et al.*
251 (2020) who state that high water content in powder products would seriously disrupt product stability
252 and would cause the product to agglomerate when stored. The high-water content in a product can cause
253 damage due to the activity of microorganisms.

254 The type of coating also affects the stability value. Of the three types of coating used, dextrin has
255 the most stable results compared to other types of coating. Dextrin's can wrap or encapsulate the active
256 ingredient particles from oxidation reactions during storage thereby increasing product stability
257 (Septevani *et al.*, 2013). Dextrin has a stronger ability to bind water because it is a group of
258 polysaccharides that has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic
259 bonds (Xu *et al.*, 2012). The addition of maltodextrin can increase the stability of the drink which can
260 reduce the precipitate formed (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the
261 product does not precipitate too much (Prमितasari *et al.*, 2011). Gum arabic has a more complex
262 molecular structure than dextrin and contains starch in it, so gum arabic is more hygroscopic (Sutardi *et*
263 *al.*, 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-
264 glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence
265 of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin
266 treatment with a drying temperature of 50°C is the coating material with the highest stability value of
267 93.33%.

268

269 3.4 Water content

270 The average water content of lemongrass and Malang apple powder drinks ranged from 2.06% to
271 2.57% (Table 4). In the manufacturing process, powder drinks are made by drying separately at 40°C, 45°C
272 and 50°C for 18 hrs . The results show that the higher the drying temperature, the lower the water content
273 of the powder. Drying causes the water content in the lemongrass and Malang apple powder to evaporate.
274 The higher the temperature produces powder with lower water content. According to Wiyono (2011), the
275 drying temperature factor is important to note because it can remove the water content quickly when the
276 material is dried at high temperatures. The increase of the heating temperature tends to reduce the water
277 content. The decrease in the amount of water is due to the higher heating temperature. Thus, there are
278 more water molecules that evaporate from the dried raw materials so that the water content obtained is
279 lower.

280 The type of coating has a relatively similar effect on the value of the water content. Of the three
281 types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by
282 maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic,
283 that is, it easily absorbs water; but when it is dried, the absorbed water is released. The water content
284 absorbed by the presence of coating material will evaporate more easily than the water content in the
285 material tissue so that the evaporation process of water in powder drinks becomes easier (Paramita *et*
286 *al.*, 2015). Maltodextrin has a low molecular weight and a simple structure, so that water is easily
287 evaporated during the drying process (Prमितasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic so
288 that the water in the material is more retained and difficult to evaporate. Gum arabic has a high molecular
289 weight and a complex molecular structure and contains a large amount of starch (Sutardi *et al.*, 2010).
290 Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50°C
291 dextrin and it was in accordance with SNI number 01-4320-1996 in which the water content of powder
292 drinks was a maximum of 3% (BSN, 1996). It shows that powder drink products meet the requirements of
293 SNI number 01-4320-1996 and have a small possibility of being contaminated with microorganisms.

294

295 3.5 Ash content

296 According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of
297 minerals in a food. Ash is composed of various types of minerals with varying composition depending on

298 the type and source in food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content
299 of the results of the study was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher
300 the ash content. The increase in ash content is thought to be related to the higher drying temperature. It
301 causes more water in the material to evaporate, so that the water content is lower. It causes the
302 percentage of mineral content in the material to increase. The results of the study are in line with Shadri
303 *et al.* (2018).

304 Dextrin coating is a polysaccharide group which has a simpler chemical structure than gum arabic.
305 Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile gum arabic has
306 a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-
307 rhamnose (Alftren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of
308 minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a
309 sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin
310 coating with a drying temperature of 45°C. In general, the ash content of the product was still within the
311 limits of SNI 01-4320-1996 regarding the quality requirements for powder drinks, namely a maximum of
312 1.5% (BSN, 1996). Malang apple has a fairly high nutritional content, especially vitamins and minerals such
313 as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2,
314 and vitamin C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A,
315 vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

316

317 3.6 Vitamin C

318 The results of the vitamin C test are presented in Table 6, showing an average value of vitamin C
319 between 53.15 mg/100g to 72.69 mg/100g. The vitamin C content tend to decrease with increasing drying
320 temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C and is easily
321 degraded, especially by heat (Parfiyanti *et al.*, 2016). It shows that the drying process at high temperature
322 can reduce the vitamin C content found in powder drinks. Vitamin C is classified as a natural antioxidant.
323 Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid which plays a role in
324 inhibiting excessive oxidation reactions (Susanti *et al.*, 2014).

325 The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin
326 produces the highest content of vitamin C compared to other types of coating. It is because dextrin can
327 protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the more
328 dextrin is added, the more vitamin C content in the product is maintained. Dextrin has the characteristic
329 of protecting vitamin C and compounds that are sensitive to heat or oxidation because the molecules of
330 dextrin are stable to heat and oxidation, so that the vitamin C content can be maintained. In addition,
331 according to Aretzy *et al.* (2018), maltodextrin can protect volatile compounds and protect compounds
332 that are sensitive to oxidation. According to Alfonsius (2015), the addition of gum arabic in the processing
333 process can protect important compounds such as vitamins due to extreme temperatures, since gum
334 arabic has the ability to form a body as a coating and has a strong bond to the compounds coated. The
335 highest content of vitamin C was produced in powder drinks dried at 40°C with dextrin coating (72.68
336 mg/100 g) and the lowest was produced at 50°C with gum arabic coating (53.15 mg/100 g). The vitamin C
337 content of mix fruit powder drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and
338 tween 80 dried at 50°C produces the vitamin C content between 425 mg/100g – 550 mg/100g, which is
339 higher than lemongrass and Malang apple powder drinks (Minah, *et al.*, 2021).

340

341 3.7 Water activity

342 Table 7 shows the mean value of water activity (a_w) of lemongrass and Malang apple powder drinks,
343 namely 0.44 to 0.50. The a_w value of lemongrass and Malang apple powder drinks is lower than the a_w
344 value for the bacterial growth requirement, namely 0.90. The a_w value for yeast growth is 0.80-0.90, and
345 the a_w value for mold growth is 0.60-0.70. The a_w value is relatively decreased with increasing drying
346 temperature. In the drying process, the free water in the material will evaporate. The higher temperature
347 causes more water to evaporate. The lower the water content, the lower the water activity (Martins *et*
348 *al.*, 2019). According to Adri *et al.* (2013), the composition of water in foodstuffs such as free water and
349 bound water can affect the rate or duration of food drying. The relatively small a_w value does not allow
350 the growth of bacteria, molds and yeasts in the product. Lemongrass extract shows great potential as an
351 antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella yphimurium* and
352 *Staphylococcus aureus*; this indicates the possibility of using medicinal plants as natural antibacterial
353 agents (Ibrahim *et al.*, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying is to reduce water
354 content so that it is not easy for mold and bacteria to grow, eliminate the activity of enzymes that can
355 decompose the active substance content and facilitate further processing so that it can be more compact,
356 durable and easy to store.

357 The use of various coatings in this study relatively produces the same a_w value. The use of
358 maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray
359 drying can protect protein, calcium, lactose powder (Martins *et al.*, 2019). The lowest water activity value
360 of lemongrass and Malang apple powder drinks was obtained for products with gum arabic coating at
361 drying temperature of 45°C (0.44).

362

363 3.8 The percent inhibition of antioxidant content

364 Percent inhibition shows the radical scavenging activity possessed by antioxidant compounds. One
365 of the plants that has potential as an antioxidant is lemongrass (Wibisono, 2011) and apple (Yudhianto *et*
366 *al.*, 2013). Based on the antioxidant test in Table 8, the average inhibition value was 37.45% to 60.13%.
367 Based on Table 8 it is also known that drying temperature affects antioxidant content. The higher the
368 drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant
369 activity in the lemongrass and Malang apple powder drinks is thought to be related to the damage to the
370 antioxidant compounds due to high temperatures. According to Patras *et al.* (2010), antioxidant
371 compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these
372 compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat.
373 Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna *et al.* (2013)
374 that antioxidant bioactive components have heat-resistant characteristics, so if the sample is extracted in
375 hot conditions it will reduce the value of its antioxidant activity. The results of the research by Widiastuti
376 *et al.* (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the
377 higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content
378 in lemongrass is due to the large number of phenolic compounds it contains. The high content of phenolic
379 compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential
380 oil in lemongrass stems is very high with an effective inhibition of 89% and 89.63%, whereas in lemongrass
381 leaves it is slightly lower with antioxidant and antidiabetic activities ranging from 78.89% and 79.26%
382 respectively (Mirghani, *et al.*, 2012).

383 The use of dextrin coating with a drying temperature of 40°C produced the highest inhibition value
384 compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explains that dextrin is
385 composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the

386 oxidation process can be prevented. Dextrin has the characteristic of protecting volatile compounds and
387 compounds that are sensitive to heat or oxidation. Gum arabic can improve and maintain the stability of
388 the compounds being coated. Gum arabic is also a type of coating that is resistant to heat (Dauqan *et al.*,
389 2013). Meanwhile, maltodextrin can protect volatile compounds and protect compounds that are
390 sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high oxidation resistance and can
391 reduce the viscosity of the emulsion; combined with other coatings that have better emulsifying
392 properties, it causes the antioxidant compounds in the microencapsulants to be well covered and
393 protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural
394 antioxidants and anti-inflammatories which can prevent free radicals in the human body. Antioxidants in
395 lemongrass are able to inhibit the release of arachidonic acid by the mechanism of inhibiting kinase
396 protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid
397 synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are
398 citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants which are
399 very good for skin health. The very high antioxidant content is also the reason for the high consumption
400 of apples by the public as an effort to prevent diseases and other dysfunctions of body health.

401

402 *3.9 Antioxidant content with inhibition concentration value of 50% (IC₅₀)*

403 The IC₅₀ value is the concentration of the antioxidant source to neutralize 50% of the radical
404 compounds. The lower the IC₅₀ value, the better the antioxidant activity of the sample. IC₅₀ antioxidant
405 content are determined from the 3 best samples based on the highest inhibition percentage, namely on
406 lemongrass and Malang apple powders which are coated with dextrin with drying temperatures of 40°C,
407 45°C and 50°C. According to Phongpaichit *et al.* (2007), IC₅₀ value < 10 ppm indicates a very strong activity.
408 IC₅₀ 10-50 ppm indicates a strong activity, IC₅₀ > 50-100 ppm indicates moderate activity, and IC₅₀ > 100-
409 250 ppm indicates a weak activity. The results showed that the IC₅₀ value in the lemongrass and Malang
410 apple powder drinks was 0.9 ppm to 1.47 ppm (Table 9), which indicated a very strong activity. The results
411 of research by Andriyani *et al.*, (2015) show that the IC₅₀ value of temulawak and red ginger powder
412 functional drinks made using the spray drying method has the highest or strongest average value of 0.62
413 ppm at 4% maltodextrin concentration and the lowest or weakest value of 1.00 ppm at 0% maltodextrin
414 concentration.

415

416 **4. Conclusion**

417 The results showed that the type of coating significantly affected the parameters of stability,
418 dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly
419 affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and
420 antioxidants. There was an interaction between the type of coating and the drying time that affected the
421 bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was
422 determined based on the antioxidant content and high stability. The fast dissolution time was found in
423 lemongrass and Malang apple powder that was dried at 45°C with dextrin coating. The best lemongrass
424 and Malang apple powder drinks had the following characteristics: a solubility of 0.96 seconds, a bulk
425 density of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin
426 C content of 70.22%, a percent antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 ppm, and a water
427 activity 0.50.

428 **Conflict of interest - Disclose any potential conflict of interest appropriately.**

429 The authors declare no conflict of interest.

430

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680 **Tables and Figures – 1 PAGE 1 TABLE/FIGURE. PLACE ALL TABLES AND FIGURES AT THE END OF THE**
 681 **MANUSCRIPT BODY AFTER THE REFERENCES. ARRANGE THE TABLES AND FIGURES ACCORDING TO**
 682 **THEIR APPEARANCE IN TEXT.**

683 Table 1. The mean value of bulk density for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.58 ^a	0.63 ^{bcd}	0.64 ^{bcd}	0.62 ± 0.03
45°C	0.67 ^{ab}	0.58 ^{abc}	0.64 ^{bcd}	0.63 ± 0.05
50°C	0.58 ^{abc}	0.67 ^{cd}	0.52 ^a	0.59 ± 0.08
Mean ± SD	0.61 ± 0.05	0.63 ± 0.05	0.60 ± 0.60	

684 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

685

686 Table 2. The mean value of dissolution time for lemongrass and Malang apple powder drinks (second)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.06 ^{bc}	1.11 ^{ab}	1.29 ^d	1.15 ± 0.12 ^c
45°C	1.04 ^{abc}	0.96 ^a	1.05 ^{abc}	1.02 ± 0.05 ^b
50°C	1.07 ^{bc}	1.01 ^{cd}	1.17 ^e	1.08 ± 0.08 ^a
Mean ± SD	1.05 ± 0.01 ^a	1.03 ± 0.08 ^a	1.17 ± 0.12 ^b	

687 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

688

689 Table 3. The mean value of stability for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	65.30 ^{ab}	87.32 ^e	63.89 ^a	72.17 ± 13.14 ^c
45°C	73.01 ^d	89.19 ^e	69.69 ^c	77.30 ± 10.43 ^b
50°C	78.74 ^d	93.33 ^f	80.19 ^e	84.09 ± 8.03 ^a
Mean ± SD	72.35 ± 6.74 ^a	89.95 ± 3.07 ^a	71.26 ± 8.26 ^b	

690

691 Table 4. The mean value of water content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	2.57	2.51	2.54	2.54 ± 0.03 ^c
45°C	2.39	2.38	2.31	2.36 ± 0.04 ^b
50°C	2.07	2.16	2.06	2.10 ± 0.05 ^a
Mean ± SD	2.34 ± 0.25	2.35 ± 0.18	2.30 ± 0.24	

692 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

693

694 Table 5. The mean value of ash content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.17 ^{ab}	1.46 ^e	1.06 ^a	1.23 ± 0.21 ^a
45°C	1.26 ^{bcd}	1.21 ^{abc}	1.24 ^{bcd}	1.23 ± 0.02 ^a
50°C	1.26 ^{bcd}	1.37 ^{cde}	1.38 ^{de}	1.33 ± 0.07 ^b
Mean ± SD	1.23 ± 0.05 ^a	1.34 ± 0.13 ^b	1.23 ± 0.16 ^a	

695 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

696 Table 6. The mean value of vitamin C content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	68.11 ^d	72.69 ^e	61.95 ^c	67.58 ± 5.39 ^c
45°C	63.36 ^c	70.22 ^{de}	58.26 ^b	63.95 ± 6.99 ^b
50°C	54.91 ^a	63.36 ^c	53.15 ^a	57.14 ± 5.46 ^a
Mean ± SD	62.13 ± 6.69 ^a	68.76 ± 4.83 ^b	57.79 ± 4.42 ^c	

701 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

702

703 Table 7. The mean value of water activity for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.48	0.48	0.51	0.49 ± 0.02
45°C	0.51	0.50	0.44	0.49 ± 0.04
50°C	0.49	0.46	0.46	0.47 ± 0.02
Mean ± SD	0.49 ± 0.02	0.48 ± 0.02	0.47 ± 0.03	

704 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

705

706 Table 8. The mean value of antioxidant content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	

40°C	56.96 ^f	60.13 ^h	53.66 ^g	56.92 ± 3.24 ⁷⁰⁷
45°C	45.73 ^c	50.97 ^e	48.17 ^d	48.29 ± 2.62 ⁷⁰⁸
50°C	37.45 ^a	43.98 ^b	37.53 ^a	39.65 ± 3.75 ^a

710

711

712 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

713

714 Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powder drinks (%)
 715 on the best product

Drying Temperature	Coating Type
	Dekstrin
40°C	0.9 ± 0.01
45°C	1.279 ± 0.08
50°C	1.47 ± 0.01

716

MANUSCRIPT EVALUATION FORM

Date : 14th February 2023

Manuscript ID : FR-2023-077

Please return by : 14th March 2023

Title of Manuscript : Physico-chemical properties of lemongrass and Malang apple powder drinks

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2. Your review should consider the article's scholarly merit including originality of the research issue and/or methodology, adequacy and rigor of the research methodology and techniques used, quality and rigor of data analysis, comprehensiveness of literature review, and the readability and presentation of the article. Please provide detailed and specific comments to all items. Also, where appropriate please provide suggestions for revision.

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Using item 2 in page 1 as a guideline, please indicate the reasons for your recommendations. Most author(s) will appreciate frankness, combined with a modicum of tact. Even if you recommend that the manuscript be accepted for publication, please provide some general comments to the author(s).

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		<p>*NOTE FOR AUTHOR: Please state your response to the reviewer's comments/suggestion below</p>
<p>1.</p>	<p>Title <i>It should reflect the article</i></p> <p>Qualify</p>	<p>Thank you very much for your comments.</p>
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<p>3.</p>	<p>Keywords <i>Min. 3 and Max. 6</i></p> <p>Qualify</p>	<p>Thank you very much for your comments.</p>
<p>4.</p>	<p>Introduction <i>Concise with sufficient background</i></p> <p>Qualify Please add a description of how the ability of maltodextrin and dextrin to trap volatile compounds</p>	<p>Thank you very much for your comments.</p> <p>We have explained about the maltodextrin and dextrin. Please see line 59-62 page 2.</p>
<p>5.</p>	<p>Research design/Methodology <i>Clearly described and reproducible</i></p> <p>Minor revision</p> <ol style="list-style-type: none"> 1. Capital letter: Materials and methods 2. Repetitive: measuring cups, burette 3. Without filtering process? 4. With apple peel? 5. Delete: separately 6. Delete: The already homogeneous 7. Use common abbreviations: hrs 8. Use common abbreviations: mins 9. Delete: of the test 10. Please add the reference used. Complete for others analytical procedures too 	<p>Thank you for your suggestion</p> <ol style="list-style-type: none"> 1. We have revised the sentence to be: Materials and Methods. Please see line 72 page 2. 2. We have deleted the repetitive words. The sentence to be: burettes, measuring pipettes, suction ball, funnel pipette, beaker glass, filter paper, stative. Please see line 78-79 page 2. 3. Fruit pulp was making, yes, without filtering process. 4. Yes, we use unpeeled apple

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<ol style="list-style-type: none">11. use common abbreviations: in a smoke chamber12. Replace with “radical scavenging activity”13. Wrong order14. Revised	<ol style="list-style-type: none">5. We have revised the sentence to be: were added as much as 5% w/w. Please see line 90 page 3.6. We have revised the sentence to be: The homogeneous fruit pulp. Please see line 94 page 3.7. We have revised, the sentence to be: 18 hours. Please see line 95 page 3.8. We have revised, the sentence to be: minutes. Please see line 89 page 3.9. We have revised, the sentence to be: A total of 5 g sample was... Please see line 109 page 3.10. We have added the reference for all methods have used. The sentence to be: <i>2.5 Analysis procedure of bulk density</i> (Sandhu et al., 2007); <i>2.6 Analysis procedure of dissolution time testing</i> (Pentury et al., 2013); <i>2.7 Analysis procedure of stability testing</i> (Pentury et al., 2013); <i>2.8 Analysis procedure of water content by oven drying method</i> (AOAC, 2006); <i>2.9 Analysis procedure of ash content by muffle furnace method</i> (AOAC, 2006); <i>2.13 Analysis procedure of vitamin C testing</i> (AOAC, 2006). Please see line 102, 109, 112, 118, 126, 133, 144, 158, 166, page 3-4.11. We have revised the sentence to be: ..was burned in a crucibles until it no longer emitted smoke. Please see line 127-128 page 4.12. We have revised the sentence to be: 2.10 Analysis procedure of <i>radical scavenging activity</i> (Tristantini et al., 2016). Please see line 132 page 4.13. We have revised the sentence to be: 2.11 Analysis procedure of IC₅₀ antioxidant activity (Tristantini et al., 2016). Please see line 143 page 4.14. We have revised the chemical formula writing to be: adding BaCl₂.2H₂O. Please see line 159, page 4.
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<p>6. Data Analysis <i>Results well presented and discussed</i></p> <p>Minor revision</p> <ol style="list-style-type: none"> 1. Capital letter: Results and discussion 2. Capital letter: malang apple 3. Delete: expressed in (%) which shows the powder drinks made 4. How about maltodextrin and gum arabic? Please give more explanation 5. hrs? 6. Repetition: The decrease in the amount of water is due to the higher heating temperature. 7. There is no clear explanation about this: Dextrin coating is a polysaccharide group which has a simpler chemical structure than gum arabic. 8. But why the vitamin C of gum arabic was lower than dexktrin. Please give the reason. 9. Can be added explanation why aw of all coating type was not significant? 10. Typo: <i>Salmonella yphimurium</i> 11. Replace with "radical scavenging activity" 12. Replace with radical scavenging activity 13. antioxidant content? 14. ppm or %? 	<p style="text-align: center;">Thank you for your suggestion</p> <ol style="list-style-type: none"> 1. We have revised the sentence to be: 3. Results and Discussion. Please see line 184, page 5. 2. We have revised the sentence to be: <i>Bulk density of lemongrass and Malang apple powder drinks</i>. Please see line 185, page 5. 3. We have revised the sentence to be: The stability testing is expressed in the percentage of stability of the powder drinks made. Please see line 256, page 6. 4. We have written the explanation about maltodextrin dan gum Arabic. The sentence to be: The addition of maltodextrin can increase the stability of the drink which can reduce the precipitate formed (Paramita <i>et al.</i>, 2015). Maltodextrin has a high solubility so that the product does not precipitate too much (Pramitasari <i>et al.</i>, 2011). Gum arabic has a more complex molecular structure than dextrin and contains starch in it, so gum arabic is more hygroscopic (Sutardi <i>et al.</i>, 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren <i>et al.</i>, 2012). According to Anggraini <i>et al.</i> (2016), the presence of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin treatment with a drying temperature of 50°C is the coating material with the highest stability value of 93.33%. Please see line 269-277, page 7. 5. We have revised the sentence to be: 18 hours. Please see line 282, page 7. 6. We have revised the sentence to be: The increase of the heating temperature tends to reduce the water content. Thus, there are more water molecules that evaporate from the dried raw materials so that the water content obtained is lower. Please see line 289-291, page 7.
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		<p>7. We have revised the sentence to be: Dextrin is a polysaccharide group that has a simpler chemical structure than gum Arabic. Please see line 316, page 8.</p> <p>8. We have revised the sentence to be: because the molecules of dextrin are stable to heat and oxidation. In addition, according to. Please see line 344-345, page 8.</p> <p>9. We have revised the sentence to be: According to Morodi <i>et al.</i> (2022), gum arabic alone or combined with other biopolymers has been successfully applied on tomato slices and grapefruit slices to preserve the dried products' quality. Please see line 346-348, page 8-9.</p> <p>10. We have revised the sentence to be: <i>Salmonella typhimurium</i>. Please see line 366-367, page 9</p> <p>11. We have revised the sentence to be: 3.8 Radical scavenging activity. Please see line 378, page 9.</p> <p>12. We have revised the sentence to be: Based on the <i>percent of radical scavenging activity</i> test. Please see line 381, page 9.</p> <p>13. We have revised the sentence to be: Based on Table 8 it is also known that drying temperature affects <i>the percent of radical scavenging activity</i>. Please see line 384-385, page 9.</p> <p>14. We have revised the sentence to be: The results showed that the IC₅₀ value in the lemongrass and Malang apple powder drinks was 0.9 to 1.47 %. Please see line 427-428, page 10.</p>
7.	<p>Conclusion <i>A clear summary of the study</i></p> <p>Qualify ppm or %?</p>	<p>Thank you for your suggestion</p> <p>We have revised the sentence to be: IC₅₀ content of 1.29 %. Please see line 444 page 11.</p>
8.	<p>References <i>References should follow the journal's format</i></p> <p>Minor revision</p>	<p>Thank you for your suggestion</p> <p>We have revised the references base on authors' name alphabetically. Please see line 453-692 page 11-17.</p>

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9.	English Proficiency Good	Thank you for your suggestion
10.	Additional comments/suggestions by the reviewer about the article Good topic but needs a little revision	Thank you for your suggestion <ol style="list-style-type: none"> 1. We have revised the title and the article base on the reviewer comment. 2. We have revised the sentence to be: Table 8. The mean value of radical scavenging activity content for lemongrass and Malang apple powder drinks (%). Please see line 719 page 19. 3. We have revised the sentence to be: Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powder drinks (%) on the best product. Please see line 728 page 20.

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1 Physico-chemical properties of lemongrass and Malang apple powder drinks

3 Abstract

4 The immunity of the human body can be enhanced by food and beverages. Beverage products generally
5 have a short shelf life, so they need to be made into powder drinks. Currently popular drinks come from
6 spices containing antioxidants that can boost the body's immunity. To maintain the antioxidant
7 compounds that exist during drying, it is necessary to have a coating material. This study aims to
8 investigate the effect of coating type and drying temperature on the quality of lemongrass and Malang
9 apple powder drinks. The study used a Completely Randomized Design (CRD) with two factors and two
10 replications. The first factor was the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the
11 second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). Data were analyzed using
12 ANAVA test and Duncan's further test if the treatment was significantly different. The results showed that
13 the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin
14 C, and antioxidants. Drying time significantly affected the parameters of stability, dissolution time, water
15 content, ash content, vitamin C and antioxidants. There was an interaction between the coating type and
16 drying time which affected the bulk density, stability, dissolution time, ash content, vitamin C, and
17 antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin
18 coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96
19 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of
20 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of
21 1.29, and a water activity of 0.50.

22 **Keywords:** Apples, Dextrin, Powder Drinks, Drying, Lemongrass

24 1. Introduction

25 A brief literature review and previous relevant work with references. The ongoing COVID-19 pandemic
26 has forced people to maintain their health through increasing their body's immunity. Body immunity can
27 be improved through foods and drinks. Beverage products generally have a short shelf life, so they need
28 to be made into powder drinks. Powder drinks are a processed food product in powder form, easily
29 dissolved in water, practical in serving and have a relatively long shelf life. In addition, powder drinks are
30 easy to carry and ship (Tangkeallo *et al.*, 2014). It causes powder drinks to be liked by the public. One of
31 the ingredients that can increase the body's immunity is spices. Spices are known to contain antioxidant
32 compounds. Antioxidants are able to capture free radicals to enhance the immunity of the body.
33 (Cakmakci *et al.*, 2015). One of the spices that contain antioxidants and is popular today is lemongrass or
34 often called "serai". Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*,
35 *eugenol*, *dipentene*, *citral* (Wibisono, 2011). These compounds act as anticancer and antioxidants, stabilize
36 blood pressure, treat constipation, help the digestive system, tighten the body after childbirth
37 (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). Apart from lemongrass, a food ingredient
38 that can improve the body's immunity and has a good taste is Malang apples. Malang apples are a famous
39 fruit typical of Malang city. Malang apples that are small in size have low economic value because they
40 are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019),

41 Malang apples contain lots of vitamins such as vitamins A, B, C, minerals, fiber, and flavonoid compounds,
42 one of which is quercetin. Vitamin C and quercetin act as antioxidants, antivirals and anti-inflammatories
43 that protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free
44 radicals and change or reduce free radicals (Suparni *et al.*, 2012).

45 There are limitations in using lemongrass and Malang apples for drinks. Those materials are difficult
46 to carry and do not last long. To overcome this, powder drinks made from a mixture of lemongrass and
47 Malang apples are made. In the making of lemongrass and Malang apple powder drinks as functional
48 drinks, there is a critical point during the drying process (Naibaho *et al.*, 2015). It is because the active
49 ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures and for
50 a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the
51 amount of antioxidants, present, it is necessary to find the right drying temperature. In addition to
52 maintaining the existing volatile compounds, it is necessary to have a coating material. The commonly
53 used coating material is gum arabic because this material has the ability to form good emulsions and films.
54 Gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the
55 highest volatile components compared to modified starch (Santoso *et al.*, 2013). According to Harahap *et*
56 *al.* (2021), maltodextrin can disperse quickly, has a high solubility, forms low hygroscopic properties, has
57 low browning properties, is able to inhibit crystallization and has strong binding power. Meanwhile,
58 dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity
59 (Asia *et al.*, 2012). Based on the description above, this study aimed at investigating the effect of coating
60 type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The quality
61 of the powder drinks was determined based on physical tests in the form of bulk density, dissolution time,
62 and stability test. These tests were required to determine packaging and consumer acceptance. In
63 addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity,
64 water activity, and vitamin C. These tests would indirectly determine the shelf life and ability of the
65 product to increase body immunity. This research has yielded products that can increase body immunity,
66 are easy to carry, and have a relatively long shelf life.

67

68 2. Materials and methods

69 2.1 Material

70 The materials used in the study were lemongrass, Malang apples, Maltodextrin, Dextrin, Gum Arabic,
71 water, and ant sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N
72 NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a "Mitzui"
73 blender, cutting boards, measuring cups, knives, "WTC Binder 78532" blower ovens, baking sheets,
74 spoons and "Matrix ESJ210-4B" scales, volumetric flasks, erlenmeyer, burettes, measuring cups,
75 measuring pipettes, suction ball, funnel pipette, beaker glass, filter paper, burette, stative, Siever 60 mesh,
76 and spectrophotometer "UV2100 Spectrophotometer".

77

78 2.2 The process of making lemongrass and malang apple powder drinks

79 The process of making powder drinks was a modification of the research of Susanti *et al.* (2014). The
80 process of making powder drinks consisted of two stages, that is, the making of fruit pulp and the drying
81 process.

82 2.3 Making fruit pulp

Commented [A1]: Please add a description of how the ability of maltodextrin and dextrin to trap volatile compounds

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Commented [A5]: Explain which part was modified in your research

83 The making of fruit pulp began with sorting and washing the lemongrass and Malang apples, followed
84 by cutting the lemongrass and Malang apples and then crushing them with a blender for 5 mins at speed
85 number 2. After that, the pulp was added with water in a ratio of 1:1. Furthermore, the coating materials
86 (maltodextrin, dextrin, and gum Arabic) were added separately as much as 5% w/w of fruit pulp
87 separately. The pulp was stirred until homogeneous.

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Commented [A7]: With apple peel?

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89 2.4 Drying

90 The already homogeneous fruit pulp, each was placed on a 60x40x2 cm baking sheet as much as 250
91 mL and dried with a blower oven at a predetermined temperature (40°C, 45°C, and 50°C) separately for
92 18 hrs. The dried sheets of lemongrass and Malang apples were then crushed separately with a blender
93 for 3 mins at speed number 2. Then, ant sugar was added as much as 10% w/w of the dry powder. After
94 that, the powder was sieved using a 60-mesh sieve. Lemongrass powder drinks were packaged in
95 aluminum foil zip lock with a size of 7 X 13 cm.

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Commented [A11]: use common abbreviations

97 2.5 Analysis procedure of bulk density

98 The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring
99 cup containing the powder sample was tapped 30 times until there were no more cavities when the
100 powder sample was adjusted to 10 mL. The measuring cup containing the powder sample was then
101 weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its
102 volume (10 mL).

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Complete for others analytical procedures too

104 2.6 Analysis procedure of dissolution time testing

105 A total of 5 g of the test sample was weighed then dissolved in 50 mL of warm water and stirred 20
106 times until homogeneous. How long it took the sample to dissolve in water was recorded.

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108 2.7 Analysis procedure of stability testing

109 A total of 5 g of powder was weighed and brewed in 50 mL of water then put into a 10 mL measuring
110 cup and kept for 24 hrs. Afterwards, the suspension or solution was measured for the volume of the
111 precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

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113 2.8 Analysis procedure of water content by oven drying method

114 An empty cup was dried in the oven for 15 mins and cooled in a desiccator (10 mins for an aluminum
115 cup and 20 mins for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2-3
116 g then it was put in a dry cup. After that, it was put in the oven at 105°C for 6 hrs. Next, the cup containing
117 the sample was cooled in a desiccator, then weighed. Drying was repeated until a constant weight was
118 obtained. Water content was calculated based on the loss of weight, namely the difference between the
119 initial weight of the sample before drying and the final weight after drying.

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Commented [A17]: use common abbreviations

121 2.9 Analysis procedure of ash content by muffle furnace method

122 A porcelain cup was dried in the oven for 15 mins and then cooled in a desiccator and weighed. The
123 sample was weighed as much as 3 g in a cup that had been dried and then it was burned in a smoke
124 chamber until it no longer emitted smoke. Next, ashing was carried out using an electric furnace at a
125 temperature of 400-600°C for 4-6 hrs until white ash was formed and had a constant weight. The ash
126 formed in the cup was cooled in a desiccator and then weighed.

Commented [A18]:

Commented [A19]: use common abbreviations

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2.10 Analysis procedure of **antioxidant content testing**

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2.10 Analysis procedure of **IC₅₀ antioxidant activity testing**

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2.12 Analysis procedure of **water activity testing**

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2.13 Analysis procedure of **vitamin C testing**

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2.14 Statistical analysis

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3. Results and **discussion**

169

3.1 Bulk density of lemongrass and **malang** apple powder drinks

Commented [A21]: Replace with "radical scavenging activity"

Commented [A22]: Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. Analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 mL of sample in 100 mL of methanol PA

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170 The bulk density value indicates void space, namely the number of empty cavities between the
171 material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2007).
172 The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The higher the drying
173 temperature causes the bulk density value to decrease. It is because the higher the drying temperature
174 causes more water in the material to be evaporated so that the resulting water content is lower, causing
175 the weight of the powder to become lighter. It is in line with Andriyani *et al.* (2015) who state that as the
176 drying temperature increases, the bulk density decreases. The bulk density is influenced by the type of
177 material, water content, shape and size of the material. The smaller the bulk density, the more porous
178 the product is (Widowati *et al.*, 2010).

179 Of the three types of coating used, gum arabic has the lowest bulk density compared to other
180 coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and
181 hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan
182 *et al.*, 2013). Meanwhile dextrin has the characteristic of quickly dispersing, has high solubility, is able to
183 form films, has hygroscopic properties, is able to form body, has characteristic of low browning, is able to
184 inhibit crystallization, and has strong binding power (Purbasari, 2019). The dextrin film layer has a higher
185 proportion of solids than gum arabic, because the DE value of dextrin is lower than gum arabic, therefore
186 the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*,
187 2010). Maltodextrin is a coating material that has a high level of solubility, this is due to the nature of
188 maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has
189 the ability to absorb water) so that the water in the material is more retained and difficult to evaporate
190 (Yuliwati *et al.*, 2015).

191 According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space
192 needed for that material. The greater the bulk density (particles), the smaller the space needed, and vice
193 versa. The smaller the size of the molecule, the more easily the product will be compressed; with smaller
194 gaps between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum
195 arabic with a drying temperature of 50°C resulted in the lowest bulk density value of 0.52. According to
196 Palijama *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact
197 (non-voluminous), meaning that in the same certain volume, the product is available in more weight.
198 According to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small, meaning
199 that light weight requires a large space; the smaller the bulk density, the more porous the product is.
200 Sadeghi *et al.* (2010) state that the higher sphericity of the corn kernels results in a more regular
201 arrangement of the kernels so that the cavities between the kernels were smaller, resulting in a higher
202 bulk density.

203

204 3.2 Dissolution Time

205 Dissolution time in water is a time that shows all beverage powder dissolves in water perfectly. The
206 testing of dissolution time is carried out to determine the speed of solubility of the drinks when it will be
207 consumed. The higher the solubility value of the powder product, the better the product is; it is because
208 the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang
209 *et al.*, 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 seconds
210 (Table 2). The results show that, the higher the drying temperature, the faster the dissolution time (Table
211 2). It is because the powder produced is drier. The higher the drying temperature, the more water
212 evaporated on the powder drinks so that the water content is lower. The lower the water content, the
213 more hygroscopic so that the dissolution time is faster (Paramita *et al.*, 2015 and Sakdiyah *et al.*, 2019).

214 The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin
215 has a faster dissolution time compared to other types of coating (Table 2). It is because when powder
216 drinks are dissolved in water, especially warm water, the hydroxyl groups contained in the coating
217 material will interact with the water so that the solubility of the powder can increase (Yuliwaty *et al.*,
218 2015). Dextrin has a dextrose equivalent (DE) value of 3–5 and has the ability to form layers (Tyanjani *et al.*,
219 2015). With the addition of dextrin, the solubility of powder drinks increases. It is because dextrin is
220 easily soluble in water. It is in accordance with Nurhidayah *et al.* (2014), who state that dextrin is easily
221 soluble in water, disperse more quickly, is not viscous and is more stable than starch.

222 According to Wulansari *et al.* (2012), Dextrose Equivalent (DE) of maltodextrin is 3-20. The higher
223 the DE value, the higher the monosaccharide content, causing the binding power to be greater. Thus, the
224 use of maltodextrin causes a higher water content compared to dextrin. Maltodextrin is a filler that has a
225 high level of solubility; it is due to the characteristic of maltodextrin that is soluble in water (Hofman *et al.*,
226 2021). Gum arabic has a longer dissolution time than maltodextrin and dextrin. However, according
227 to Herawati (2018), gum arabic has the advantage of having high solubility in water, making it better as a
228 coating material in making powder drinks. The DE value of gum arabic is 6 (Soottitantawat *et al.*, 2006).
229 According to Hofman *et al.* (2016) the factor that affects the level of solubility in water is the DE value;
230 the higher the DE value, the better the solubility level.

232 3.3 Stability

233 Beverage products will be stable if the particles acting as the dispersed phase can be retained
234 without changing for a long time or without experiencing grouping with each other (Anjani *et al.*, 2011).
235 The stability testing is expressed in (%) which shows the percentage of stability of the powder drinks made.
236 The stability of lemongrass and Malang apple powder drinks obtained an average of 63.89% to 93.33%
237 (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The
238 higher the drying temperature, the lower the powder water content. It causes the product to absorb water
239 more easily so that the product becomes more stable when rehydrated. It is in line with Kryzhska *et al.*
240 (2020) who state that high water content in powder products would seriously disrupt product stability
241 and would cause the product to agglomerate when stored. The high-water content in a product can cause
242 damage due to the activity of microorganisms.

243 The type of coating also affects the stability value. Of the three types of coating used, dextrin has
244 the most stable results compared to other types of coating. Dextrin's can wrap or encapsulate the active
245 ingredient particles from oxidation reactions during storage thereby increasing product stability
246 (Septevani *et al.*, 2013). Dextrin has a stronger ability to bind water because it is a group of
247 polysaccharides that has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic
248 bonds (Xu *et al.*, 2012). The addition of maltodextrin can increase the stability of the drink which can
249 reduce the precipitate formed (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the
250 product does not precipitate too much (Prमितasari *et al.*, 2011). Gum arabic has a more complex
251 molecular structure than dextrin and contains starch in it, so gum arabic is more hygroscopic (Sutardi *et al.*,
252 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-
253 glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence
254 of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin
255 treatment with a drying temperature of 50°C is the coating material with the highest stability value of
256 93.33%.

257

Commented [A28]: This statement contradiction with DE of maltodextrin?

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Commented [A30]: How about maltodextrin and gum arabic?
Please give more explanation

258 3.4 Water content

259 The average water content of lemongrass and Malang apple powder drinks ranged from 2.06% to
260 2.57% (Table 4). In the manufacturing process, powder drinks are made by drying separately at 40°C, 45°C
261 and 50°C for 18 hrs. The results show that the higher the drying temperature, the lower the water content
262 of the powder. Drying causes the water content in the lemongrass and Malang apple powder to evaporate.
263 The higher the temperature produces powder with lower water content. According to Wiyono (2011), the
264 drying temperature factor is important to note because it can remove the water content quickly when the
265 material is dried at high temperatures. The increase of the heating temperature tends to reduce the water
266 content. The decrease in the amount of water is due to the higher heating temperature. Thus, there are
267 more water molecules that evaporate from the dried raw materials so that the water content obtained is
268 lower.

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269 The type of coating has a relatively similar effect on the value of the water content. Of the three
270 types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by
271 maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic,
272 that is, it easily absorbs water; but when it is dried, the absorbed water is released. The water content
273 absorbed by the presence of coating material will evaporate more easily than the water content in the
274 material tissue so that the evaporation process of water in powder drinks becomes easier (Paramita *et*
275 *al.*, 2015). Maltodextrin has a low molecular weight and a simple structure, so that water is easily
276 evaporated during the drying process (Pramitasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic so
277 that the water in the material is more retained and difficult to evaporate. Gum arabic has a high molecular
278 weight and a complex molecular structure and contains a large amount of starch (Sutardi *et al.*, 2010).
279 Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50°C
280 dextrin and it was in accordance with SNI number 01-4320-1996 in which the water content of powder
281 drinks was a maximum of 3% (BSN, 1996). It shows that powder drink products meet the requirements of
282 SNI number 01-4320-1996 and have a small possibility of being contaminated with microorganisms.
283

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Commented [A33]: Contradiction, the water content of gum arabic is the lowest compared to other types of coatings. see in Table 4.

284 3.5 Ash content

285 According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of
286 minerals in a food. Ash is composed of various types of minerals with varying composition depending on
287 the type and source in food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content
288 of the results of the study was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher
289 the ash content. The increase in ash content is thought to be related to the higher drying temperature. It
290 causes more water in the material to evaporate, so that the water content is lower. It causes the
291 percentage of mineral content in the material to increase. The results of the study are in line with Shadri
292 *et al.* (2018).

293 Dextrin coating is a polysaccharide group which has a simpler chemical structure than gum arabic.
294 Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile gum arabic has
295 a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-
296 rhamnose (Alftren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of
297 minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a
298 sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin
299 coating with a drying temperature of 45°C. In general, the ash content of the product was still within the
300 limits of SNI 01-4320-1996 regarding the quality requirements for powder drinks, namely a maximum of
301 1.5% (BSN, 1996). Malang apple has a fairly high nutritional content, especially vitamins and minerals such

Commented [A34]: there is no clear explanation about this.

Commented [A35]: Not clear related with above statement. Give explanation why ash content of dextrin is higher than maltodextrin and gum arabic.

302 as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2,
303 and vitamin C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A,
304 vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

305

306 3.6 Vitamin C

307 The results of the vitamin C test are presented in Table 6, showing an average value of vitamin C
308 between 53.15 mg/100g to 72.69 mg/100g. The vitamin C content tend to decrease with increasing drying
309 temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C and is easily
310 degraded, especially by heat (Parfiyanti *et al.*, 2016). It shows that the drying process at high temperature
311 can reduce the vitamin C content found in powder drinks. Vitamin C is classified as a natural antioxidant.
312 Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid which plays a role in
313 inhibiting excessive oxidation reactions (Susanti *et al.*, 2014).

314 The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin
315 produces the highest content of vitamin C compared to other types of coating. It is because dextrin can
316 protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the more
317 dextrin is added, the more vitamin C content in the product is maintained. Dextrin has the characteristic
318 of protecting vitamin C and compounds that are sensitive to heat or oxidation because the molecules of
319 dextrin are stable to heat and oxidation, so that the vitamin C content can be maintained. In addition,
320 according to Aretzy *et al.* (2018), maltodextrin can protect volatile compounds and protect compounds
321 that are sensitive to oxidation. According to Alfonsius (2015), the addition of gum arabic in the processing
322 process can protect important compounds such as vitamins due to extreme temperatures, since gum
323 arabic has the ability to form a body as a coating and has a strong bond to the compounds coated. The
324 highest content of vitamin C was produced in powder drinks dried at 40°C with dextrin coating (72.68
325 mg/100 g) and the lowest was produced at 50°C with gum arabic coating (53.15 mg/100 g). The vitamin C
326 content of mix fruit powder drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and
327 tween 80 dried at 50°C produces the vitamin C content between 425 mg/100g – 550 mg/100g, which is
328 higher than lemongrass and Malang apple powder drinks (Minah, *et al.*, 2021).

329

330 3.7 Water activity

331 Table 7 shows the mean value of water activity (*aw*) of lemongrass and Malang apple powder drinks,
332 namely 0.44 to 0.50. The *aw* value of lemongrass and Malang apple powder drinks is lower than the *aw*
333 value for the bacterial growth requirement, namely 0.90. The *aw* value for yeast growth is 0.80-0.90, and
334 the *aw* value for mold growth is 0.60-0.70. The *aw* value is relatively decreased with increasing drying
335 temperature. In the drying process, the free water in the material will evaporate. The higher temperature
336 causes more water to evaporate. The lower the water content, the lower the water activity (Martins *et*
337 *al.*, 2019). According to Adri *et al.* (2013), the composition of water in foodstuffs such as free water and
338 bound water can affect the rate or duration of food drying. The relatively small *aw* value does not allow
339 the growth of bacteria, molds and yeasts in the product. Lemongrass extract shows great potential as an
340 antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella typhimurium* and
341 *Staphylococcus aureus*; this indicates the possibility of using medicinal plants as natural antibacterial
342 agents (Ibrahim *et al.*, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying is to reduce water
343 content so that it is not easy for mold and bacteria to grow, eliminate the activity of enzymes that can
344 decompose the active substance content and facilitate further processing so that it can be more compact,
345 durable and easy to store.

Commented [A36]: repetition

Commented [A37]: But why the vitamin C of gum arabic was lower than dextrin. Please give the reason

Commented [A38]: Can be added explanation why *aw* of all coating type was not significant

Commented [A39]: typo

346 The use of various coatings in this study relatively produces the same aw value. The use of
347 maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray
348 drying can protect protein, calcium, lactose powder (Martins et al., 2019). The lowest water activity value
349 of lemongrass and Malang apple powder drinks was obtained for products with gum arabic coating at
350 drying temperature of 45°C (0.44).

351

352 3.8 The percent of inhibition of antioxidant content

353 Percent inhibition shows the radical scavenging activity possessed by antioxidant compounds. One
354 of the plants that has potential as an antioxidant is lemongrass (Wibisono, 2011) and apple (Yudhianto *et al.*,
355 2013). Based on the antioxidant test in Table 8, the average inhibition value was 37.45% to 60.13%.
356 Based on Table 8 it is also known that drying temperature affects antioxidant content. The higher the
357 drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant
358 activity in the lemongrass and Malang apple powder drinks is thought to be related to the damage to the
359 antioxidant compounds due to high temperatures. According to Patras et al. (2010), antioxidant
360 compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these
361 compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat.
362 Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna *et al.* (2013)
363 that antioxidant bioactive components have heat-resistant characteristics, so if the sample is extracted in
364 hot conditions it will reduce the value of its antioxidant activity. The results of the research by Widiastuti
365 *et al.* (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the
366 higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content
367 in lemongrass is due to the large number of phenolic compounds it contains. The high content of phenolic
368 compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential
369 oil in lemongrass stems is very high with an effective inhibition of 89% and 89.63%, whereas in lemongrass
370 leaves it is slightly lower with antioxidant and antidiabetic activities ranging from 78.89% and 79.26%
371 respectively (Mirghani, *et al.*, 2012).

372 The use of dextrin coating with a drying temperature of 40°C produced the highest inhibition value
373 compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explains that dextrin is
374 composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the
375 oxidation process can be prevented. Dextrin has the characteristic of protecting volatile compounds and
376 compounds that are sensitive to heat or oxidation. Gum arabic can improve and maintain the stability of
377 the compounds being coated. Gum arabic is also a type of coating that is resistant to heat (Dauqan *et al.*,
378 2013). Meanwhile, maltodextrin can protect volatile compounds and protect compounds that are
379 sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high oxidation resistance and can
380 reduce the viscosity of the emulsion; combined with other coatings that have better emulsifying
381 properties, it causes the antioxidant compounds in the microencapsulants to be well covered and
382 protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural
383 antioxidants and anti-inflammatories which can prevent free radicals in the human body. Antioxidants in
384 lemongrass are able to inhibit the release of arachidonic acid by the mechanism of inhibiting kinase
385 protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid
386 synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are
387 citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants which are
388 very good for skin health. The very high antioxidant content is also the reason for the high consumption
389 of apples by the public as an effort to prevent diseases and other dysfunctions of body health.

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391 **3.9 Antioxidant content with inhibition concentration value of 50% (IC₅₀)**

392 The IC₅₀ value is the concentration of the antioxidant source to neutralize 50% of the radical
393 compounds. The lower the IC₅₀ value, the better the antioxidant activity of the sample. IC₅₀ antioxidant
394 content are determined from the 3 best samples based on the highest inhibition percentage, namely on
395 lemongrass and Malang apple powders which are coated with dextrin with drying temperatures of 40°C,
396 45°C and 50°C. According to Phongpaichit et al. (2007), IC₅₀ value < 10 ppm indicates a very strong activity.
397 IC₅₀ 10-50 ppm indicates a strong activity, IC₅₀ > 50-100 ppm indicates moderate activity, and IC₅₀ > 100-
398 250 ppm indicates a weak activity. The results showed that the IC₅₀ value in the lemongrass and Malang
399 apple powder drinks was 0.9 ppm to 1.47 ppm (Table 9), which indicated a very strong activity. The results
400 of research by Andriyani et al., (2015) show that the IC₅₀ value of temulawak and red ginger powder
401 functional drinks made using the spray drying method has the highest or strongest average value of 0.62
402 ppm at 4% maltodextrin concentration and the lowest or weakest value of 1.00 ppm at 0% maltodextrin
403 concentration.

404

405 **4. Conclusion**

406 The results showed that the type of coating significantly affected the parameters of stability,
407 dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly
408 affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and
409 antioxidants. There was an interaction between the type of coating and the drying time that affected the
410 bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was
411 determined based on the antioxidant content and high stability. The fast dissolution time was found in
412 lemongrass and Malang apple powder that was dried at 45°C with dextrin coating. The best lemongrass
413 and Malang apple powder drinks had the following characteristics: a solubility of 0.96 seconds, a bulk
414 density of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin
415 C content of 70.22%, a percent antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 ppm, and a water
416 activity 0.50.

417 **Conflict of interest - Disclose any potential conflict of interest appropriately.**

418 The authors declare no conflict of interest.

419

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669 **Tables and Figures – 1 PAGE 1 TABLE/FIGURE. PLACE ALL TABLES AND FIGURES AT THE END OF THE**
670 **MANUSCRIPT BODY AFTER THE REFERENCES. ARRANGE THE TABLES AND FIGURES ACCORDING TO**
671 **THEIR APPEARANCE IN TEXT.**

672 Table 1. The mean value of bulk density for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.58 ^a	0.63 ^{bcd}	0.64 ^{bcd}	0.62 ± 0.03
45°C	0.67 ^{ab}	0.58 ^{abc}	0.64 ^{bcd}	0.63 ± 0.05
50°C	0.58 ^{abc}	0.67 ^{cd}	0.52 ^a	0.59 ± 0.08
Mean ± SD	0.61 ± 0.05	0.63 ± 0.05	0.60 ± 0.60	

673 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

674

675 Table 2. The mean value of dissolution time for lemongrass and Malang apple powder drinks (second)

Coating Type	Mean
--------------	------

Commented [A49]:

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.06 ^{bc}	1.11 ^{ab}	1.29 ^d	1.15 ± 0.12 ^c
45°C	1.04 ^{abc}	0.96 ^a	1.05 ^{abc}	1.02 ± 0.05 ^b
50°C	1.07 ^{bc}	1.01 ^{cd}	1.17 ^e	1.08 ± 0.08 ^a
Mean ± SD	1.05 ± 0.01 ^a	1.03 ± 0.08 ^a	1.17 ± 0.12 ^b	

676 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

677

678 Table 3. The mean value of stability for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	65.30 ^{ab}	87.32 ^e	63.89 ^a	72.17 ± 13.14 ^c
45°C	73.01 ^d	89.19 ^e	69.69 ^c	77.30 ± 10.43 ^b
50°C	78.74 ^d	93.33 ^f	80.19 ^e	84.09 ± 8.03 ^a
Mean ± SD	72.35 ± 6.74 ^a	89.95 ± 3.07 ^a	71.26 ± 8.26 ^b	

679

680 Table 4. The mean value of water content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	2.57	2.51	2.54	2.54 ± 0.03 ^c
45°C	2.39	2.38	2.31	2.36 ± 0.04 ^b
50°C	2.07	2.16	2.06	2.10 ± 0.05 ^a
Mean ± SD	2.34 ± 0.25	2.35 ± 0.18	2.30 ± 0.24	

681 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

682

683 Table 5. The mean value of ash content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.17 ^{ab}	1.46 ^e	1.06 ^a	1.23 ± 0.21 ^a
45°C	1.26 ^{bcd}	1.21 ^{abc}	1.24 ^{bcd}	1.23 ± 0.02 ^a
50°C	1.26 ^{bcd}	1.37 ^{cde}	1.38 ^{de}	1.33 ± 0.07 ^b
Mean ± SD	1.23 ± 0.05 ^a	1.34 ± 0.13 ^b	1.23 ± 0.16 ^a	

684 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

685 Table 6. The mean value of vitamin C content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	68.11 ^d	72.69 ^e	61.95 ^c	67.58 ± 5.39 ^c

45°C	63.36 ^c	70.22 ^{de}	58.26 ^b	63.95 ± 6.85 ^b
50°C	54.91 ^a	63.36 ^c	53.15 ^a	57.14 ± 5.46 ^a
Mean ± SD	62.13 ± 6.69 ^a	68.76 ± 4.83 ^b	57.79 ± 4.42 ^c	63.87

688

689

690 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

691

692 Table 7. The mean value of water activity for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.48	0.48	0.51	0.49 ± 0.02
45°C	0.51	0.50	0.44	0.49 ± 0.04
50°C	0.49	0.46	0.46	0.47 ± 0.02
Mean ± SD	0.49 ± 0.02	0.48 ± 0.02	0.47 ± 0.03	

693 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

694

695 Table 8. The mean value of antioxidant content for lemongrass and Malang apple powder drinks (%)

696

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	56.96 ^f	60.13 ^b	53.66 ^g	56.92 ± 3.24 ^g
45°C	45.73 ^c	50.97 ^e	48.17 ^d	48.29 ± 2.62 ^g
50°C	37.45 ^a	43.98 ^b	37.53 ^a	39.65 ± 3.75 ^a

Commented [A50]: Replace with "radical scavenging activity"

Commented [A51]: Add mean and SD for coating type

701 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

702

703 Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powder drinks (%) on the best product

704

Drying Temperature	Coating Type
	Dekstrin
40°C	0.9 ± 0.01
45°C	1.279 ± 0.08
50°C	1.47 ± 0.01

Commented [A52]: Change with "radical scavenging activity"

Commented [A53]: ppm or %?

705

MANUSCRIPT EVALUATION FORM

Date : 14th February 2023

Manuscript ID : FR-2023-077

Please return by : 14th March 2023

Title of Manuscript : Physico-chemical properties of lemongrass and Malang apple powder drinks

1. IF YOU CANNOT REVIEW THIS MANUSCRIPT OR MEET THE DEADLINE, PLEASE INFORM US WITHOUT DELAY.
2. Your review should consider the article’s scholarly merit including originality of the research issue and/or methodology, adequacy and rigor of the research methodology and techniques used, quality and rigor of data analysis, comprehensiveness of literature review, and the readability and presentation of the article. Please provide detailed and specific comments to all items. Also, where appropriate please provide suggestions for revision.

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Using item 2 in page 1 as a guideline, please indicate the reasons for your recommendations. Most author(s) will appreciate frankness, combined with a modicum of tact. Even if you recommend that the manuscript be accepted for publication, please provide some general comments to the author(s).

Evaluation Criteria	Grade				
	A (Excellent)	B	C	D	E (Worst)
1. Appropriateness of Contents		x			
2. Originality of Topic		x			
3. Manuscript Format		x			
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5. Data Analysis			x		
6. Relevance to the Journal	x				

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		<p>*NOTE FOR AUTHOR: Please state your response to the reviewer's comments/suggestion below</p>
<p>1.</p>	<p>Title <i>It should reflect the article</i></p> <p>My suggest tittle: The effect of coating and drying temperature on the physicochemical properties of the mixture lemongrass and apple powder drink</p>	<p>Thank you for your suggestion.</p> <p>We have changed the title to be: "The effect of coating and drying temperature on the physicochemical properties of the mixture lemongrass and apple powder drink". Please see line 1-2, page 1.</p>
<p>2.</p>	<p>Abstract <i>Background, Aim, Methodology and Conclusion</i></p> <p>No</p> <p>See the comments in manuscript.</p> <p>1. What beverage products have short shelf life?</p>	<p>Thank you for your suggestion.</p> <p>1. We have improved the sentence to be: The fresh beverage products generally have a short shelf life product, so they need to be made into powder drinks. Please see line 5-6, page 1.</p>
<p>3.</p>	<p>Keywords <i>Min. 3 and Max. 6</i></p>	<p>-</p>
<p>4.</p>	<p>Introduction <i>Concise with sufficient background</i></p> <p>See the comments in manuscript!</p> <p>1. What beverage products have short shelf life?</p> <p>2. Berikan alasan lain yang lebih masuk akal untuk diganti dengan minuman powder, saat ini banyak berkembang minuman ready to drink yang lebih efisien dalam penggunaannya</p> <p>3. Apakah campuran dua macam bahan ini pernah diteliti sebelumnya? Apa alasan memilih dua macam bahan ini untuk digabungkan?</p> <p>4. Apakah ada hasil pengukuran terhadap daya terima konsumen?</p> <p>5. Untuk melihat hasil peningkatan imunit</p>	<p>Thank you for your suggestion</p> <p>1. We have revised the sentence to be: The fresh beverage products generally have a short shelf life, so they need to be made into powder drinks. Please see line 28-29, page 1.</p> <p>2. We have completed the sentence to be: However, although containing beneficial antioxidants, lemongrass and Malang apples are rarely used as ingredients to make powdered beverages. Due to its practicality, ready-to-serve drinks in powder form. Please see line 46-47, page 2.</p> <p>3. The use of the 2 ingredients as a drink has not been done. We have explained the reasons for choosing the 2 ingredients and</p>

FOOD RESEARCH

	<p>as tubuh, indikator apa yang diuji?</p>	<p>their combination in making drinks in the introduction. Please see line 34-45, page 1-2.</p> <p>4. In this article we have not included the consumer acceptance, for this reason, we have improved the sentence to be: These tests were required to determine packaging. Please see line 67, page 2.</p> <p>5. Indicators can increase body immunity by testing antioxidant activity and vitamin C levels.</p>
<p>5.</p>	<p>Research design/Methodology <i>Clearly described and reproducible</i></p> <p>Write down the source of the literature for the measurement methods used! See the comments in manuscript!</p> <ol style="list-style-type: none"> 1. Deskripsi bahan-bahan ini harus jelas (bagian yang digunakan) 2. Jelaskan perbandingan bahan yang digunakan 3. Apakah diukur kadar air akhir? Suhu yang berbeda dengan waktu pengeringan yang sama akan menghasilkan kadar air yang berbeda. Pengeringan 18 jam belum tentu akan menghasilkan bubuk yang baik untuk dihancurkan dengan blender 4. What is this? Is mean 'gula semut'? That is brown sugar, isn't it? 5. Untuk setiap prosedur analisis harus disebutkan sumber pustaka untuk metode yang digunakan 6. Berapa lama proses pengulangannya untuk mendapatkan bobot konstan 7. Sumber pustaka untuk metode yang digunakan. Apakah yang diukur ini adalah aktivitas antioksidan atau kandungan senyawa antioksidan?? 8. Perbaiki cara penulisan rumus kimia 9. Bagaimana caranya memperoleh kandungan Vit C nya? Ada rumus yang digunakan 	<p>Thank you for your suggestion.</p> <ol style="list-style-type: none"> 1. We have revised the sentence to be: lemongrass stems and seedless Malang apples. Please see line 75, page 2. 2. We have written the comparison of materials, the sentence to be: by cutting the lemongrass and Malang apples (1:1 w/w). Please see line 89, page 3. 3. We have dried the materials at the same time (18 hours), but at different temperatures (40°C, 45°C, and 50°C) because we have studied the effect of temperature on the quality of the final product. Please see line 96, page 3. 4. We have revised to be: brown sugar. Please see line 98, page 3. 5. We have added the reference, the sentence to be: 2.5 <i>Analysis procedure of bulk density</i> (Sandhu et al., 2007); 2.6 <i>Analysis procedure of dissolution time testing</i> (Pentury et al., 2013); 2.7 <i>Analysis procedure of stability testing</i> (Pentury et al., 2013); 2.8 <i>Analysis procedure of water content by oven drying method</i> (AOAC, 2006); 2.9 <i>Analysis procedure of ash content by muffle furnace method</i> (AOAC, 2006); 2.13 <i>Analysis procedure of vitamin C testing</i> (AOAC, 2006). Please see line 102, 109, 113, 118, 126, 133, 144, 158, 166, page 3-4. 6. Repetition is carried out until a constant weight is obtained. 7. We have revised the procedure to be: 2.10 <i>Analysis procedure of radical scavenging activity</i>. Please see line 133, page 4. 8. We have revised the chemical formula written

		<p>g to be: adding $BaCl_2 \cdot 2H_2O$. Please see line 160, page 4.</p> <p>9. We have added the formula for obtaining vitamin c. Please see line 173, page 5.</p>
<p>6.</p>	<p>Data Analysis <i>Results well presented and discussed</i></p> <p>Discussion for the results of the analysis that occurs the effect of interaction of drying temperature and the type of coating must be distinguished. See the comments on manuscript!</p> <ol style="list-style-type: none"> 1. Bila dilihat dari data analisis, terjadi pengaruh interaksi antara suhu pengeringan dan jenis coating yang digunakan, sebaiknya dijelaskan di awal kalimat, dan apa makna dari interaksi tersebut! 2. Hasil analisis yang memiliki pengaruh interaksi dan tidak, tidak tercermin di dalam pembahasan. 3. Vitamin C mudah rusak dengan suhu tinggi, tetapi malah semakin tinggi kandungannya, sebaiknya dihubungkan dengan coating yang digunakan, karena berdasarkan hasil analisisnya, ada pengaruh interaksi antara suhu dan type coating 4. Judulnya tidak sesuai dengan metode pengukuran yang disampaikan di dalam metodologi 5. Bagaimana [pengaruh coating terhadap penurunan aktivitas antioksidan akibat penggunaan suhu yang lebih tinggi 6. Angka2 hasil analisis sebaiknya dilengkapi standar deviasi untuk meyakinkan bahwa nilai yang ditunjukkan adalah hasil rata-rata sampel 	<p>Thank you for your suggestion.</p> <ol style="list-style-type: none"> 1. We have completed the statement, the sentence to be: The findings revealed that the drying temperature and coating type had an effect on the bulk density value of the powdered drink. Furthermore, the bulk density value is affected by a relationship between the drying temperature and coating type. Please see line 189-192 page 5. 2. We have revised the sentence to be: The results reveal that the drying temperature has an effect on the water content of lemongrass and Malang apple powdered drinks. Meanwhile, the type of coating had no effect on the water content. Similarly, there was no interaction between the drying temperature and coating type affecting the moisture content of the powdered drinks. The higher the drying temperature, the lower the water content of the powder. Please see line 283-287 page 7. 3. We have completed the statement, the sentence to be: The results demonstrated that the drying temperature and type of coating affected the vitamin C content. There was an interaction between the drying temperature and the type of coating in determining the vitamin C content of powdered drinks. The vitamin C content tends to decrease along with the increase in the drying temperature. Please see line 332-335 page 8. 4. We have revised the title and methodology. The sentence to be: 3.8 Radical scavenging activity. Please see line 133 page 4 and line 379, page 9 5. We have completed the reference, the sentence to be: Dextrin protects volatile chemicals and molecules vulnerable to heat

		<p>or oxidation. Gum arabic can help increase the stability of the coating component. Gum arabic is another sort of heat-resistant coating (Dauqan and Abdullah, 2013). Please see line 383-385 page 9.</p> <p>6. We have completed the standard deviation for all data in the Table. Please see line 698 (Table 1); 701 (Table 2); 704 (Table 3); 706 (Table 4); 709 (Table 5); 711 (Table 6); 718 (Table 7); 722 (Table 8); 731 (Table 9).</p>
7.	<p>Conclusion <i>A clear summary of the study</i></p>	Thank you very much for your comments.
8.	<p>References <i>References should follow the journal's format</i></p>	<p>Thank you for your suggestion.</p> <p>We have revised the references format. Please see line 454-696 page 11-18.</p>
9.	<p>English Proficiency Correct the writing for peer review</p>	<p>Thank you for your suggestion.</p> <p>We have corrected the writing.</p>
10.	<p>Additional comments/suggestions by the reviewer about the article Revise the manuscript according to the comments</p>	<p>Thank you for your suggestion.</p> <p>We have revised base on the reviewer comment.</p>

Overall Evaluation

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Food Research

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Physico-chemical properties of lemongrass and Malang apple powder drinks

Commented [A1]:

- Is it a mixture ingredient or separate powder?
- The effect of coating and drying temperature on the physicochemical properties of the mixture lemongrass and apple powder drink

Abstract

The immunity of the human body can be enhanced by food and beverages. Beverage products generally have a short shelf life produk, so they need to be made into powder drinks. Currently popular drinks come from spices containing antioxidants that can boost the body's immunity. To maintain the antioxidant compounds that exist during drying, it is necessary to have a coating material. This study aims to investigate the effect of coating type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The study used a Completely Randomized Design (CRD) with two factors and two replications. The first factor was 3 levels coating type (maltodextrin, dextrin, gum arabic) and the second factor was 3 levels drying temperature (40°C, 45°C, 50°C). Data were analyzed using ANAVA test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C and antioxidants. There was an interaction between the coating type and drying time which affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of 1.29, and a water activity of 0.50.

Commented [A2]: What beverage products have short shelf life?

Deleted: the coating type with

Deleted: the drying temperature with

Keywords: Apples, Dextrin, Powder Drinks, Drying, Lemongrass

1. Introduction

The ongoing COVID-19 pandemic has forced people to maintain their health through increasing their body's immunity. Body immunity can be improved through foods and drinks. Beverage products generally have a short shelf life, so they need to be made into powder drinks. Powder drinks are a processed food product in powder form, easily dissolved in water, practical in serving and have a relatively long shelf life. In addition, powder drinks are easy to carry and ship (Tangkeallo *et al.*, 2014). It causes powder drinks to be liked by the public. One of the ingredients that can increase the body's immunity is spices. Spices are known to contain antioxidant compounds. Antioxidants are able to capture free radicals to enhance the immunity of the body. (Cakmakci *et al.*, 2015). One of the spices that contain antioxidants and is popular today is lemongrass or often called "serai". Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*, *eugenol*, *dipentene*, *citral* (Wibisono, 2011). These compounds act as anticancer and antioxidants, stabilize blood pressure, treat constipation, help the digestive system, tighten the body after childbirth (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). Apart from lemongrass, a food ingredient that can improve the body's immunity and has a good taste is Malang apples. Malang apples are a famous fruit typical of Malang city. Malang apples that are small in size have low economic value because they are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019), Malang apples contain lots of vitamins such as vitamins A, B, C, minerals,

Deleted: A brief literature review and previous relevant work with references. ...

Commented [A3]: The same question with 5th line

45 fiber, and flavonoid compounds, one of which is quercetin. Vitamin C and quercetin act as antioxidants,
46 antivirals and anti-inflammatories that protect the body's reproductive system. Flavonoids as antioxidants
47 have the ability to act as anti-free radicals and change or reduce free radicals (Suparni *et al.*, 2012).

48 There are limitations in using lemongrass and Malang apples for drinks. Those materials are difficult
49 to carry and do not last long. To overcome this, powder drinks made from a mixture of lemongrass and
50 Malang apples are made. In the making of lemongrass and Malang apple powder drinks as functional
51 drinks, there is a critical point during the drying process (Naibaho *et al.*, 2015). It is because the active
52 ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures and for
53 a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the
54 amount of antioxidants, present, it is necessary to find the right drying temperature. In addition to
55 maintaining the existing volatile compounds, it is necessary to have a coating material. The commonly
56 used coating material is gum arabic because this material has the ability to form good emulsions and films.
57 Gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the
58 highest volatile components compared to modified starch (Santoso *et al.*, 2013). According to Harahap *et al.*
59 (2021), maltodextrin can disperse quickly, has a high solubility, forms low hygroscopic properties, has
60 low browning properties, is able to inhibit crystallization and has strong binding power. Meanwhile,
61 dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity
62 (Asia *et al.*, 2012). Based on the description above, this study aimed at investigating the effect of coating
63 type and drying temperature on the quality of lemongrass and Malang apple powder drinks. The quality
64 of the powder drinks was determined based on physical tests in the form of bulk density, dissolution time,
65 and stability test. These tests were required to determine packaging and consumer acceptance. In
66 addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity,
67 water activity, and vitamin C. These tests would indirectly determine the shelf life and ability of the
68 product to increase body immunity. This research has yielded products that can increase body immunity,
69 are easy to carry, and have a relatively long shelf life.

70

71 2. Materials and methods

72 2.1 Material

73 The materials used in the study were lemongrass, Malang apples, Maltodextrin, Dextrin, Gum Arabic,
74 water, and ant sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N
75 NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a "Mitzui"
76 blender, cutting boards, measuring cups, knives, "WTC Binder 78532" blower ovens, baking sheets,
77 spoons and "Matrix ESJ210-4B" scales, volumetric flasks, erlenmeyer, burettes, measuring cups,
78 measuring pipettes, suction ball, funnel pipette, beaker glass, filter paper, burette, stative, Siever 60 mesh,
79 and spectrophotometer "UV2100 Spectrophotometer".

80

81 2.2 The process of making lemongrass and malang apple powder drinks

82 The process of making powder drinks was a modification of the research of Susanti *et al.* (2014). The
83 process of making powder drinks consisted of two stages, that is, the making of fruit pulp and the drying
84 process.

85 2.3 Making fruit pulp

86 The making of fruit pulp began with sorting and washing the lemongrass and Malang apples, followed
87 by cutting the lemongrass and Malang apples and then crushing them with a blender for 5 minutes at

Commented [A4]: Berikan alasan lain yang lebih masuk akal untuk diganti dengan minuman powder, saat ini banyak berkembang minuman ready to drink yang lebih efisien dalam penggunaannya

Commented [A5]: Apakah campuran dua macam bahan ini pernah diteliti sebelumnya? Apa alasan memilih dua macam bahan ini untuk digabungkan?

Commented [A6]: Apakah ada hasil pengukuran terhadap daya terima konsumen?

Commented [A7]: Untuk melihat hasil ini, indikator apa yang diuji?

Commented [A8]: Deskripsi bahan-bahan ini harus jelas (bagian yang digunakan, sumber bahan)

Commented [A9]: Jelaskan perbandingan bahan yang digunakan

88 speed number 2. After that, the pulp was added with water in a ratio of 1:1. Furthermore, the coating
89 materials (maltodextrin, dextrin, and gum Arabic) were added separately as much as 5% w/w fruit pulp
90 separately. The pulp was stirred until homogeneous.

91

92 2.4 Drying

93 The already homogeneous fruit pulp, each was placed on a 60x40x2 cm baking sheet as much as 250
94 mL and dried with a blower oven at a predetermined temperature (40°C, 45°C, and 50°C) separately for
95 18 hours. The dried sheets of lemongrass and Malang apples were then crushed separately with a blender
96 for 3 minutes at speed number 2. Then, ant sugar was added as much as 10% w/w of the dry powder.
97 After that, the powder was sieved using a 60-mesh sieve. Lemongrass powder drinks were packaged in
98 aluminum foil zip lock with a size of 7 X 13 cm.

99

100 2.5 Analysis procedure of bulk density

101 The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring
102 cup containing the powder sample was tapped 30 times until there were no more cavities when the
103 powder sample was adjusted to 10 mL. The measuring cup containing the powder sample was then
104 weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its
105 volume (10 mL).

106

107 2.6 Analysis procedure of dissolution time testing

108 A total of 5 g of the test sample was weighed then dissolved in 50 mL of warm water and stirred 20
109 times until homogeneous. How long it took the sample to dissolve in water was recorded.

110

111 2.7 Analysis procedure of stability testing

112 A total of 5 g of powder was weighed and brewed in 50 mL of water then put into a 10 mL measuring
113 cup and kept for 24 hrs. Afterwards, the suspension or solution was measured for the volume of the
114 precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

115

116 2.8 Analysis procedure of water content by oven drying method

117 An empty cup was dried in the oven for 15 mins and cooled in a desiccator (10 mins for an aluminum
118 cup and 20 mins for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2-3
119 g then it was put in a dry cup. After that, it was put in the oven at 105°C for 6 hrs. Next, the cup containing
120 the sample was cooled in a desiccator, then weighed. Drying was repeated until a constant weight was
121 obtained. Water content was calculated based on the loss of weight, namely the difference between the
122 initial weight of the sample before drying and the final weight after drying.

123

124 2.9 Analysis procedure of ash content by muffle furnace method

125 A porcelain cup was dried in the oven for 15 mins and then cooled in a desiccator and weighed. The
126 sample was weighed as much as 3 g in a cup that had been dried and then it was burned in a smoke
127 chamber until it no longer emitted smoke. Next, ashing was carried out using an electric furnace at a
128 temperature of 400-600°C for 4-6 hrs until white ash was formed and had a constant weight. The ash
129 formed in the cup was cooled in a desiccator and then weighed.

130

131 2.10 Analysis procedure of antioxidant content testing

Commented [A10]: Apakah diukur kadar air akhir? Suhu yang berbeda dengan waktu pengeringan yang sama akan menghasilkan kadar air yang berbeda. Pengeringan 18 jam belum tentu kan menghasilkan bubuk yang baik untuk dihalurkan dengan blender

Deleted: hrs

Commented [A11]: What is this? Is mean 'gula semut'? That is brown sugar, isn't it?

Commented [A12]: Untuk setiap prosedur analisis harus disebutkan sumber pustaka untuk metode yang digunakan

Commented [A13]: Berapa lama proses pengulangannya untuk mendapatkan bobot konstan

Commented [A14]: Sumber pustaka untuk metode yang digunakan. Apakah yang diukur ini adalah aktivitas antioksidan atau kandungan senyawa antioksidan??

133 A total of 1 mL of DPPH solution (10 mg/L) was added to 50 μ L of sample solution and then added
134 methanol pro analyzed up to 5 mL, then incubated for 30 mins at 37°C. The absorbance was measured at
135 a wavelength of 513 nm. The antioxidant activity of the sample was determined by the magnitude of the
136 DPPH radical uptake inhibition by calculating the percentage of DPPH uptake inhibition.

137

138 2.10 Analysis procedure of IC_{50} antioxidant activity testing

139 Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging
140 activity) of DPPH. Analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl)
141 method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample.
142 A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made
143 by dissolving 0.01 mL of sample in 100 mL of methanol PA. Furthermore, dilution was carried out using
144 methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each
145 sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was
146 prepared by dissolving 5 mg of solid DPPH in 100 mL of methanol PA. Then a comparison solution was
147 prepared, namely a control solution containing 2 mL of methanol PA and 1 mL of 50 ppm DPPH solution.
148 For the test sample, 2 mL of sample solution and 2 mL of DPPH solution were prepared. Then, the solution
149 was kept for 30 mins. All samples, extract samples that had been kept, were tested for measuring the
150 absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

151

152 2.12 Analysis procedure of water activity testing

153 The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated
154 by adding $BaCl_2 \cdot 2H_2O$. It was then closed and kept for 3 mins until the number on the scale became 0.9.
155 The aw-meter was opened and the sample was inserted. The tool was then closed and waited until the
156 aw scale was read. The temperature scale and the correction factor were observed. When the
157 temperature scale was above 20°C, then the aw scale reading was added as much as the excess of the
158 temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.

159

160 2.13 Analysis procedure of vitamin C testing

161 Vitamin C analysis was performed by iodometric method. The crushed sample was weighed as much
162 as 5 g. It was put into a 100 mL measuring flask. Distilled water was then added up to the line mark. The
163 sample was shaken until homogeneous. The solution was filtered and the filtrate was pipetted as much
164 as 25 mL and put into an erlenmeyer. Then a few drops of starch indicator were added, then titrated
165 rapidly using 0.01 N iodine solution until a blue color appeared.

166

167 2.14 Statistical analysis

168 The data obtained were analyzed using analysis of variance (ANOVA). When the data showed that
169 there was a significant effect, then the Duncan Multiple Range Test was carried out. The testing was done
170 using IBM SPSS Statistics 29 software. The significant level was set at $\alpha = 0.05$.

171

172 3. Results and discussion

173 3.1 Bulk density of lemongrass and malang apple powder drinks

174 The bulk density value indicates void space, namely the number of empty cavities between the
175 material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2007).
176 The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The higher the drying

Commented [A15]: Sumber pustaka

Commented [A16]: Perbaiki cara penulisan rumus kimia

Commented [A17]: Bagaimana caranya memperoleh kandungan Vit C nya? Ada rumus yang digunakan

Commented [A18]: Bila dilihat dari data analisis, terjadi pengaruh interaksi antara suhu pengeringan dan jenis coating yang digunakan, sebaiknya dijelaskan di awal kalimat, dan apa makna dari interaksi tersebut!

177 temperature causes the bulk density value to decrease. It is because the higher the drying temperature
178 causes more water in the material to be evaporated so that the resulting water content is lower, causing
179 the weight of the powder to become lighter. It is in line with Andriyani *et al.* (2015) who state that as the
180 drying temperature increases, the bulk density decreases. The bulk density is influenced by the type of
181 material, water content, shape and size of the material. The smaller the bulk density, the more porous
182 the product is (Widowati *et al.*, 2010).

183 Of the three types of coating used, gum arabic has the lowest bulk density compared to other
184 coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and
185 hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan
186 *et al.*, 2013). Meanwhile dextrin has the characteristic of quickly dispersing, has high solubility, is able to
187 form films, has hygroscopic properties, is able to form body, has characteristic of low browning, is able to
188 inhibit crystallization, and has strong binding power (Purbasari, 2019). The dextrin film layer has a higher
189 proportion of solids than gum arabic, because the DE value of dextrin is lower than gum arabic, therefore
190 the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*,
191 2010). Maltodextrin is a coating material that has a high level of solubility, this is due to the nature of
192 maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has
193 the ability to absorb water) so that the water in the material is more retained and difficult to evaporate
194 (Yuliwati *et al.*, 2015).

195 According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space
196 needed for that material. The greater the bulk density (particles), the smaller the space needed, and vice
197 versa. The smaller the size of the molecule, the more easily the product will be compressed; with smaller
198 gaps between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum
199 arabic with a drying temperature of 50°C resulted in the lowest bulk density value of 0.52. According to
200 Palijama *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact
201 (non-voluminous), meaning that in the same certain volume, the product is available in more weight.
202 According to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small, meaning
203 that light weight requires a large space; the smaller the bulk density, the more porous the product is.
204 Sadeghi *et al.* (2010) state that the higher sphericity of the corn kernels results in a more regular
205 arrangement of the kernels so that the cavities between the kernels were smaller, resulting in a higher
206 bulk density.

207

208 3.2 Dissolution Time

209 Dissolution time in water is a time that shows all beverage powder dissolves in water perfectly. The
210 testing of dissolution time is carried out to determine the speed of solubility of the drinks when it will be
211 consumed. The higher the solubility value of the powder product, the better the product is; it is because
212 the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang
213 *et al.*, 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 seconds
214 (Table 2). The results show that, the higher the drying temperature, the faster the dissolution time (Table
215 2). It is because the powder produced is drier. The higher the drying temperature, the more water
216 evaporated on the powder drinks so that the water content is lower. The lower the water content, the
217 more hygroscopic so that the dissolution time is faster (Paramita *et al.*, 2015 and Sakdiyah *et al.*, 2019).

218 The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin
219 has a faster dissolution time compared to other types of coating (Table 2). It is because when powder
220 drinks are dissolved in water, especially warm water, the hydroxyl groups contained in the coating

221 material will interact with the water so that the solubility of the powder can increase (Yuliwaty *et al.*,
222 2015). Dextrin has a dextrose equivalent (DE) value of 3–5 and has the ability to form layers (Tyanjani *et al.*,
223 *et al.*, 2015). With the addition of dextrin, the solubility of powder drinks increases. It is because dextrin is
224 easily soluble in water. It is in accordance with Nurhidayah *et al.* (2014), who state that dextrin is easily
225 soluble in water, disperse more quickly, is not viscous and is more stable than starch.

226 According to Wulansari *et al.* (2012), Dextrose Equivalent (DE) of maltodextrin is 3-20. The higher
227 the DE value, the higher the monosaccharide content, causing the binding power to be greater. Thus, the
228 use of maltodextrin causes a higher water content compared to dextrin. Maltodextrin is a filler that has a
229 high level of solubility; it is due to the characteristic of maltodextrin that is soluble in water (Hofman *et al.*,
230 *et al.*, 2021). Gum arabic has a longer dissolution time than maltodextrin and dextrin. However, according
231 to Herawati (2018), gum arabic has the advantage of having high solubility in water, making it better as a
232 coating material in making powder drinks. The DE value of gum arabic is 6 (Soottitantawat *et al.*, 2006).
233 According to Hofman *et al.* (2016) the factor that affects the level of solubility in water is the DE value;
234 the higher the DE value, the better the solubility level.

235

236 3.3 Stability

237 Beverage products will be stable if the particles acting as the dispersed phase can be retained
238 without changing for a long time or without experiencing grouping with each other (Anjani *et al.*, 2011).
239 The stability testing is expressed in (%) which shows the percentage of stability of the powder drinks made.
240 The stability of lemongrass and Malang apple powder drinks obtained an average of 63.89% to 93.33%
241 (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The
242 higher the drying temperature, the lower the powder water content. It causes the product to absorb water
243 more easily so that the product becomes more stable when rehydrated. It is in line with Kryzhska *et al.*
244 (2020) who state that high water content in powder products would seriously disrupt product stability
245 and would cause the product to agglomerate when stored. The high-water content in a product can cause
246 damage due to the activity of microorganisms.

247 The type of coating also affects the stability value. Of the three types of coating used, dextrin has
248 the most stable results compared to other types of coating. Dextrin's can wrap or encapsulate the active
249 ingredient particles from oxidation reactions during storage thereby increasing product stability
250 (Septevani *et al.*, 2013). Dextrin has a stronger ability to bind water because it is a group of
251 polysaccharides that has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic
252 bonds (Xu *et al.*, 2012). The addition of maltodextrin can increase the stability of the drink which can
253 reduce the precipitate formed (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the
254 product does not precipitate too much (Prमितasari *et al.*, 2011). Gum arabic has a more complex
255 molecular structure than dextrin and contains starch in it, so gum arabic is more hygroscopic (Sutardi *et al.*,
256 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-
257 glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence
258 of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin
259 treatment with a drying temperature of 50°C is the coating material with the highest stability value of
260 93.33%.

261

262 3.4 Water content

263 The average water content of lemongrass and Malang apple powder drinks ranged from 2.06% to
264 2.57% (Table 4). In the manufacturing process, powder drinks are made by drying separately at 40°C, 45°C

Commented [A19]: Hasil analisis yang memiliki pengaruh interaksi dan tidak, tidak tercermin di dalam pembahasan.

265 and 50°C for 18 hrs . The results show that the higher the drying temperature, the lower the water content
266 of the powder. Drying causes the water content in the lemongrass and Malang apple powder to evaporate.
267 The higher the temperature produces powder with lower water content. According to Wiyono (2011), the
268 drying temperature factor is important to note because it can remove the water content quickly when the
269 material is dried at high temperatures. The increase of the heating temperature tends to reduce the water
270 content. The decrease in the amount of water is due to the higher heating temperature. Thus, there are
271 more water molecules that evaporate from the dried raw materials so that the water content obtained is
272 lower.

273 The type of coating has a relatively similar effect on the value of the water content. Of the three
274 types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by
275 maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic,
276 that is, it easily absorbs water; but when it is dried, the absorbed water is released. The water content
277 absorbed by the presence of coating material will evaporate more easily than the water content in the
278 material tissue so that the evaporation process of water in powder drinks becomes easier (Paramita *et*
279 *al.*, 2015). Maltodextrin has a low molecular weight and a simple structure, so that water is easily
280 evaporated during the drying process (Prमितasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic so
281 that the water in the material is more retained and difficult to evaporate. Gum arabic has a high molecular
282 weight and a complex molecular structure and contains a large amount of starch (Sutardi *et al.*, 2010).
283 Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50°C
284 dextrin and it was in accordance with SNI number 01-4320-1996 in which the water content of powder
285 drinks was a maximum of 3% (BSN, 1996). It shows that powder drink products meet the requirements of
286 SNI number 01-4320-1996 and have a small possibility of being contaminated with microorganisms.
287

288 3.5 Ash content

289 According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of
290 minerals in a food. Ash is composed of various types of minerals with varying composition depending on
291 the type and source in food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content
292 of the results of the study was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher
293 the ash content. The increase in ash content is thought to be related to the higher drying temperature. It
294 causes more water in the material to evaporate, so that the water content is lower. It causes the
295 percentage of mineral content in the material to increase. The results of the study are in line with Shadri
296 *et al.* (2018).

297 Dextrin coating is a polysaccharide group which has a simpler chemical structure than gum arabic.
298 Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile gum arabic has
299 a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-
300 rhamnose (Alftren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of
301 minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a
302 sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin
303 coating with a drying temperature of 45°C. In general, the ash content of the product was still within the
304 limits of SNI 01-4320-1996 regarding the quality requirements for powder drinks, namely a maximum of
305 1.5% (BSN, 1996). Malang apple has a fairly high nutritional content, especially vitamins and minerals such
306 as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2,
307 and vitamin C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A,
308 vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

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3.6 Vitamin C

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3.7 Water activity

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The results of the vitamin C test are presented in Table 6, showing an average value of vitamin C between 53.15 mg/100g to 72.69 mg/100g. The vitamin C content tend to decrease with increasing drying temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C and is easily degraded, especially by heat (Parfiyanti *et al.*, 2016). It shows that the drying process at high temperature can reduce the vitamin C content found in powder drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid which plays a role in inhibiting excessive oxidation reactions (Susanti *et al.*, 2014).

The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin produces the highest content of vitamin C compared to other types of coating. It is because dextrin can protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the more dextrin is added, the more vitamin C content in the product is maintained. Dextrin has the characteristic of protecting vitamin C and compounds that are sensitive to heat or oxidation because the molecules of dextrin are stable to heat and oxidation, so that the vitamin C content can be maintained. In addition, according to Aretzy *et al.* (2018), maltodextrin can protect volatile compounds and protect compounds that are sensitive to oxidation. According to Alfonsius (2015), the addition of gum arabic in the processing process can protect important compounds such as vitamins due to extreme temperatures, since gum arabic has the ability to form a body as a coating and has a strong bond to the compounds coated. The highest content of vitamin C was produced in powder drinks dried at 40°C with dextrin coating (72.68 mg/100 g) and the lowest was produced at 50°C with gum arabic coating (53.15 mg/100 g). The vitamin C content of mix fruit powder drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and tween 80 dried at 50°C produces the vitamin C content between 425 mg/100g – 550 mg/100g, which is higher than lemongrass and Malang apple powder drinks (Minah, *et al.*, 2021).

Table 7 shows the mean value of water activity (*aw*) of lemongrass and Malang apple powder drinks, namely 0.44 to 0.50. The *aw* value of lemongrass and Malang apple powder drinks is lower than the *aw* value for the bacterial growth requirement, namely 0.90. The *aw* value for yeast growth is 0.80-0.90, and the *aw* value for mold growth is 0.60-0.70. The *aw* value is relatively decreased with increasing drying temperature. In the drying process, the free water in the material will evaporate. The higher temperature causes more water to evaporate. The lower the water content, the lower the water activity (Martins *et al.*, 2019). According to Adri *et al.* (2013), the composition of water in foodstuffs such as free water and bound water can affect the rate or duration of food drying. The relatively small *aw* value does not allow the growth of bacteria, molds and yeasts in the product. Lemongrass extract shows great potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella yphimurium* and *Staphylococcus aureus*; this indicates the possibility of using medicinal plants as natural antibacterial agents (Ibrahim *et al.*, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying is to reduce water content so that it is not easy for mold and bacteria to grow, eliminate the activity of enzymes that can decompose the active substance content and facilitate further processing so that it can be more compact, durable and easy to store.

The use of various coatings in this study relatively produces the same *aw* value. The use of maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray drying can protect protein, calcium, lactose powder (Martins *et al.*, 2019). The lowest water activity value

Commented [A20]: Vitamin C mudah rusak dengan suhu tinggi, tetapi malah semakin tinggi kandungannya, sebaiknya dihubungkan dengan coating yang digunakan, karena berdasarkan hasil analisisnya, ada pengaruh interaksi antara suhu dan type coating

353 of lemongrass and Malang apple powder drinks was obtained for products with gum arabic coating at
354 drying temperature of 45°C (0.44).

355

356 3.8 *The percent inhibition of antioxidant content*

357 Percent inhibition shows the radical scavenging activity possessed by antioxidant compounds. One
358 of the plants that has potential as an antioxidant is lemongrass (Wibisono, 2011) and apple (Yudhianto *et*
359 *al.*, 2013). Based on the antioxidant test in Table 8, the average inhibition value was 37.45% to 60.13%.
360 Based on Table 8 it is also known that drying temperature affects antioxidant content. The higher the
361 drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant
362 activity in the lemongrass and Malang apple powder drinks is thought to be related to the damage to the
363 antioxidant compounds due to high temperatures. According to Patras *et al.* (2010), antioxidant
364 compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these
365 compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat.
366 Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna *et al.* (2013)
367 that antioxidant bioactive components have heat-resistant characteristics, so if the sample is extracted in
368 hot conditions it will reduce the value of its antioxidant activity. The results of the research by Widiastuti
369 *et al.* (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the
370 higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content
371 in lemongrass is due to the large number of phenolic compounds it contains. The high content of phenolic
372 compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential
373 oil in lemongrass stems is very high with an effective inhibition of 89% and 89.63%, whereas in lemongrass
374 leaves it is slightly lower with antioxidant and antidiabetic activities ranging from 78.89% and 79.26%
375 respectively (Mirghani, *et al.*, 2012).

376 The use of dextrin coating with a drying temperature of 40°C produced the highest inhibition value
377 compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explains that dextrin is
378 composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the
379 oxidation process can be prevented. Dextrin has the characteristic of protecting volatile compounds and
380 compounds that are sensitive to heat or oxidation. Gum arabic can improve and maintain the stability of
381 the compounds being coated. Gum arabic is also a type of coating that is resistant to heat (Dauqan *et al.*,
382 2013). Meanwhile, maltodextrin can protect volatile compounds and protect compounds that are
383 sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high oxidation resistance and can
384 reduce the viscosity of the emulsion; combined with other coatings that have better emulsifying
385 properties, it causes the antioxidant compounds in the microencapsulants to be well covered and
386 protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural
387 antioxidants and anti-inflammatories which can prevent free radicals in the human body. Antioxidants in
388 lemongrass are able to inhibit the release of arachidonic acid by the mechanism of inhibiting kinase
389 protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid
390 synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are
391 citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants which are
392 very good for skin health. The very high antioxidant content is also the reason for the high consumption
393 of apples by the public as an effort to prevent diseases and other dysfunctions of body health.

394

395 3.9 *Antioxidant content with inhibition concentration value of 50% (IC₅₀)*

Commented [A21]: Judulnya tidak sesuai dengan metode pengukuran yang disampaikan di dalam metodologi

Commented [A22]: Bagaimana [pengaruh coating terhadap penurunan aktivitas antioksidan akibat penggunaan suhu yang lebih tinggi

396 The IC₅₀ value is the concentration of the antioxidant source to neutralize 50% of the radical
397 compounds. The lower the IC₅₀ value, the better the antioxidant activity of the sample. IC₅₀ antioxidant
398 content are determined from the 3 best samples based on the highest inhibition percentage, namely on
399 lemongrass and Malang apple powders which are coated with dextrin with drying temperatures of 40°C,
400 45°C and 50°C. According to Phongpaichit et al. (2007), IC₅₀ value < 10 ppm indicates a very strong activity.
401 IC₅₀ 10-50 ppm indicates a strong activity, IC₅₀ > 50-100 ppm indicates moderate activity, and IC₅₀ > 100-
402 250 ppm indicates a weak activity. The results showed that the IC₅₀ value in the lemongrass and Malang
403 apple powder drinks was 0.9 ppm to 1.47 ppm (Table 9), which indicated a very strong activity. The results
404 of research by Andriyani et al., (2015) show that the IC₅₀ value of temulawak and red ginger powder
405 functional drinks made using the spray drying method has the highest or strongest average value of 0.62
406 ppm at 4% maltodextrin concentration and the lowest or weakest value of 1.00 ppm at 0% maltodextrin
407 concentration.

408

409 **4. Conclusion**

410 The results showed that the type of coating significantly affected the parameters of stability,
411 dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly
412 affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and
413 antioxidants. There was an interaction between the type of coating and the drying time that affected the
414 bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was
415 determined based on the antioxidant content and high stability. The fast dissolution time was found in
416 lemongrass and Malang apple powder that was dried at 45°C with dextrin coating. The best lemongrass
417 and Malang apple powder drinks had the following characteristics: a solubility of 0.96 seconds, a bulk
418 density of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin
419 C content of 70.22%, a percent antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 ppm, and a water
420 activity 0.50.

421 **Conflict of interest - Disclose any potential conflict of interest appropriately.**

422 The authors declare no conflict of interest.

423

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673 **Tables and Figures – 1 PAGE 1 TABLE/FIGURE. PLACE ALL TABLES AND FIGURES AT THE END OF THE**
674 **MANUSCRIPT BODY AFTER THE REFERENCES. ARRANGE THE TABLES AND FIGURES ACCORDING TO**
675 **THEIR APPEARANCE IN TEXT.**

676 Table 1. The mean value of bulk density for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.58 ^a	0.63 ^{bcd}	0.64 ^{bcd}	0.62 ± 0.03
45°C	0.67 ^{ab}	0.58 ^{abc}	0.64 ^{bcd}	0.63 ± 0.05
50°C	0.58 ^{abc}	0.67 ^{cd}	0.52 ^a	0.59 ± 0.08
Mean ± SD	0.61 ± 0.05	0.63 ± 0.05	0.60 ± 0.60	

677 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

678

679 Table 2. The mean value of dissolution time for lemongrass and Malang apple powder drinks (second)

Coating Type	Mean

Commented [A23]: Diperiksa kembali hasil analisis Duncan, nilai 0,67 memiliki huruf yang berbeda, untuk analisis yang interaksinya positif, semua angka dibandingkan. Angka2 hasil analisis sebaiknya dilengkapi standar deviasi untuk meyakinkan bahwa nilai yang ditunjukkan adalah hasil rata-rata sampel

Commented [A24]: sda

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.06 ^{bc}	1.11 ^{ab}	1.29 ^d	1.15 ± 0.12 ^c
45°C	1.04 ^{abc}	0.96 ^a	1.05 ^{abc}	1.02 ± 0.05 ^b
50°C	1.07 ^{bc}	1.01 ^{cd}	1.17 ^e	1.08 ± 0.08 ^a
Mean ± SD	1.05 ± 0.01 ^a	1.03 ± 0.08 ^a	1.17 ± 0.12 ^b	

680 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

681

682 Table 3. The mean value of stability for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	65.30 ^{ab}	87.32 ^e	63.89 ^a	72.17 ± 13.14 ^c
45°C	73.01 ^d	89.19 ^e	69.69 ^c	77.30 ± 10.43 ^b
50°C	78.74 ^d	93.33 ^f	80.19 ^e	84.09 ± 8.03 ^a
Mean ± SD	72.35 ± 6.74 ^a	89.95 ± 3.07 ^a	71.26 ± 8.26 ^b	

683

684 Table 4. The mean value of water content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	2.57	2.51	2.54	2.54 ± 0.03 ^c
45°C	2.39	2.38	2.31	2.36 ± 0.04 ^b
50°C	2.07	2.16	2.06	2.10 ± 0.05 ^a
Mean ± SD	2.34 ± 0.25	2.35 ± 0.18	2.30 ± 0.24	

685 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

686

687 Table 5. The mean value of ash content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.17 ^{ab}	1.46 ^e	1.06 ^a	1.23 ± 0.21 ^a
45°C	1.26 ^{bcd}	1.21 ^{abc}	1.24 ^{bcd}	1.23 ± 0.02 ^a
50°C	1.26 ^{bcd}	1.37 ^{cde}	1.38 ^{de}	1.33 ± 0.07 ^b
Mean ± SD	1.23 ± 0.05 ^a	1.34 ± 0.13 ^b	1.23 ± 0.16 ^a	

688 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

689 Table 6. The mean value of vitamin C content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	68.11 ^d	72.69 ^e	61.95 ^c	67.58 ± 5.39 ^c

45°C	63.36 ^c	70.22 ^{de}	58.26 ^b	63.95 ± 6.99 ^b
50°C	54.91 ^a	63.36 ^c	53.15 ^a	57.14 ± 5.46 ^a
Mean ± SD	62.13 ± 6.69 ^a	68.76 ± 4.83 ^b	57.79 ± 4.42 ^c	66.91

692

693

694 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

695

696 Table 7. The mean value of water activity for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.48	0.48	0.51	0.49 ± 0.02
45°C	0.51	0.50	0.44	0.49 ± 0.04
50°C	0.49	0.46	0.46	0.47 ± 0.02
Mean ± SD	0.49 ± 0.02	0.48 ± 0.02	0.47 ± 0.03	

697 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

698

699 Table 8. The mean value of antioxidant content for lemongrass and Malang apple powder drinks (%)

700

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	56.96 ^f	60.13 ^b	53.66 ^g	56.92 ± 3.24 ^g
45°C	45.73 ^c	50.97 ^e	48.17 ^d	48.29 ± 2.62 ^d
50°C	37.45 ^a	43.98 ^b	37.53 ^a	39.65 ± 3.75 ^a

705 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

706

707 Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powder drinks (%) on the best product

708

Drying Temperature	Coating Type
	Dekstrin
40°C	0.9 ± 0.01
45°C	1.279 ± 0.08
50°C	1.47 ± 0.01

709

1 The effect of coating and drying temperature on the physicochemical properties of the mixture
2 lemongrass and apple powder drink

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4 **Abstract**

5 The immunity of the human body can be enhanced by food and beverages. The fresh beverage products
6 generally have a short shelf life product, so they need to be made into powder drinks. Currently popular
7 drinks come from spices containing antioxidants that can boost the body's immunity. To maintain the
8 antioxidant compounds that exist during drying, it is necessary to have a coating material. This study aims
9 to investigate the effect of coating type and drying temperature on the quality of lemongrass and Malang
10 apple powder drinks. The study used a Completely Randomized Design (CRD) with two factors and two
11 replications. The first factor was the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the
12 second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). Data were analyzed using
13 ANAVA test and Duncan's further test if the treatment was significantly different. The results showed that
14 the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin
15 C, and antioxidants. Drying time significantly affected the parameters of stability, dissolution time, water
16 content, ash content, vitamin C and antioxidants. There was an interaction between the coating type and
17 drying time which affected the bulk density, stability, dissolution time, ash content, vitamin C, and
18 antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin
19 coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96
20 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of
21 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of
22 1.29, and a water activity of 0.50.

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23 **Keywords:** Apples, Dextrin, Powder Drinks, Drying, Lemongrass

25 **1. Introduction**

26 The ongoing COVID-19 pandemic has forced people to maintain their health through increasing their
27 body's immunity. Body immunity can be improved through on an adequate diet and nutrition from foods
28 and drinks (Iddir *et al.*, 2020). The fresh beverage products generally have a short shelf life, so they need
29 to be made into powder drinks. Powder drinks are a processed food product in powder form, easily
30 dissolved in water, practical in serving and have a relatively long shelf life. In addition, powder drinks are
31 easy to carry and ship (Tangkeallo *et al.*, 2014). It causes powder drinks to be liked by the public. One of
32 the ingredients that can increase the body's immunity is spices. Spices are known to contain antioxidant
33 compounds. Antioxidants are able to capture free radicals to enhance the immunity of the body,
34 (Cakmakci *et al.*, 2015). One of the spices that contain antioxidants and is popular today is lemongrass or
35 often called "serai". Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*,
36 *eugenol*, *dipentene*, *citral* (Wibisono, 2011). These compounds act as anticancer and antioxidants, stabilize
37 blood pressure, treat constipation, help the digestive system, tighten the body after childbirth
38 (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). Apart from lemongrass, a food ingredient
39 that can improve the body's immunity and has a good taste is Malang apples. Malang apples are a famous
40 fruit typical of Malang city. Malang apples that are small in size have low economic value because they

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57 are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019),
58 Malang apples contain lots of vitamins such as vitamins A, B, C, minerals, fiber, and flavonoid compounds,
59 one of which is quercetin. Vitamin C and quercetin act as antioxidants, antivirals and anti-inflammatories
60 that protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free
61 radicals and change or reduce free radicals (Suparni *et al.*, 2012).

62 However, although containing beneficial antioxidants, lemongrass and Malang apples are rarely used
63 as ingredients to make powdered beverages. Due to its practicality, ready-to-serve drinks in powder form,
64 (Sari *et al.*, 2021). To overcome this, powder drinks made from a mixture of lemongrass and Malang
65 apples are made. In the making of lemongrass and Malang apple powder drinks as functional drinks, there
66 is a critical point during the drying process (Naibaho *et al.*, 2015). It is because the active ingredients
67 contained in lemongrass and Malang apples are volatile. Drying at high temperatures and for a long time
68 can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the amount of
69 antioxidants, present, it is necessary to find the right drying temperature. In addition to maintaining the
70 existing volatile compounds, it is necessary to have a coating material. The commonly used coating
71 material is gum arabic because this material has the ability to form good emulsions and films. Gum arabic
72 as a coating material is able to maintain the stability of volatile compounds and trap the highest volatile
73 components compared to modified starch (Santoso *et al.*, 2013). Gum arabic can preserve the flavor of
74 dried materials by coating the flavor particles, protecting them from oxidation, absorption, and
75 evaporation of water from the air. (Herawati, 2018). According to Harahap *et al.* (2021), maltodextrin can
76 disperse quickly, has a high solubility, forms low hygroscopic properties, has low browning properties, is
77 able to inhibit crystallization and has strong binding power. Meanwhile, dextrin has a high solubility, but
78 it has a relatively low ability to bind water and a relatively low viscosity (Asia *h* *et al.*, 2012).

79 Based on the description above, this study aimed at investigating the effect of coating type and drying
80 temperature on the quality of lemongrass and Malang apple powder drinks. The quality of the powder
81 drinks was determined based on physical tests in the form of bulk density, dissolution time, and stability
82 test. These tests were required to determine packaging. In addition, chemical tests were carried out in
83 the form of water content, ash content, antioxidant activity, water activity, and vitamin C. These tests
84 would indirectly determine the shelf life and ability of the product to increase body immunity. This
85 research has yielded products that have the potential to increase body immunity, are easy to carry, and
86 have a relatively long shelf life.

87

88 2. Materials and Methods

89 2.1 Material

90 The materials used in the study were lemongrass stems and seedless Malang apples, maltodextrin,
91 dextrin, gum Arabic powder, water, and brown sugar. The materials for chemical analysis were distilled
92 water, starch indicator, 0.1 N NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the
93 study were a Mizui blender, cutting boards, measuring cups, knives, WTC Binder 78532 blower ovens,
94 baking sheets, spoons and Matrix ESJ210-4B scales, volumetric flasks, Erlenmeyer, burettes, measuring
95 pipettes, suction ball, funnel pipette, beaker glass, filter paper, stativ, Siever 60 mesh, and
96 spectrophotometer JUV2100 Spectrophotometer.

97

98 2.2 The process of making lemongrass and malang apple powder drinks

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133 The process of making powder drinks was a modification of the research of Susanti and Putri, (2014).
134 The process of making powder drinks consisted of two stages, that is, the making of fruit pulp and the
135 drying process.

136 2.3 Making fruit pulp

137 The making of fruit pulp began with sorting and washing the lemongrass and Malang apples, followed
138 by cutting the lemongrass and Malang apples (1:1 w/w) and then crushing them with a blender for 5
139 minutes at speed number 2. After that, the pulp was added with water in a ratio of 1:1 w/w. Furthermore,
140 the coating materials (maltodextrin, dextrin, and gum Arabic) were added as much as 5% w/w fruit pulp
141 separately. The pulp was stirred until homogeneous.

143 2.4 Drying

144 The homogeneous fruit pulp, each was placed on a 60x40x2 cm baking sheet as much as 250 mL and
145 dried with a blower oven at a predetermined temperature (40°C, 45°C, and 50°C) separately for 18 hours.
146 The dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3
147 minutes at speed number 2. Then, brown sugar was added as much as 10% w/w of the dry powder. After
148 that, the powder was sieved using a 60-mesh sieve. Lemongrass powder drinks were packaged in
149 aluminum foil zip lock with a size of 7 X 13 cm.

151 2.5 Analysis procedure of bulk density (Sandhu et al., 2007)

152 The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring
153 cup containing the powder sample was tapped 30 times until there were no more cavities when the
154 powder sample was adjusted to 10 mL. The measuring cup containing the powder sample was then
155 weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its
156 volume (10 mL).

158 2.6 Analysis procedure of dissolution time testing (Pentury et al., 2013)

159 A total of 5 g sample was weighed then dissolved in 50 mL of warm water and stirred 20 times until
160 homogeneous. How long it took the sample to dissolve in water was recorded.

162 2.7 Analysis procedure of stability testing (Pentury et al., 2013)

163 A total of 5 g of powder was weighed and brewed in 50 mL of water then put into a 10 mL measuring
164 cup and kept for 24 hrs. Afterwards, the suspension or solution was measured for the volume of the
165 precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

167 2.8 Analysis procedure of water content by oven drying method (AOAC, 2006)

168 An empty cup was dried in the oven for 15 minutes and cooled in a desiccator (10 mins for an
169 aluminum cup and 20 minutes for a porcelain cup). The dry cup was weighed. The sample was weighed
170 as much as 2-3 g then it was put in a dry cup. After that, it was put in the oven at 105°C for 6 hours. Next,
171 the cup containing the sample was cooled in a desiccator, then weighed. Drying was repeated until a
172 constant weight was obtained. Water content was calculated based on the loss of weight, namely the
173 difference between the initial weight of the sample before drying and the final weight after drying.

175 2.9 Analysis procedure of ash content by muffle furnace method (AOAC, 2006)

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195 A porcelain cup was dried in the oven for 15 minutes and then cooled in a desiccator and weighed.
196 The sample was weighed as much as 3 g in a cup that had been dried and then it was burned in a crucibles
197 until it no longer emitted smoke. Next, ashing was carried out using an electric furnace at a temperature
198 of 400-600°C for 4-6 hours until white ash was formed and had a constant weight. The ash formed in the
199 cup was cooled in a desiccator and then weighed.
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201 2.10 Analysis procedure of radical scavenging activity (Tristantini et al., 2016)
202 Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging
203 activity) of DPPH. Analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl)
204 method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample.
205 A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made
206 by dissolving 0.01 mL of sample in 100 mL of methanol PA. A total of 1 mL of DPPH solution (10 mg/L) was
207 added to 50 µL of sample solution and then added methanol pro analyzed up to 5 mL, then incubated for
208 30 minutes at 37°C. The absorbance was measured at a wavelength of 513 nm. The antioxidant activity
209 of the sample was determined by the magnitude of the DPPH radical uptake inhibition by calculating the
210 percentage of DPPH uptake inhibition.
211

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212 2.11 Analysis procedure of IC₅₀ antioxidant activity (Tristantini et al., 2016)
213 Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging
214 activity) of DPPH. Analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl)
215 method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample.
216 A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made
217 by dissolving 0.01 mL of sample in 100 mL of methanol PA. Furthermore, dilution was carried out using
218 methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each
219 sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was
220 prepared by dissolving 5 mg of solid DPPH in 100 mL of methanol PA. Then a comparison solution was
221 prepared, namely a control solution containing 2 mL of methanol PA and 1 mL of 50 ppm DPPH solution.
222 For the test sample, 2 mL of sample solution and 2 mL of DPPH solution were prepared. Then, the solution
223 was kept for 30 minutes. All samples, extract samples that had been kept, were tested for measuring the
224 absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.
225

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226 2.12 Analysis procedure of water activity testing (Susanto, 2009)
227 The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated
228 by adding BaCl₂·2H₂O. It was then closed and kept for 3 mins until the number on the scale became 0.9.
229 The aw-meter was opened and the sample was inserted. The tool was then closed and waited until the
230 aw scale was read. The temperature scale and the correction factor were observed. When the
231 temperature scale was above 20°C, then the aw scale reading was added as much as the excess of the
232 temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.
233

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234 2.13 Analysis procedure of vitamin C testing (AOAC, 2006)
235 Vitamin C analysis was performed by iodometric method. The crushed sample was weighed as much
236 as 5 g. It was put into a 100 mL measuring flask. Distilled water was then added up to the line mark. The
237 sample was shaken until homogeneous. The solution was filtered and the filtrate was pipetted as much
238 as 25 mL and put into an erlenmeyer. Then a few drops of starch indicator were added, then titrated

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251 rapidly using 0.01 N iodine solution until a blue color appeared. Vitamin C content is obtained from the
252 following formula:

253
$$\text{Vitamin C (mg/100 g)} = \frac{V I_2 \times 0.88 \times f_p \times 100}{W (g)}$$

254 $V I_2$ = Iodine volume (mL)

255 0.88 = 0.88 mg ascorbic acid equivalent to 1 ml I₂ 0.01 N solution

256 f_p = dilution factor

257 W = sample mass (gram)

258

259

260 2.14 Statistical analysis

261 The data obtained were analyzed using analysis of variance (ANOVA). When the data showed that
262 there was a significant effect, then the Duncan Multiple Range Test was carried out. The testing was done
263 using IBM SPSS Statistics 29 software. The significant level was set at $\alpha = 0.05$.

264

265 3. Results and Discussion

266 3.1 Bulk density of lemongrass and Mplang apple powder drinks

267 The bulk density value indicates void space, namely the number of empty cavities between the
268 material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2007).
269 The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The findings revealed that
270 the drying temperature and coating type had an effect on the bulk density value of the powdered drink.
271 Furthermore, the density value of Kamba is affected by a relationship between the drying temperature
272 and coating type. The higher the drying temperature causes the bulk density value to decrease. It is
273 because the higher the drying temperature causes more water in the material to be evaporated so that
274 the resulting water content is lower, causing the weight of the powder to become lighter. It is in line with
275 Andriyani *et al.* (2015) who state that as the drying temperature increases, the bulk density decreases.
276 The bulk density is influenced by the type of material, water content, shape and size of the material. The
277 smaller the bulk density, the more porous the product is (Widowati *et al.*, 2010).

278 Of the three types of coating used, gum arabic has the lowest bulk density compared to other
279 coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and
280 hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan
281 and Abdullah, 2013). Meanwhile dextrin has the characteristic of quickly dispersing, has high solubility, is
282 able to form films, has hygroscopic properties, is able to form body, has characteristic of low browning, is
283 able to inhibit crystallization, and has strong binding power (Purbasari, 2019). The dextrin film layer has a
284 higher proportion of solids than gum arabic, because the DE value of dextrin is lower than gum arabic,
285 therefore the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi
286 *et al.*, 2010). Maltodextrin is a coating material that has a high level of solubility, this is due to the nature
287 of maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic
288 (has the ability to absorb water) so that the water in the material is more retained and difficult to
289 evaporate (Yuliwaty and Susanto, 2015).

290 According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space
291 needed for that material. The greater the bulk density (particles), the smaller the space needed, and vice
292 versa. The smaller the size of the molecule, the more easily the product will be compressed; with smaller
293 gaps between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum

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303 arabic with a drying temperature of 50°C resulted in the lowest bulk density value of 0.52. According to
304 Palijama *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact
305 (non-voluminous), meaning that in the same certain volume, the product is available in more weight.
306 According to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small, meaning
307 that light weight requires a large space; the smaller the bulk density, the more porous the product is.
308 Sadeghi *et al.* (2010) state that the higher sphericity of the corn kernels results in a more regular
309 arrangement of the kernels so that the cavities between the kernels were smaller, resulting in a higher
310 bulk density. Dari uraian di atas tergambar bahwa suhu pengeringan dan jenis pelapis sama-sama
311 memengaruhi nilai densitas kamba. Hal ini menunjukkan ada interaksi di antara keduanya dalam
312 memengaruhi nilai denistas kamba.

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314 3.2 Dissolution Time

315 Dissolution time in water is a time that shows all beverage powder dissolves in water perfectly. The
316 testing of dissolution time is carried out to determine the speed of solubility of the drinks when it will be
317 consumed. The higher the solubility value of the powder product, the better the product is; it is because
318 the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang
319 *et al.*, 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 seconds
320 (Table 2). The results show that, the higher the drying temperature, the faster the dissolution time (Table
321 2). It is because the powder produced is drier. The higher the drying temperature, the more water
322 evaporated on the powder drinks so that the water content is lower. The lower the water content, the
323 more hygroscopic so that the dissolution time is faster (Paramita *et al.*, 2015 and Sakdiyah and Rekna,
324 2019).

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325 The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin
326 has a faster dissolution time compared to other types of coating (Table 2). It is because when powder
327 drinks are dissolved in water, especially warm water, the hydroxyl groups contained in the coating
328 material will interact with the water so that the solubility of the powder can increase (Yuliwaty and
329 Susanto, 2015). Dextrin has a dextrose equivalent (DE) value of 3–5 and has the ability to form layers
330 (Tyanjani and Yunianta, 2015). With the addition of dextrin, the solubility of powder drinks increases. It is
331 because dextrin is easily soluble in water. It is in accordance with Nurhidayah *et al.* (2014), who state that
332 dextrin is easily soluble in water, disperse more quickly, is not viscous and is more stable than starch.

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333 According to Wulansari *et al.* (2012), Dextrose Equivalent (DE) of maltodextrin is 3-20. The higher
334 the DE value, the higher the monosaccharide content, causing the binding power to be greater. Thus, the
335 use of maltodextrin causes a higher water content compared to dextrin. Maltodextrin is a filler that has a
336 high level of solubility; it is due to the characteristic of maltodextrin that is soluble in water (Hofman *et*
337 *al.*, 2016). Gum arabic has a longer dissolution time than maltodextrin and dextrin. However, according
338 to Herawati (2018), gum arabic has the advantage of having high solubility in water, making it better as a
339 coating material in making powder drinks. The DE value of gum arabic is 6 (Soottitantawat *et al.*, 2006).
340 According to Hofman *et al.* (2016) the factor that affects the level of solubility in water is the DE value;
341 the higher the DE value, the better the solubility level.

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343 3.3 Stability

344 Beverage products will be stable if the particles acting as the dispersed phase can be retained
345 without changing for a long time or without experiencing grouping with each other (Anjani *et al.*, 2011).
346 The stability testing is expressed in the percentage of stability of the powder drinks made. The stability of

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353 lemongrass and Malang apple powder drinks obtained an average of 63.89% to 93.33% (Table 3). The
354 results show that the higher the drying temperature, the higher the resulting stability. The higher the
355 drying temperature, the lower the powder water content. It causes the product to absorb water more
356 easily so that the product becomes more stable when rehydrated. It is in line with Kryzhska *et al.* (2020)
357 who state that high water content in powder products would seriously disrupt product stability and would
358 cause the product to agglomerate when stored. The high-water content in a product can cause damage
359 due to the activity of microorganisms.

360 The type of coating also affects the stability value. Of the three types of coating used, dextrin has
361 the most stable results compared to other types of coating. Dextrin's can wrap or encapsulate the active
362 ingredient particles from oxidation reactions during storage thereby increasing product stability
363 (Septevani *et al.*, 2013). Dextrin has a stronger ability to bind water because it is a group of
364 polysaccharides that has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic
365 bonds (Xu *et al.*, 2012). The addition of maltodextrin can increase the stability of the drink which can
366 reduce the precipitate formed (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the
367 product does not precipitate too much (Prमितasari *et al.*, 2011). Gum arabic has a more complex
368 molecular structure than dextrin and contains starch in it, so gum arabic is more hygroscopic (Sutardi *et*
369 *al.*, 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-
370 glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence
371 of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin
372 treatment with a drying temperature of 50°C is the coating material with the highest stability value of
373 93.33%.

374 3.4 Water content

376 The average water content of lemongrass and Malang apple powder drinks ranged from 2.06% to
377 2.57% (Table 4). In the manufacturing process, powder drinks are made by drying separately at 40°C, 45°C
378 and 50°C for 18 hours. The results reveal that the drying temperature has an effect on the water content
379 of lemongrass and Malang apple powdered drinks. Meanwhile, the type of coating had no effect on the
380 water content. Similarly, there was no interaction between the drying temperature and coating type
381 affecting the moisture content of the powdered drinks. The higher the drying temperature, the lower the
382 water content of the powder. Drying causes the water content in the lemongrass and Malang apple
383 powder to evaporate. The higher the temperature produces powder with lower water content. According
384 to Wiyono (2011), the drying temperature factor is important to note because it can remove the water
385 content quickly when the material is dried at high temperatures. The increase of the heating temperature
386 tends to reduce the water content. Thus, there are more water molecules that evaporate from the dried
387 raw materials so that the water content obtained is lower.

388 The type of coating has a relatively similar effect on the value of the water content. Of the three
389 types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by
390 maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic,
391 that is, it easily absorbs water; but when it is dried, the absorbed water is released. The water content
392 absorbed by the presence of coating material will evaporate more easily than the water content in the
393 material tissue so that the evaporation process of water in powder drinks becomes easier (Paramita *et*
394 *al.*, 2015). Maltodextrin has a low molecular weight and a simple structure, so that water is easily
395 evaporated during the drying process (Prमितasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic so
396 that the water in the material is more retained and difficult to evaporate. Gum arabic has a high molecular
397 weight and a complex molecular structure and contains a large amount of starch (Sutardi *et al.*, 2010).

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Deleted: The results show bahwa suhu pengeringan memengaruhi kadar air lemongrass and Malang apple powder drinks. Sementara itu, jenis pelapis tidak memengaruhi kadar air lemongrass and Malang apple powder drinks. Demikian juga, tidak ada interaksi antara suhu pengeringan dan jenis pelapis terhadap dalam memengaruhi kadar air lemongrass and Malang apple powder drinks. that the higher the drying temperature, the lower the water content of the powder.

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410 Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50°C
411 dextrin and it was in accordance with SNI number 01-4320-1996 in which the water content of powder
412 drinks was a maximum of 3% (BSN, 1996). It shows that powder drink products meet the requirements of
413 SNI number 01-4320-1996 and have a small possibility of being contaminated with microorganisms.

414

415 3.5 Ash content

416 According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of
417 minerals in a food. Ash is composed of various types of minerals with varying composition depending on
418 the type and source in food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content
419 of the results of the study was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher
420 the ash content. The increase in ash content is thought to be related to the higher drying temperature. It
421 causes more water in the material to evaporate, so that the water content is lower. It causes the
422 percentage of mineral content in the material to increase. The results of the study are in line with Shadri
423 *et al.* (2018).

424 ~~Dextrin is a polysaccharide group that has a simpler chemical structure than gum arabic.~~ Dextrin
425 consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile gum arabic has a more
426 complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose
427 (Alftren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of minerals that
428 are not burnt into substances that can evaporate. Ash content is the residue left when a sample of a food
429 ingredient is completely burned. The highest ash content is obtained in the dextrin coating with a drying
430 temperature of 45°C. In general, the ash content of the product was still within the limits of SNI 01-4320-
431 1996 regarding the quality requirements for powder drinks, namely a maximum of 1.5% (BSN, 1996).
432 Malang apple has a fairly high nutritional content, especially vitamins and minerals such as calcium,
433 phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2, and vitamin
434 C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A, vitamin C,
435 potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

436

437 3.6 Vitamin C

438 The results of the vitamin C test are presented in Table 6, showing an average value of vitamin C
439 between ~~72.69~~ mg/100g to ~~53.15~~ mg/100g. ~~The results demonstrated that the drying temperature and~~
440 ~~type of coating affected the vitamin C content. There was an interaction between the drying temperature~~
441 ~~and the type of coating in determining the vitamin C content of powdered drinks. The vitamin C content~~
442 ~~tends to decrease along with the increase in the drying temperature.~~ A decrease in vitamin C can occur
443 due to the unstable nature of vitamin C and is easily degraded, especially by heat (Parfiyanti *et al.*, 2016).
444 It shows that the drying process at high temperature can reduce the vitamin C content found in powder
445 drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily
446 oxidized to dehydroascorbic acid which plays a role in inhibiting excessive oxidation reactions (Susanti ~~and~~
447 ~~Putri~~, 2014).

448 The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin
449 produces the highest content of vitamin C compared to other types of coating. It is because dextrin can
450 protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the more
451 dextrin is added, the more vitamin C content in the product is maintained. Dextrin has the characteristic
452 of protecting vitamin C and compounds that are sensitive to heat or oxidation because the molecules of
453 dextrin are stable to heat and oxidation. In addition, according to Aretzy *et al.* (2018), maltodextrin can
454 protect volatile compounds and protect compounds that are sensitive to oxidation. ~~According to Morodi~~
455 ~~*et al.* (2022), gum arabic alone or combined with other biopolymers has been successfully applied on~~

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471 tomato slices and grapefruit slices to preserve the dried products' quality. The highest content of vitamin
472 C was produced in powder drinks dried at 40°C with dextrin coating (72.68 mg/100 g) and the lowest was
473 produced at 50°C with gum arabic coating (53.15 mg/100 g). The vitamin C content of mix fruit powder
474 drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and tween 80 dried at 50°C
475 produces the vitamin C content between 425 mg/100g – 550 mg/100g, which is higher than lemongrass
476 and Malang apple powder drinks (Minah, *et al.*, 2021).
477

478 3.7 Water activity

479 Table 7 shows the mean value of water activity (aw) of lemongrass and Malang apple powder drinks,
480 namely 0.44 to 0.50. The aw value of lemongrass and Malang apple powder drinks is lower than the aw
481 value for the bacterial growth requirement, namely 0.90. The aw value for yeast growth is 0.80-0.90, and
482 the aw value for mold growth is 0.60-0.70. The aw value is relatively decreased with increasing drying
483 temperature. In the drying process, the free water in the material will evaporate. The higher temperature
484 causes more water to evaporate. The lower the water content, the lower the water activity (Martins *et*
485 *al.*, 2019). According to Adri and Hersoelistyorini, (2013), the composition of water in foodstuffs such as
486 free water and bound water can affect the rate or duration of food drying. The relatively small aw value
487 does not allow the growth of bacteria, molds and yeasts in the product. Lemongrass extract shows great
488 potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella*
489 *typhimurium* and *Staphylococcus aureus*; this indicates the possibility of using medicinal plants as natural
490 antibacterial agents (Ibrahim and Salem, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying
491 is to reduce water content so that it is not easy for mold and bacteria to grow, eliminate the activity of
492 enzymes that can decompose the active substance content and facilitate further processing so that it can
493 be more compact, durable and easy to store.

494 The use of various coatings in this study relatively produces the same aw value. The use of
495 maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray
496 drying can protect protein, calcium, lactose powder (Martins *et al.*, 2019). The lowest water activity value
497 of lemongrass and Malang apple powder drinks was obtained for products with gum arabic coating at
498 drying temperature of 45°C (0.44).
499

500 3.8 Radical scavenging activity

501 The percent of radical scavenging activity shows the radical scavenging activity possessed by
502 antioxidant compounds. One of the plants that has potential as an antioxidant is lemongrass (Wibisono,
503 2011) and apple (Yudhianto *et al.*, 2013). Based on the percent of radical scavenging activity test in Table
504 8, the average inhibition value was 37.45% to 60.13%. Dextrin protects volatile chemicals and molecules
505 vulnerable to heat or oxidation. Gum arabic can help increase the stability of the coating component. Gum
506 arabic is another sort of heat-resistant coating (Daugan and Abdullah, 2013). Based on Table 8 it is also
507 known that drying temperature affects the percent of radical scavenging activity. The higher the drying
508 temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant activity in
509 the lemongrass and Malang apple powder drinks is thought to be related to the damage to the antioxidant
510 compounds due to high temperatures. According to Patras *et al.* (2010), antioxidant compounds are easily
511 degraded when exposed to heat. Heat accelerates the oxidation reaction of these compounds. The
512 degradation process occurs due to an increase in the rate of oxidation reactions by heat. Antioxidant
513 compounds that have been oxidized will be damaged. It is confirmed by Husna *et al.* (2013) that
514 antioxidant bioactive components have heat-resistant characteristics, so if the sample is extracted in hot
515 condition, it will reduce the value of its antioxidant activity. The results of the research by Widiastuti *et al.*
516 (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the higher

Deleted: According to Alfonsius (2015), the addition of gum arabic in the processing process can protect important compounds such as vitamins due to extreme temperatures, since gum arabic has the ability to form a body as a coating and has a strong bond to the compounds coated.

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538 the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content in
539 lemongrass is due to the large number of phenolic compounds it contains. The high content of phenolic
540 compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential
541 oil in lemongrass stems is very high with an effective inhibition of 89% and 89.63%, whereas in lemongrass
542 leaves it is slightly lower with antioxidant and antidiabetic activities ranging from 78.89% and 79.26%
543 respectively (Mirghani, *et al.*, 2012).

544 The use of dextrin coating with a drying temperature of 40°C produced the highest inhibition value
545 compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explains that dextrin is
546 composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the
547 oxidation process can be prevented. Dextrin has the characteristic of protecting volatile compounds and
548 compounds that are sensitive to heat or oxidation. Gum arabic can improve and maintain the stability of
549 the compounds being coated. Gum arabic is also a type of coating that is resistant to heat (Dauqan *and*
550 *Abdullah*, 2013). Meanwhile, maltodextrin can protect volatile compounds and protect compounds that
551 are sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high oxidation resistance and
552 can reduce the viscosity of the emulsion; combined with other coatings that have better emulsifying
553 properties, it causes the antioxidant compounds in the microencapsulants to be well covered and
554 protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural
555 antioxidants and anti-inflammatories which can prevent free radicals in the human body. Antioxidants in
556 lemongrass are able to inhibit the release of arachidonic acid by the mechanism of inhibiting kinase
557 protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid
558 synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are
559 citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants which are
560 very good for skin health. The very high antioxidant content is also the reason for the high consumption
561 of apples by the public as an effort to prevent diseases and other dysfunctions of body health.
562

563 3.9 Antioxidant content with inhibition concentration value of 50% (IC₅₀)

564 The IC₅₀ value is the concentration of the antioxidant source to neutralize 50% of the radical
565 compounds. The lower the IC₅₀ value, the better the antioxidant activity of the sample. IC₅₀ antioxidant
566 content are determined from the 3 best samples based on the highest inhibition percentage, namely on
567 lemongrass and Malang apple powders which are coated with dextrin with drying temperatures of 40°C,
568 45°C and 50°C. According to Phongpaichit *et al.* (2007), IC₅₀ value < 10 ppm indicates a very strong activity.
569 IC₅₀ 10-50 ppm indicates a strong activity, IC₅₀ > 50-100 ppm indicates moderate activity, and IC₅₀ > 100-
570 250 ppm indicates a weak activity. The results showed that the IC₅₀ value in the lemongrass and Malang
571 apple powder drinks was 0.9 to 1.47 % (Table 9), which indicated a very strong activity. The results of
572 research by Andriyani *et al.*, (2015) show that the IC₅₀ value of *Curcuma zanthorrhiza L.* and red ginger
573 powder functional drinks made using the spray drying method has the highest or strongest average value
574 of 0.62 ppm at 4% maltodextrin concentration and the lowest or weakest value of 1.00 ppm at 0%
575 maltodextrin concentration.
576

577 4. Conclusion

578 The results showed that the type of coating significantly affected the parameters of stability,
579 dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly
580 affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and
581 antioxidants. There was an interaction between the type of coating and the drying time that affected the

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586 bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was
587 determined based on the antioxidant content and high stability. The fast dissolution time was found in
588 lemongrass and Malang apple powder that was dried at 45°C with dextrin coating. The best lemongrass
589 and Malang apple powder drinks had the following characteristics: a solubility of 0.96 seconds, a bulk
590 density of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin
591 C content of 70.22%, a percent antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 %, and a water
592 activity 0.50.

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593 **Conflict of interest - Disclose any potential conflict of interest appropriately.**

594 The authors declare no conflict of interest.

595

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972 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

973

974 Table 5. The mean value of ash content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.17 ± 0.13 ^{ab}	1.46 ± 0.11 ^e	1.06 ± 0.07 ^a	1.23 ± 0.21 ^a
45°C	1.26 ± 0.01 ^{bcd}	1.21 ± 0.03 ^{abc}	1.24 ± 0.03 ^{bcd}	1.23 ± 0.02 ^a
50°C	1.26 ± 0.02 ^{bcd}	1.37 ± 0.01 ^{cde}	1.38 ± 0.09 ^{de}	1.33 ± 0.07 ^b
Mean ± SD	1.23 ± 0.05 ^a	1.34 ± 0.13 ^b	1.23 ± 0.16 ^a	

975 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

976 Table 6. The mean value of vitamin C content for lemongrass and Malang apple powder drinks (%)

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	68.11 ± 1.74 ^d	72.69 ± 2.74 ^e	61.95 ± 0.50 ^c	67.58 ± 5.39 ^c
45°C	63.36 ± 1.49 ^c	70.22 ± 1.24 ^{de}	58.26 ± 1.24 ^b	63.95 ± 6.09 ^b
50°C	54.91 ± 0.50 ^a	63.36 ± 1.49 ^c	53.15 ± 0.50 ^a	57.14 ± 5.46 ^a
Mean ± SD	62.13 ± 6.69 ^a	68.76 ± 4.83 ^b	57.79 ± 4.42 ^c	

981 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

982

983 Table 7. The mean value of water activity for lemongrass and Malang apple powder drinks

Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.48 ± 0.00	0.48 ± 0.02	0.51 ± 0.00	0.49 ± 0.02
45°C	0.51 ± 0.03	0.50 ± 0.01	0.44 ± 0.02	0.49 ± 0.04
50°C	0.49 ± 0.04	0.46 ± 0.05	0.46 ± 0.01	0.47 ± 0.02
Mean ± SD	0.49 ± 0.02	0.48 ± 0.02	0.47 ± 0.03	

984 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

985

986 Table 8. The mean value of radical scavenging activity content for lemongrass and Malang apple powder drinks (%)

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Drying Temperature	Coating Type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	56.96 ± 1.13 ^f	60.13 ± 0.05 ^h	53.66 ± 0.14 ^g	56.92 ± 3.24 ^e
45°C	45.73 ± 0.67 ^c	50.97 ± 0.11 ^e	48.17 ± 0.18 ^d	48.29 ± 2.69 ^d
50°C	37.45 ± 1.07 ^a	43.98 ± 0.71 ^b	37.53 ± 0.21 ^a	39.65 ± 3.75 ^a
Mean ± SD				

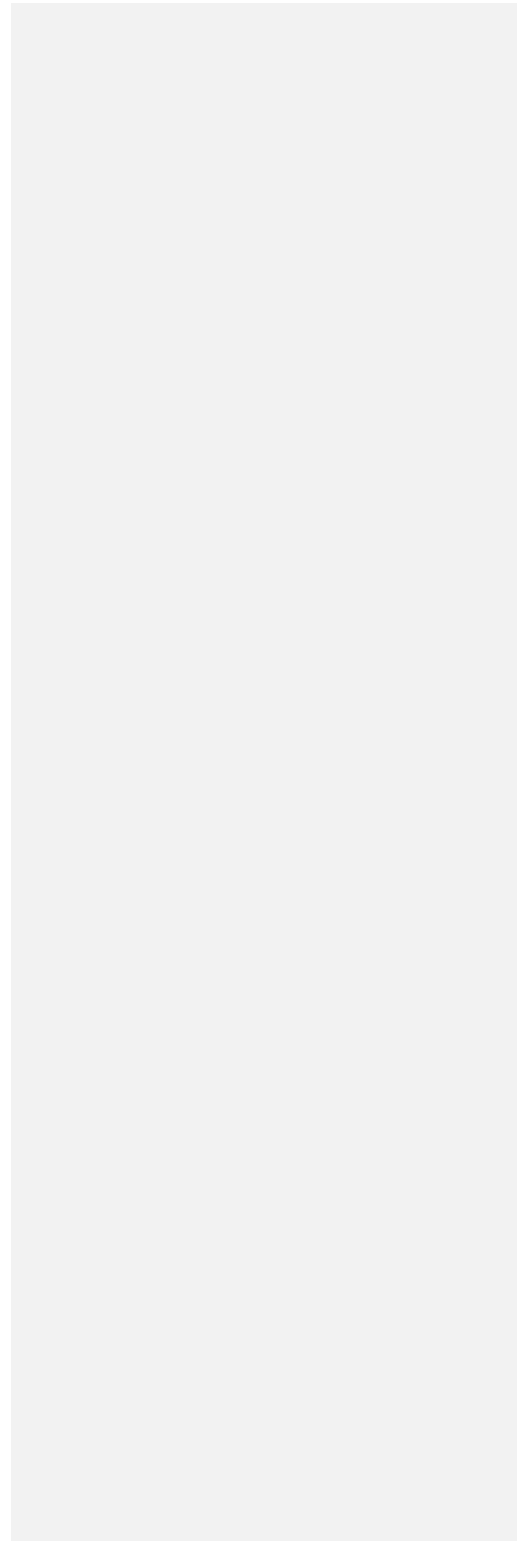
993 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

994

996 Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powder drinks (%)
997 on the best product

Drying Temperature	Coating Type Dekstrin
40°C	0.9 ± 0.01
45°C	1.279 ± 0.08
50°C	1.47 ± 0.01

998



1 **The effects of coating type and drying temperature on the physicochemical properties of the mixture**
2 **of lemongrass and apple powder drinks**

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20 **Abstract**

21 Fresh beverages from fruits and herbal plants that contain antioxidants are able to enhance the immunity
22 of the human body. However, such fresh beverage products generally have a short shelf life. As an
23 alternative, the products must be converted into powder drinks. Coating materials are thus needed to
24 avoid the loss of antioxidant compounds during the drying process. This study aimed to scrutinize the
25 effects of coating type and drying temperature on the quality of lemongrass and Malang apple powder
26 drinks. The study employed a completely randomized design (CRD) with two factors and two replications.
27 The first factor was the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second
28 factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). The data were analyzed using ANAVA
29 test and Duncan's further test if the treatment was significantly different. The results showed that the
30 type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C,
31 and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution
32 time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the
33 coating type and drying time that affected the bulk density, stability, dissolution time, ash content, vitamin
34 C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin

35 coating type with the drying temperature of 45°C. Product characteristics included a solubility of 0.96
36 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of
37 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of
38 1.29, and a water activity of 0.50.

39 **Keywords:** Apples, Dextrin, Powder Drinks, Drying, Lemongrass

40

41 1. Introduction

42 The COVID-19 pandemic has forced people to maintain their health through increasing their body's
43 immunity. Body immunity can be enhanced through an adequate diet and nutrition from drinks (Iddir *et*
44 *al.*, 2020). Powder drinks are a processed food product in the form of a powder. Having a relatively long
45 shelf life, the product is easy to serve and can be rapidly dissolved in water. In addition, powder drinks are
46 easy to carry and ship (Tangkeallo *et al.*, 2014), making the product to be liked by the public. One of the
47 ingredients that can boost the body's immunity is herbal plants. The plants are known to contain
48 antioxidant compounds. Antioxidants are able to capture free radicals to enhance the immunity of the
49 body (Cakmakci *et al.*, 2015). One of the popular herbal plants that contain antioxidants is lemongrass.
50 Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*, *eugenol*, *dipentene*,
51 *citral* (Wibisono, 2011). Acting as anticancer and antioxidants, these compounds can stabilize blood
52 pressure, treat constipation, help the digestive system, tighten the body after childbirth (Poeloengan,
53 2009), and reduce pain (Royhanaty *et al.*, 2018). In addition to lemongrass, Malang apples, a famous fruit
54 typical of the city of Malang, also belong to the food ingredient that can enhance the body's immunity.
55 Being small in size, Malang apples have low economic value because they are less attractive to consumers
56 (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019), Malang apples contain lots of
57 vitamins such as vitamins A, B, C, minerals, and fiber. The apples also contain flavonoid compounds,
58 including quercetin. Vitamin C and quercetin act as antioxidants, antivirals, and anti-inflammatories that
59 protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free
60 radicals and reduce free radicals (Suparni dan Wulandari, 2012).

61 However, although containing beneficial antioxidants, lemongrass and Malang apples are rarely used
62 as ingredients to make powdered beverages. Due to its practicality, ready-to-serve drinks in a powder
63 form (Sari *et al.*, 2021) with both ingredients are necessary to be made. In order to function as nutritional
64 drinks, the making of powder drinks from lemongrass and Malang apples should pay special attention to
65 the drying process (Naibaho *et al.*, 2015). It is because the active ingredients contained in lemongrass and
66 Malang apples are volatile. Drying at high temperatures in a long time can reduce the antioxidant activity
67 of the dried material (Yamin *et al.*, 2017). To maintain the amount of antioxidants present, it is necessary
68 to find the right drying temperature. In addition, coating materials are needed to maintain the existing
69 volatile compounds. The commonly used coating material is gum arabic because this material has the
70 ability to form good emulsions and films. Compared to modified starch, gum arabic as a coating material
71 is able at maintaining the stability of volatile compounds and trapping the highest volatile components
72 (Santoso *et al.*, 2013). Gum arabic can preserve the flavor of dried materials by coating the flavor particles,
73 protecting them from oxidation, absorption, and evaporation of water from the air (Herawati, 2018).
74 According to Harahap *et al.* (2021), maltodextrin has a high solubility, a strong binding power, and low
75 browning properties. In addition, being able to disperse quickly, maltodextrin can inhibit crystallization
76 and form low hygroscopic properties. Meanwhile, dextrin has a high solubility, but it has a relatively low

77 ability to bind water and a relatively low viscosity (Asiah *et al.*, 2012). Based on the description above, this
78 study aimed at investigating the effects of coating type and drying temperature on the quality of
79 lemongrass and Malang apple powder drinks. The quality of the powder drinks was determined based on
80 physical tests in the form of bulk density, dissolution time, and stability test. These tests were required to
81 determine packaging. In addition, chemical tests were carried out in the form of water content, ash
82 content, antioxidant activity, water activity, and vitamin C. These tests would indirectly determine the
83 shelf life of the product and its ability to enhance the body immunity. This research has yielded a product
84 with the following characteristics: easy to carry, having a potential to boost the body immunity, and having
85 a relatively long shelf life.

86

87 **2. Materials and methods**

88 *2.1 Material*

89 The materials used in the study were lemongrass stems and seedless Malang apples, maltodextrin,
90 dextrin, gum arabic powder, water, and brown sugar. The materials for chemical analysis were distilled
91 water, starch indicator, 0.1 N NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the
92 study were a Mitzui blender, cutting boards, measuring cups, knives, WTC Binder 78532 blower ovens,
93 baking sheets, spoons, Matrix ESJ210-4B scales, volumetric flasks, erlenmeyer, burettes, measuring
94 pipettes, a suction ball, a funnel pipette, a beaker glass, a filter paper, a burette, a stative, a Siever 60
95 mesh, and a UV2100 spectrophotometer.

96

97 *2.2 The process of making lemongrass and malang apple powder drinks*

98 The process of making powder drinks was a modification of the research of Susanti and Putri (2014).
99 The process of making powder drinks consisted of two stages including the making of fruit pulp and the
100 drying process.

101

102 *2.2.1 Making fruit pulp*

103 The making of fruit pulp began with the sorting of the lemongrass and Malang apples. The ingredients
104 sorted were washed and cut (1:1 w/w), and then crushed with a blender for 5 mins at speed number 2.
105 Afterwards, the pulp was added with water in a ratio of 1:1 w/w. The coating materials (maltodextrin,
106 dextrin, and gum Arabic) were then added as much as 5% w/w of the fruit pulp separately. The pulp was
107 stirred until homogeneous.

108

109 *2.2.2 Drying*

110 Each homogeneous fruit pulp was placed on a 60 × 40 × 2 cm baking sheet as much as 250 mL. It was
111 then dried with a blower oven at a predetermined temperature (40°C, 45°C, and 50°C) separately for 18
112 hrs. Afterwards, the dried sheets of lemongrass and Malang apples were then crushed separately with a
113 blender for 3 mins at speed number 2. Then, brown sugar was added at 10% w/w of the dry powder. After
114 that, the powder was sieved using a 60-mesh sieve. Lemongrass powder drinks were packaged in
115 aluminum foil zip lock with a size of 7 × 13 cm.

116

117 *2.3. Analysis procedure of bulk density*

118 The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring
119 cup containing the powder sample was tapped 30 times until there were no more cavities when the

120 powder sample was adjusted to 10 mL. The measuring cup containing the powder sample was then
121 weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its
122 volume (10 mL).

123

124 *2.4 Analysis procedure of dissolution time testing*

125 A total of 5 g sample was weighed. The sample was then dissolved in 50 mL of warm water and stirred
126 20 times until homogeneous. The dissolving time of the sample was recorded.

127

128 *2.5 Analysis procedure of stability testing*

129 A total of 5 g of powder was weighed and brewed in 50 mL of water. It was then put into a 10 mL
130 measuring cup and kept for 24 h. Afterwards, the solution was measured for the volume of the precipitate
131 and the height of the solution volume as the percentage of stability of the drink obtained.

132

133 *2.6 Analysis procedure of water content by oven drying method*

134 An empty cup was dried in the oven for 15 mins. The cup was then cooled in a desiccator (10 mins for
135 an aluminum cup and 20 mins for a porcelain cup). The dry cup was weighed. The sample was weighed as
136 much as 2-3 g and then put in the dry cup. After that, the cup containing the sample was put in the oven
137 at 105°C for 6 h. Next, it was cooled in a desiccator, and then weighed. The drying process was repeated
138 until a constant weight was obtained. The water content was calculated based on the loss of weight, by
139 calculating the difference between the initial weight of the sample before the drying and the final weight
140 after the drying.

141

142 *2.7 Analysis procedure of ash content by muffle furnace method*

143 A porcelain cup was dried in the oven for 15 mins. The cup was cooled in a desiccator, and then
144 weighed. The sample was weighed as much as 3 g in a cup that had been dried. Afterwards, it was burned
145 in a crucible until it no longer emitted smoke. Next, the ashing process was carried out using an electric
146 furnace at a temperature of 400-600°C for 4-6 h until the white ash was formed and had a constant weight.
147 The ash formed in the cup was cooled in a desiccator, and then weighed.

148

149 *2.8 Analysis procedure of radical scavenging activity*

150 Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging
151 activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-
152 1picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free
153 radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample
154 of 100 ppm was made by dissolving 0.01 mL of sample in 100 mL of methanol PA. A total of 1 mL of DPPH
155 solution (10 mg/L) was added to 50 µL of sample solution. Afterwards, methanol pro analyzed was added
156 up to 5 mL, then incubated for 30 mins at 37°C. The absorbance was measured at a wavelength of 513
157 nm. The antioxidant activity of the sample was determined by the magnitude of the DPPH radical uptake
158 inhibition through calculating the percentage of DPPH uptake inhibition.

159

160 *2.9 Analysis procedure of IC₅₀ antioxidant activity*

161 Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging
162 activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-
163 1picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free

164 radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample
165 of 100 ppm was made by dissolving 0.01 mL of the sample in 100 mL of methanol PA. Furthermore, dilution
166 was carried out using the methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8
167 ppm and 9 ppm for each sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH
168 stock solution was prepared by dissolving 5 mg of solid DPPH in 100 mL of methanol PA. Then a
169 comparison solution was prepared, namely a control solution containing 2 mL of methanol PA and 1 mL
170 of 50 ppm DPPH solution. For the test sample, 2 mL of the sample solution and 2 mL of the DPPH solution
171 were prepared. Then, the solution was kept for 30 mins. All samples, the extract samples that had been
172 kept, were tested for measuring the absorbance values using a UV-visible spectrophotometer at a
173 wavelength of 517 nm.

174

175 *2.10 Analysis procedure of water activity testing*

176 The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated
177 by adding BaCl₂.2H₂O. It was then closed and kept for 3 mins until the number on the scale became 0.9.
178 The aw-meter was then opened and the sample was inserted. Afterwards, the tool was closed and waited
179 until the aw scale was read. The temperature scale and the correction factor were observed. When the
180 temperature scale was above 20°C, the aw scale reading was added as much as the excess of the
181 temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.

182

183 *2.11 Analysis procedure of vitamin C testing*

184 The analysis of vitamin C was performed by iodometric method. The crushed sample was weighed as
185 much as 5 g. The sample was put into a 100 mL measuring flask. Distilled water was then added up to the
186 line mark. The sample was then shaken until homogeneous. Afterwards, the solution was filtered and the
187 filtrate was pipetted as much as 25 mL, and put into an Erlenmeyer flask. A few drops of starch indicator
188 were added, then titrated rapidly using 0.01 N iodine solution until a blue color appeared. The vitamin C
189 content was obtained from the following formula:

$$190 \quad \text{Vitamin C (mg/100 g)} = \frac{V I_2 \times 0.88 \times Fp \times 100}{W(g)}$$

191 V I₂ = iodine volume (mL)

192 0.88 = 0.88 mg ascorbic acid equivalent to 1 ml I₂ 0.01 N solution

193 Fp = dilution factor

194 W = sample mass (gram)

195

196

197 *2.12 Statistical analysis*

198 The data obtained were analyzed using the analysis of variance (ANOVA). When the data showed
199 that there was a significant effect, the Duncan Multiple Range Test was carried out. The testing was done
200 using the IBM SPSS Statistics 29 software. The significant level was set at α = 0.05.

201

202 **3. Results and discussion**

203 *3.1 Bulk density of lemongrass and Malang apple powder drinks*

204 The bulk density value indicates void space, namely the number of empty cavities between the
205 material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2008).
206 The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The findings revealed that

207 the drying temperature and coating type had an effect on the density value of the Kamba powder drink.
208 Furthermore, the density value of Kamba is affected by a relationship between the drying temperature
209 and coating type. The higher the drying temperature causes the bulk density value to decrease. It is
210 because the higher the drying temperature causes more water in the material to be evaporated.
211 Therefore, the resulting water content is lower, causing the weight of the powder to become lighter.
212 According to Andriyani *et al.* (2015), as the drying temperature rises, the bulk density falls. The bulk
213 density is influenced by the type of material, the water content, and the shape and size of the material.
214 The smaller the bulk density, the more porous the product is (Widowati *et al.*, 2010).

215 Of the three types of coating used, gum arabic has the lowest bulk density compared to other
216 coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and
217 hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan
218 and Abdullah, 2013). Meanwhile, according to Purbasari (2019), dextrin is able to form films, form body,
219 inhibit crystallization, and quickly disperse. Dextrin also has high solubility, hygroscopic properties, low
220 browning properties, strong binding power. The dextrin film layer has a higher proportion of solids than
221 gum arabic since the DE value of dextrin is lower than gum arabic. Therefore, the drying process using
222 dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*, 2010). Maltodextrin is a
223 coating material that has a high level of solubility. It is due to the nature of maltodextrin which is soluble
224 in water and has a fast dispersion process. Maltodextrin is hygroscopic (has the ability to absorb water)
225 so that the water in the material is more retained and difficult to evaporate (Yuliaty and Susanto, 2015).

226 According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space
227 needed for that material. The greater the bulk density, the smaller the space needed, and vice versa. The
228 smaller the size of the molecule, the more easily the product will be compressed. The smaller gaps
229 between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum arabic
230 with a drying temperature of 50°C resulted in the lowest bulk density value of 0.52. According to Palijama
231 *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact (non-
232 voluminous). It means that in the same certain volume, the product is available in more weight. According
233 to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small. It means that light
234 weight requires a large space. The smaller the bulk density, the more porous the product is. Sadeghi *et al.*
235 (2010) state that the higher sphericity of the corn kernels results in a more regular arrangement of the
236 kernels. Therefore, the cavities between the kernels were smaller, resulting in a higher bulk density.
237 According to the preceding description, the drying temperature and the type of coating both affect the
238 density value of Kamba. It demonstrates that the two interact in altering the value of Kamba density.

239

240 3.2 Dissolution time

241 Dissolution time is a time for all beverage powder to dissolve in water perfectly. The testing of
242 dissolution time was carried out to determine the speed of solubility of the drinks. The higher the solubility
243 value of the powder product, the better the product is. It is because the perfect solubility will produce
244 products that do not float on the surface of the water (Phoungchandang *et al.*, 2009). The dissolution time
245 of lemongrass and Malang apple powder was 0.96 to 1.29 s (Table 2). The results showed that the higher
246 the drying temperature, the faster the dissolution time (Table 2). It is because the powder produced is
247 drier. The higher the drying temperature, the more water evaporated on the powder drinks so that the
248 water content is lower. The lower the water content, the more hygroscopic, the dissolution time is faster
249 (Paramita *et al.*, 2015 and Sakdiyah and Rekna, 2019).

250 The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin
251 has the fastest dissolution time (Table 2). When powder drinks are dissolved in water, especially warm
252 water, the hydroxyl groups in the coating substance will interact with the water, increasing the powder's
253 solubility (Yuliwaty and Susanto, 2015). Dextrin has a dextrose equivalent (DE) value of 3-5 and has the
254 ability to form layers (Tyanjani and Yunianta, 2015). With the addition of dextrin, the solubility of powder
255 drinks increases. It is because dextrin is easily soluble in water. It is in accordance with Nurhidayah *et al.*
256 (2014), who state that dextrin is easily soluble in water, disperse more quickly. Dextrin is not viscous and
257 more stable than starch.

258 According to Wulansari *et al.* (2012), Dextrose Equivalent (DE) of maltodextrin is 3-20. The higher
259 the DE value, the higher the monosaccharide content. It causes the binding power to be greater. Thus,
260 compared to dextrin, the use of maltodextrin allows the water content to be higher. Maltodextrin is a
261 filler that has a high level of solubility. It is due to the characteristic of maltodextrin that is soluble in water
262 (Hofman *et al.*, 2016). Gum arabic has a longer dissolution time than maltodextrin and dextrin. However,
263 according to Herawati (2018), gum arabic has a high solubility in water, making it better to be used as the
264 coating material in making powder drinks. The DE value of gum arabic is 6 (Soottitantawat *et al.*, 2006).
265 According to Hofman *et al.* (2016), the factor that affects the level of solubility in water is the DE value.
266 The higher the DE value, the better the solubility level.

267

268 3.3 Stability

269 Beverage products will be stable if the particles acting as the dispersed phase can be retained
270 without changing for a long time, or without experiencing grouping with each other (Anjani *et al.*, 2011).
271 The stability testing is expressed in the percentage of stability of the powder drinks made. The stability of
272 lemongrass and Malang apple powder drinks obtained an average of 63.89% to 93.33% (Table 3). The
273 results show that the higher the drying temperature, the higher the resulting stability. The higher the
274 drying temperature, the lower the powder water content. It causes the product to absorb water more
275 easily so that the product becomes more stable when rehydrated. It is in line with Kryzhska *et al.* (2020)
276 who state that the high water content in powder products would seriously disrupt the product stability.
277 It would also cause the product to agglomerate when stored. The high-water content in a product can
278 cause damage due to the activity of microorganisms.

279 The type of coating also affects the stability value. Of the three types of coating used, dextrin has
280 the most stable results compared to the other types of coating. Dextrin can wrap the active ingredient
281 particles from oxidation reactions during storage, thereby increasing the product stability (Septevani *et*
282 *al.*, 2013). Belong to a group of polysaccharides, dextrin has a stronger ability to bind water because it
283 has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012).
284 The addition of maltodextrin can increase the stability of the drink, reducing the precipitate formed
285 (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the product does not precipitate too
286 much (Pramitasari *et al.*, 2011). Gum arabic has a more complex molecular structure than dextrin and
287 contains starch in it, so that gum arabic is more hygroscopic (Sutardi *et al.*, 2010). Gum arabic has a more
288 complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose
289 (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence of sediment in beverage products
290 can be caused by the presence of pectin. Table 3 showed that the dextrin treatment with a drying
291 temperature of 50°C is the coating material with the highest stability value of 93.33%.

292

293 3.4 Water content

294 The average water content of lemongrass and Malang apple powder drinks ranged from 2.06% to
295 2.57% (Table 4). In the manufacturing process, powder drinks are made by drying separately at 40°C, 45°C
296 and 50°C for 18 h. The results reveal that the drying temperature has an effect on the water content of
297 lemongrass and Malang apple powder drinks. Meanwhile, the type of coating had no effect on the water
298 content. Similarly, there was no interaction between the drying temperature and coating type affecting
299 the moisture content of the powder drinks. The higher the drying temperature, the lower the water
300 content of the powder. Drying causes the water content in the lemongrass and Malang apple powder to
301 evaporate. The higher temperature allows the powder to have the lower water content. According to
302 Wiyono (2011), the drying temperature factor is important. The water content can be removed quickly
303 when the material is dried in the high temperature (Wiyono, 2011). The increase of the heating
304 temperature tends to reduce the water content. There are more water molecules that evaporate from
305 the dried raw materials. Thus, the water content obtained is lower.

306 The type of coating has a relatively similar effect on the value of the water content. Of the three
307 types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by
308 maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic
309 as it easily absorbs water. But when it is dried, the absorbed water is released (Wulansari *et al.*, 2012).
310 The water content absorbed by the coating material will evaporate more easily than the water content in
311 the material tissue, so that the evaporation process of water in powder drinks becomes easier (Paramita
312 *et al.*, 2015). Maltodextrin has a low molecular weight and a simple structure, so that water is easily
313 evaporated during the drying process (Prमितasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic.
314 The water in the material coated with gum arabic is difficult to evaporate. Containing a large amount of
315 starch, gum arabic has a high molecular weight and a complex molecular structure (Sutardi *et al.*, 2010).
316 Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50°C
317 dextrin. It was in accordance with the SNI number 01-4320-1996 in which the water content of powder
318 drinks was a maximum of 3% (BSN, 1996). The powder drink products meet the requirements of SNI
319 number 01-4320-1996. The products have a small possibility of being contaminated with microorganisms.

320

321 3.5 Ash content

322 According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of
323 minerals in a food. Ash is composed of various types of minerals with varying composition depending on
324 the type and source in food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content
325 was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher the ash content. The
326 increase in ash content is related to the higher drying temperature. It causes more water in the material
327 to evaporate. Thus, that the water content is lower. It causes the percentage of mineral content in the
328 material to increase. The results of the study are in line with Shadri *et al.* (2018).

329 Dextrin is a polysaccharide group that has a simpler chemical structure than gum arabic. Dextrin
330 consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile, gum arabic has a more
331 complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose
332 (Alftren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of minerals that
333 are not burnt into substances that can evaporate. Ash content is the residue left when a sample of a food
334 ingredient is completely burned. The highest ash content is obtained in the dextrin coating with a drying
335 temperature of 45°C. In general, the ash content of the product was still within the limits of SNI 01-4320-
336 1996 regarding the quality requirements for powder drinks, namely a maximum of 1.5% (BSN, 1996).
337 Malang apples have a fairly high nutritional content, especially vitamins and minerals such as calcium,

338 phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2, and vitamin
339 C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A, vitamin C,
340 potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

341

342 3.6 Vitamin C

343 The results of the vitamin C test are presented in Table 6. It shows an average value of the vitamin
344 C between 72.69 mg/100 g to 53.15 mg/100 g. The results demonstrated that the drying temperature and
345 type of coating affected the vitamin C content. There was an interaction between the drying temperature
346 and type of coating in determining the vitamin C content of powder drinks. The vitamin C content tends
347 to decrease along with the increase of the drying temperature. A decrease in vitamin C can occur due to
348 the unstable nature of vitamin C that can be easily degraded, especially by heat (Parfiyanti *et al.*, 2016). It
349 shows that the drying process at high temperature can reduce the vitamin C content in powder drinks.
350 Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to
351 dehydroascorbic acid that plays a role in inhibiting excessive oxidation reactions (Susanti and Putri, 2014).

352 The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin
353 produces the highest content of vitamin C compared to other types of coating. Dextrin can protect the
354 volatile components of materials such as vitamin C from damage due to heat. Thus, the addition of more
355 dextrin helps maintain the more vitamin C content in the product. Dextrin can protect vitamin C and
356 compounds sensitive to heat or oxidation. It is because the molecules of dextrin are stable to heat and
357 oxidation. In addition, according to Aretzy *et al.* (2018), maltodextrin can protect volatile compounds and
358 protect compounds sensitive to oxidation. According to Morodi *et al.* (2022), GA alone or combined with
359 other biopolymers has been successfully applied on tomato slices and grapefruit slices to preserve the
360 dried products' quality. The highest content of vitamin C was produced in powder drinks dried at 40°C
361 with the dextrin coating (72.68 mg/100 g) and the lowest was produced at 50°C with the gum arabic
362 coating (53.15 mg/100 g). The vitamin C content of mix fruit powder drinks (red guava, papaya, apple, and
363 tomato) coated with maltodextrin and tween 80 dried at 50°C produces the vitamin C content between
364 425 mg/100 g - 550 mg/100 g, higher than lemongrass and Malang apple powder drinks (Minah, *et al.*,
365 2021).

366

367 3.7 Water activity

368 Table 7 shows the mean value of water activity (a_w) of lemongrass and Malang apple powder drinks,
369 namely 0.44 to 0.50. The a_w value of lemongrass and Malang apple powder drinks is lower than the a_w
370 value for the bacterial growth requirement at 0.90. The a_w value for yeast growth is 0.80-0.90, and the
371 a_w value for mold growth is 0.60-0.70. The a_w value is relatively decreased along with the increase of
372 drying temperature. In the drying process, the free water in the material will evaporate. The higher
373 temperature causes more water to evaporate. The lower the water content, the lower the water activity
374 (Martins *et al.*, 2019). According to Adri and Hersoelistyorini (2013), the composition of water in
375 foodstuffs, such as free water and bound water, can affect the duration of food drying. The relatively small
376 a_w value does not allow the growth of bacteria, molds, and yeasts in the product. The lemongrass extract
377 has a great potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella*
378 *typhimurium* and *Staphylococcus aureus*, indicating the possibility of using medicinal plants as natural
379 antibacterial agents (Ibrahim and Salem, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying
380 is to reduce water content that it is not easy for mold and bacteria to grow. The drying process also

381 eliminates the activity of enzymes that can decompose the active substance content. It also facilitates
382 further processing so that the product can be more compact, durable, and easy to store.

383 The use of various coatings in this study relatively produces the same aw value. The use of
384 maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray
385 drying can protect protein, calcium, lactose powder (Martins *et al.*, 2019). The lowest water activity value
386 of lemongrass and Malang apple powder drinks was obtained for products with gum arabic coating at the
387 drying temperature of 45°C (0.44).

388

389 3.8 The percent of radical scavenging activity

390 The percent of radical scavenging activity shows the radical scavenging activity possessed by
391 antioxidant compounds. The plants that have potential as antioxidants are lemongrass (Wibisono, 2011)
392 and apples (Yudhianto *et al.*, 2013). Based on the percent of radical scavenging activity test in Table 8, the
393 average inhibition value was 37.45% to 60.13%. Dextrin protects volatile chemicals and molecules
394 vulnerable to heat or oxidation. Gum arabic can help increase the stability of the coating component. Gum
395 arabic is another sort of heat-resistant coating (Dauqan and Abdullah, 2013). Based on Table 8, the drying
396 temperature affects the percent of radical scavenging activity. The higher the drying temperature, the
397 lower the antioxidant activity value. The decrease in the value of antioxidant activity in the lemongrass
398 and Malang apple powder drinks is related to the damage to the antioxidant compounds due to high
399 temperatures. According to Patras *et al.* (2010), antioxidant compounds are easily degraded when
400 exposed to heat. Heat accelerates the oxidation reaction of these compounds. The degradation process
401 occurs due to an increase in the rate of oxidation reactions by heat. Antioxidant compounds that have
402 been oxidized will be damaged. It is confirmed by Husna *et al.* (2013) that antioxidant bioactive
403 components have heat-resistant characteristics. If the sample is extracted in hot condition, it will reduce
404 the value of its antioxidant activity. The results of the research by Widiastuti *et al.* (2019) show that the
405 more addition of lemongrass in lemongrass syrup with stevia sweetener, the higher the antioxidant
406 content. The highest antioxidant content is 50.55%. The high antioxidant content in lemongrass is due to
407 its large number of phenolic compounds. The high content of phenolic compounds also results in the
408 antidiabetic and antihypertensive activity. The antioxidant activity of essential oil in lemongrass stems is
409 very high, with an effective inhibition of 89% and 89.63%. In lemongrass leaves, it is slightly lower with
410 the antioxidant and antidiabetic activity ranging from 78.89% and 79.26% respectively (Mirghani, *et al.*,
411 2012).

412 The use of dextrin coating with a drying temperature of 40°C produced the highest inhibition value
413 compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explains that dextrin is
414 composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the
415 oxidation process can be prevented. Dextrin protects volatile compounds and compounds sensitive to
416 heat or oxidation. Gum arabic can maintain the stability of the compounds being coated. Gum arabic is
417 also resistant to heat (Dauqan and Abdullah, 2013). Meanwhile, maltodextrin can protect volatile
418 compounds and compounds sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high
419 oxidation resistance. It can reduce the viscosity of the emulsion. Combined with other coatings that have
420 better emulsifying properties, it causes the antioxidant compounds in the microencapsulants to be well
421 protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural
422 antioxidants and anti-inflammatories that can prevent free radicals in the human body. Antioxidants in
423 lemongrass are able to inhibit the release of arachidonic acid. It is through the mechanism of inhibiting
424 kinase protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic

425 acid synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are
426 citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants that are
427 very good for skin health. The very high antioxidant content is also the reason for the high consumption
428 of apples by the public. It is an effort to prevent diseases and other dysfunctions of body health.
429

430 3.9 Antioxidant content with inhibition concentration value of 50% (IC_{50})

431 The IC_{50} value is the concentration of the antioxidant source to neutralize 50% of the radical
432 compounds. The lower the IC_{50} value, the better the antioxidant activity of the sample. IC_{50} antioxidant
433 content is determined from the 3 best samples based on the highest inhibition percentage, namely on
434 lemongrass and Malang apple powders coated with dextrin with the drying temperatures of 40°C, 45°C
435 and 50°C. According to Phongpaichit *et al.* (2007), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50}
436 10-50 ppm indicates a strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250
437 ppm indicates a weak activity. The results showed that the IC_{50} value in the lemongrass and Malang apple
438 powder drinks was 0.9 to 1.47 % (Table 9), which indicated a very strong activity. The results of research
439 by Andriyani *et al.* (2015) show that the IC_{50} value of *Curcuma zanthorrhiza* L. and red ginger powder
440 functional drinks made using the spray drying method has the highest average value of 0.62 ppm at 4%
441 maltodextrin concentration, and the lowest or weakest value of 1.00 ppm at 0% maltodextrin
442 concentration.
443

444 4. Conclusion

445 The results showed that the type of coating significantly affected the parameters of stability,
446 dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly
447 affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and
448 antioxidants. There was an interaction between the type of coating and the drying time that affected the
449 bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was
450 determined based on the antioxidant content and high stability. The fast dissolution time was found in
451 the lemongrass and Malang apple powder dried at 45°C with the dextrin coating. The best lemongrass and
452 Malang apple powder drinks had the following characteristics: a solubility of 0.96 seconds, a bulk density
453 of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content
454 of 70.22%, a percent antioxidant inhibition of 50.97%, an IC_{50} content of 1.29 %, and a water activity 0.50.

455 Conflict of interest

456 The authors declare no conflict of interest.
457

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462

463

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704 Table 1. The mean value of bulk density for lemongrass and Malang apple powder drinks.

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.58±0.04 ^a	0.63±0.03 ^{bcd}	0.64±0.01 ^{bcd}	0.62±0.03
45°C	0.67±0.03 ^{ab}	0.58±0.05 ^{abc}	0.64±0.03 ^{bcd}	0.63±0.05
50°C	0.58±0.06 ^{abc}	0.67±0.02 ^{cd}	0.52±0.00 ^a	0.59±0.08
Mean±SD	0.61±0.05	0.63±0.05	0.60±0.60	

705 Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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709 Table 2. The mean value of dissolution time for lemongrass and Malang apple powder drinks (second).

Drying temperature	Coating type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.06±0.04 ^{bc}	1.11±0.01 ^{ab}	1.29±0.07 ^d	1.15±0.12 ^c
45°C	1.04±0.00 ^{abc}	0.96±0.07 ^a	1.05±0.03 ^{abc}	1.02±0.05 ^b
50°C	1.07±0.00 ^{bc}	1.01±0.02 ^{cd}	1.17±0.03 ^e	1.08±0.08 ^a
Mean±SD	1.05±0.01 ^a	1.03±0.08 ^a	1.17±0.12 ^b	

710 Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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714 Table 3. The mean value of stability for lemongrass and Malang apple powder drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	65.30±0.65 ^{ab}	87.32±0.45 ^e	63.89±2.66 ^a	72.17±13.14 ^c
45°C	73.01±0.57 ^d	89.19±0.43 ^e	69.69±0.59 ^c	77.30±10.43 ^b
50°C	78.74±1.00 ^d	93.33±0.40 ^f	80.19 ±0.00 ^e	84.09±8.03 ^a
Mean±SD	72.35±6.74 ^a	89.95±3.07 ^a	71.26±8.26 ^b	

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721 Table 4. The mean value of water content for lemongrass and Malang apple powder drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	2.57±0.06	2.51±0.04	2.54±0.02	2.54±0.03 ^c
45°C	2.39±0.06	2.38±0.12	2.31±0.03	2.36±0.04 ^b
50°C	2.07±0.02	2.16±0.02	2.06±0.02	2.10±0.05 ^a
Mean±SD	2.34±0.25	2.35±0.18	2.30±0.24	

722 Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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726 Table 5. The mean value of ash content for lemongrass and Malang apple powder drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	1.17±0.13 ^{ab}	1.46±0.11 ^e	1.06±0.07 ^a	1.23±0.21 ^a
45°C	1.26±0.01 ^{bcd}	1.21±0.03 ^{abc}	1.24±0.03 ^{bcd}	1.23±0.02 ^a
50°C	1.26±0.02 ^{bcd}	1.37±0.01 ^{cde}	1.38±0.09 ^{de}	1.33±0.07 ^b
Mean±SD	1.23±0.05 ^a	1.34±0.13 ^b	1.23±0.16 ^a	

727 Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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731 Table 6. The mean value of vitamin C content for lemongrass and Malang apple powder drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	68.11±1.74 ^d	72.69±2.74 ^e	61.95±0.50 ^c	67.58 ±5.39 ^c
45°C	63.36±1.49 ^c	70.22±1.24 ^{de}	58.26±1.24 ^b	63.95±6.03 ^d
50°C	54.91±0.50 ^a	63.36±1.49 ^c	53.15±0.50 ^a	57.14±5.46 ^a
Mean±SD	62.13±6.69 ^a	68.76±4.83 ^b	57.79±4.42 ^c	

736 Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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743 Table 7. The mean value of water activity for lemongrass and Malang apple powder drinks.

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	0.48±0.00	0.48±0.02	0.51±0.00	0.49±0.02
45°C	0.51±0.03	0.50±0.01	0.44±0.02	0.49±0.04
50°C	0.49±0.04	0.46±0.05	0.46±0.01	0.47±0.02
Mean±SD	0.49±0.02	0.48±0.02	0.47±0.03	

744 Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

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748 Table 8. The mean value of radical scavenging activity content for lemongrass and Malang apple powder
749 drinks (%).

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Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40°C	56.96±1.13 ^f	60.13±0.05 ^h	53.66±0.14 ^g	56.92±3.24 ^{f52}
45°C	45.73±0.67 ^c	50.97±0.11 ^e	48.17±0.18 ^d	48.29±2.67 ^{d53}
50°C	37.45±1.07 ^a	43.98±0.71 ^b	37.53±0.21 ^a	39.65±3.75 ^{a54}

755 Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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759 Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powder drinks (%)
760 on the best product.

Drying temperature	Coating type
	Dekstrin
40°C	0.9±0.01
45°C	1.279±0.08
50°C	1.47±0.01

761

17th June 2024

Dear Saputra,

ACCEPTANCE LETTER

Food Research is pleased to inform you that the following manuscript has been accepted for publication in Food Research journal.

Manuscript Title : The effects of coating type and drying temperature on the physicochemical properties of the mixture of lemongrass and apple powder drinks
Authors : Rahmawati, R., Azni, I.N., Saputra, D. and Maharani, A.F.

We thank you for your fine contribution to the Food Research journal and encourage you to submit other articles to the Journal.

Yours sincerely,



Professor Dr. Son Radu
Chief Editor
Food Research



Rahmawati Farasara <rahmafarasara@gmail.com>

Re: FR-2023-077 Upcoming Process

Dede Saputra <ddsaputra2020@gmail.com>
To: Food Research <foodresearch.my@outlook.com>
Cc: rahmafarasara@gmail.com, foodstandardconsultant@gmail.com

Thu, Jul 11, 2024 at 1:58 PM

Dear Chief Editor Prof. Dr. Son Radu

We would appreciate further information about the next steps in relation to the publication charges of documents.

The APC form was completed by us and returned on June 22, 2024, with the INVOICE RECIPIENT section completed.

We look forward to more details on the next procedure.

Sincerely yours,***Dede Saputra***

On Sat, Jun 29, 2024 at 8:01 PM Dede Saputra <ddsaputra2020@gmail.com> wrote:

Dear Prof. Dr. Son Radu
Chief Editor of Food Research

Regarding our document with code
FR-2023-077 dear chief editor... Kindly notify us about the upcoming procedure about the management of payments for journal issuance.

Thank you so much for many attention

Regards,

Dede Saputra

On Tue, 25 Jun 2024 at 20.53 Food Research <foodresearch.my@outlook.com> wrote:

Dear Dede Saputra,
Noted with thanks.

Best regards,
Son Radu
Chief Editor

From: Dede Saputra <ddsaputra2020@gmail.com>
Sent: Saturday, 22 June, 2024 4:20 AM
To: Food Research <foodresearch.my@outlook.com>
Cc: rahmafarasara@gmail.com <rahmafarasara@gmail.com>
Subject: Re: FR-2023-077 (revision)

Dear Professor Son Radu,
Chief Editor, Food Research Journal

FR-2023-077

We would like to extend our sincere gratitude to the journal writing team and myself for this wonderful news.

From the time of our submission through the review process, the improvements made by the review team, and the layout of the manuscript, we were able to truly enjoy each step of the process of being accepted and published by the Food Research Journal publication.

We are appreciative of your exceptional focus.

Please find attached the data from **the Article Processing Fee Form.**

Sincerely yours,

Dede Saputra
(Saputra, D)

On Mon, Jun 17, 2024 at 12:39AM Food Research <foodresearch.my@outlook.com> wrote:

Dear Saputra,

Please see attached files.

1. The Letter of Acceptance for your manuscript.
2. The Article Processing Charges (APC) Form. Please fill the APC Form at the INVOICE RECIPIENT section and return it immediately to us to enable us to process your manuscript.

Best Regards,

Professor Dr. Son Radu

Chief Editor

From: Dede Saputra <ddsaputra2020@gmail.com>
Sent: Sunday, 16 June, 2024 8:50 PM
To: Food Research <foodresearch.my@outlook.com>
Subject: Re: FR-2023-077 (revision)

Dear Professor Son Radu

Chief Editor of Food Research

The requested corrections to our journal will be sent to the email that is attached below. We're hoping that the Food Research Journal will accept and publish this enhancement.

I am grateful for your time and consideration. More positive news is what we're waiting for.

Greetings

Dede Saputra

On Fri, May 31, 2024 at 5:09AM Food Research <foodresearch.my@outlook.com> wrote:

Dear Saputra,

Please edit/revise your manuscript following the comments appended on the attached manuscript.

Please use the attached copy to to the editing.

Best regards,

Son Radu

Chief Editor



Dr. Rahmawati, ST, M.Si. <rahmafarasara@usahid.ac.id>

FR-2023-077 - Article Production

Food Research Production <fr.production@outlook.com>

Wed, Oct 23, 2024 at 5:37 AM

To: "rahmafarasara@usahid.ac.id" <rahmafarasara@usahid.ac.id>, "foodstandardconsultant@gmail.com" <foodstandardconsultant@gmail.com>, "ddsaputra2020@gmail.com" <ddsaputra2020@gmail.com>

Dear Dr Rahma and co-authors,

Manuscript ID: FR-2023-077

Manuscript Title: The effects of coating type and drying temperature on the physicochemical properties of the mixture of lemongrass and apple powdered drinks

Before we can proceed with the article production, I would like to clarify a few points that I have commented in the manuscript. Please refer to the attachment. Please address the issues raised in the comments.

Please use the attached copy to make your revisions as it has been corrected to the Journal's format. Do not delete the comments. Once you have done so, kindly revert the copy to me as soon as possible. Please note that the faster you respond, the quicker we will process your manuscript.

Thanks & Regards,

Dr Vivian New, PhD

Editor | Food Research

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Website: www.myfoodresearch.com



FR-2023-077 checked + (1).docx

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The effects of coating type and drying temperature on the physicochemical properties of the mixture of lemongrass and apple powdered drinks

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Abstract

Fresh beverages from fruits and herbal plants that contain antioxidants are able to enhance the immunity of the human body. However, such fresh beverage products generally have a short shelf life. As an alternative, the products must be converted into powdered drinks. Coating materials are thus needed to avoid the loss of antioxidant compounds during the drying process. This study aimed to scrutinize the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The study employed a completely randomized design (CRD) with two factors and two replications. The first factor was

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the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). The data were analyzed using Analysis of variance one-way (ANOVA) test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the coating type and drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of 1.29, and a water activity of 0.50.

Keywords: Apples, Dextrin, Powdered drinks, Drying, Lemongrass

1. Introduction

The COVID-19 pandemic has forced people to maintain their health by increasing their body's immunity. Body immunity can be enhanced through an adequate diet and nutrition from drinks (Iddir *et al.*, 2020). Powdered drinks are processed food products in the form of a powder. Having a relatively long shelf life, the product is easy to serve and can be rapidly dissolved in water. In addition, powdered drinks are easy to carry and ship (Tangkeallo *et al.*, 2014), making the product to be liked by the public. One of the ingredients that can boost the body's immunity is herbal plants. The plants are known to contain antioxidant compounds. Antioxidants are able to capture free radicals to enhance the immunity of the body (Cakmakci *et al.*, 2015). One of the popular herbal plants that contains antioxidants is lemongrass. Lemongrass contains compounds including *geraniol*, *citronellol*, *limonene*, *kadinene*, *eugenol*, *dipentene*, *citral* (Wibisono, 2011). Acting as an anticancer and antioxidant, these compounds can stabilize blood pressure, treat constipation, help the digestive system, tighten the body after childbirth (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). In addition to lemongrass, Malang apples, a famous fruit typical of the city of Malang, also belong to the food ingredient that can enhance the body's immunity. Being small in size, Malang apples have low economic value because they are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019), Malang apples contain lots of vitamins such as vitamins A, B,

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and C, minerals, and fiber. The apples also contain flavonoid compounds, including quercetin. Vitamin C and quercetin act as antioxidants, antivirals, and anti-inflammatories that protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free radicals and reduce free radicals (Suparni dan Wulandari, 2012).

However, although containing beneficial antioxidants, lemongrass and Malang apples are rarely used as ingredients to make powdered beverages. Due to its practicality, ready-to-serve drinks in powder form (Sari *et al.*, 2021) with both ingredients are necessary to be made. In order to function as a nutritional drink, the making of powdered drinks from lemongrass and Malang apples should pay special attention to the drying process (Naibaho *et al.*, 2015). It is because the active ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures for a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the amount of antioxidants present, it is necessary to find the right drying temperature. In addition, coating materials are needed to maintain the existing volatile compounds. The commonly used coating material is gum Arabic because this material has the ability to form good emulsions and films. Compared to modified starch, gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the highest volatile components (Santoso *et al.*, 2013). Gum arabic can preserve the flavor of dried materials by coating the flavor particles, protecting them from oxidation, absorption, and evaporation of water from the air (Herawati, 2018). According to Harahap *et al.* (2021), maltodextrin has a high solubility, a strong binding power, and low browning properties. In addition, being able to disperse quickly, maltodextrin can inhibit crystallization and form low hygroscopic properties. Meanwhile, dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity (Asiah *et al.*, 2012).

Based on the description above, this study aimed to investigate the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The quality of the powdered drinks was determined based on physical tests in the form of bulk density, dissolution time, and stability tests. These tests were required to determine packaging. In addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity, water activity, and vitamin C. These tests would indirectly determine the shelf life of the product and its ability to enhance the body's immunity. This research has yielded a product with the following characteristics: easy to carry, having the potential to boost the body's immunity, and having a relatively long shelf life.

2. Materials and methods

2.1 Materials and equipment

The materials used in the study were lemongrass stems and seedless Malang apples, maltodextrin, dextrin, gum Arabic powder, water, and brown sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a Mitzui blender, cutting boards, measuring cups, knives, WTC Binder 78532 blower ovens, baking sheets, spoons, Matrix ESJ210-4B scales, volumetric flasks, Erlenmeyer, burettes, measuring pipettes, a suction ball, a funnel pipette, a beaker glass, a filter paper, a burette, a stative, a Siever 60 mesh, and a UV2100 spectrophotometer.

2.2 The process of making lemongrass and malang apple powdered drinks

The process of making powdered drinks was a modification of the research of Susanti and Putri (2014). The process of making powdered drinks consisted of two stages including the making of fruit pulp and the drying process.

2.2.1 Making fruit pulp

The making of fruit pulp began with the sorting of the lemongrass and Malang apples. The ingredients sorted were washed and cut (1:1 w/w), and then crushed with a blender for 5 mins at speed number 2. The pulp was added with water in a ratio of 1:1 w/w. The coating materials (maltodextrin, dextrin, and gum Arabic) were then added as much as 5% w/w of the fruit pulp separately. The pulp was stirred until homogeneous.

2.2.2 Drying

Each homogeneous fruit pulp was placed on a 60 × 40 × 2 cm baking sheet as much as 250 mL. It was then dried with a blower oven at a predetermined temperature (40 °C, 45 °C, and 50 °C) separately for 18 h. Afterwards, the dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3 mins at speed number 2. Then, brown sugar was added at 10% w/w of the dry powder. After that, the powder was sieved using a 60-mesh sieve. Lemongrass powdered drinks were packaged in aluminum foil zip lock with a size of 7 × 13 cm.

2.3. Analysis procedure of bulk density

The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring cup containing the powder sample was tapped 30 times until there were no more cavities when the powder

sample was adjusted to 10 mL. The measuring cup containing the powder sample was then weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its volume (10 mL).

2.4 Analysis procedure of dissolution time testing

A total of 5 g sample was weighed. The sample was then dissolved in 50 mL of warm water and stirred 20 times until homogeneous. The dissolving time of the sample was recorded.

2.5 Analysis procedure of stability testing

A total of 5 g of powder was weighed and brewed in 50 mL of water. It was then put into a 10 mL measuring cup and kept for 24 h. Afterwards, the solution was measured for the volume of the precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

2.6 Analysis procedure of water content by oven drying method

An empty cup was dried in the oven for 15 mins. The cup was then cooled in a desiccator (10 mins for an aluminum cup and 20 mins for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2-3 g and then put in the dry cup. After that, the cup containing the sample was put in the oven at 105°C for 6 h. Next, it was cooled in a desiccator and then weighed. The drying process was repeated until a constant weight was obtained. The water content was calculated based on the loss of weight, by calculating the difference between the initial weight of the sample before the drying and the final weight after the drying.

2.7 Analysis procedure of ash content by muffle furnace method

A porcelain cup was dried in the oven for 15 mins. The cup was cooled in a desiccator and then weighed. The sample was weighed as much as 3 g in a cup that had been dried. Afterwards, it was burned in a crucible until it no longer emitted smoke. Next, the ashing process was carried out using an electric furnace at a temperature of 400-600°C for 4-6 hrs until the white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

2.8 Analysis procedure of radical scavenging activity

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenylpicrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free

radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 mL of the sample in 100 mL of methanol PA. A total of 1 mL of DPPH solution (10 mg/L) was added to 50 μ L of sample solution. Afterwards, methanol pro analyzed was added up to 5 mL, then incubated for 30 mins at 37°C. The absorbance was measured at a wavelength of 513 nm. The antioxidant activity of the sample was determined by the magnitude of the DPPH radical uptake inhibition by calculating the percentage of DPPH uptake inhibition.

2.9 Analysis procedure of IC₅₀ antioxidant activity

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenylpicrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 mL of the sample in 100 mL of methanol PA. Furthermore, dilution was carried out using the methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was prepared by dissolving 5 mg of solid DPPH in 100 mL of methanol PA. Then a comparison solution was prepared, namely a control solution containing 2 mL of methanol PA and 1 mL of 50 ppm DPPH solution. For the test sample, 2 mL of the sample solution and 2 mL of the DPPH solution were prepared. Then, the solution was kept for 30 mins. All samples, the extract samples that had been kept, were tested for measuring the absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

2.10 Analysis procedure of water activity testing

The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated by adding BaCl₂.2H₂O. It was then closed and kept for 3 mins until the number on the scale became 0.9. The aw-meter was then opened and the sample was inserted. Afterwards, the tool was closed and waited until the aw scale was read. The temperature scale and the correction factor were observed. When the temperature scale was above 20°C, the aw scale reading was added as much as the excess of the temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.

2.11 Analysis procedure of vitamin C testing

The analysis of vitamin C was performed by the iodometric method. The crushed sample was weighed as much as 5 g. The sample was put into a 100 mL measuring flask. Distilled water was then added up to

the line mark. The sample was then shaken until homogeneous. Afterwards, the solution was filtered and the filtrate was pipetted as much as 25 mL, and put into an Erlenmeyer flask. A few drops of the starch indicator were added, then titrated rapidly using 0.01 N iodine solution until a blue color appeared. The vitamin C content was obtained from the following formula:

$$\text{Vitamin C (mg/100 g)} = \frac{V_{I_2} \times 0.88 \times Fp \times 100}{W(g)}$$

Where V_{I_2} = iodine volume (mL), 0.88 = 0.88 mg ascorbic acid equivalent to 1 ml I_2 0.01 N solution, Fp = dilution factor and W = sample mass (g).

2.12 Statistical analysis

The data obtained were analyzed using the analysis of variance (ANOVA). When the data showed that there was a significant effect, the Duncan Multiple Range Test was carried out. The testing was done using the IBM SPSS Statistics 29 software. The significant level was set at $\alpha = 0.05$.

3. Results and discussion

3.1 Bulk density of lemongrass and Malang apple powdered drinks

The bulk density value indicates void space, namely the number of empty cavities between the material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2008). The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The findings revealed that the drying temperature and coating type had an effect on the density value of the Kamba powdered drink. Furthermore, the density value of Kamba is affected by a relationship between the drying temperature and coating type. The higher the drying temperature causes the bulk density value to decrease. This is because the higher the drying temperature causes more water in the material to be evaporated. Therefore, the resulting water content is lower, causing the weight of the powder to become lighter. According to Andriyani *et al.* (2015), as the drying temperature rises, the bulk density falls. The bulk density is influenced by the type of material, the water content, and the shape and size of the material. The smaller the bulk density, the more porous the product is (Widowati *et al.*, 2010).

Of the three types of coating used, gum Arabic has the lowest bulk density compared to other coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan and Abdullah, 2013). Meanwhile, according to Purbasari (2019), dextrin is able to form films, form the body, inhibit crystallization, and quickly disperse. Dextrin also has high solubility, hygroscopic properties, low browning properties, and strong binding power. The dextrin film layer has a higher proportion of solids than

gum arabic since the DE value of dextrin is lower than gum arabic. Therefore, the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*, 2010). Maltodextrin is a coating material that has a high level of solubility. It is due to the nature of maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has the ability to absorb water) so the water in the material is more retained and difficult to evaporate (Yuliwaty and Susanto, 2015).

According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space needed for that material. The greater the bulk density, the smaller the space needed, and vice versa. The smaller the size of the molecule, the more easily the product will be compressed. The smaller the gaps between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum Arabic with a drying temperature of 50 °C resulted in the lowest bulk density value of 0.52. According to Palijama *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact (non-voluminous). It means that in the same certain volume, the product is available in more weight. According to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small. It means that lightweight requires a large space. The smaller the bulk density, the more porous the product is. Sadeghi *et al.* (2010) state that the higher sphericity of the corn kernels results in a more regular arrangement of the kernels. Therefore, the cavities between the kernels were smaller, resulting in a higher bulk density. According to the preceding description, the drying temperature and the type of coating both affect the density value of Kamba. It demonstrates that the two interact in altering the value of Kamba density.

3.2 Dissolution time

Dissolution time is a time for all beverage powder to dissolve in water perfectly. The testing of dissolution time was carried out to determine the speed of solubility of the drinks. The higher the solubility value of the powder product, the better the product is. It is because the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang *et al.*, 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 s (Table 2). The results showed that the higher the drying temperature, the faster the dissolution time (Table 2). It is because the powder produced is drier. The higher the drying temperature, the more water evaporates on the powdered drinks so that the water content is lower. The lower the water content, the more hygroscopic, the dissolution time is faster (Paramita *et al.*, 2015 and Sakdiyah and Rekna, 2019).

The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin has the fastest dissolution time (Table 2). When powdered drinks are dissolved in water, especially warm water, the hydroxyl groups in the coating substance will interact with the water, increasing the powder's solubility (Yuliwaty and Susanto, 2015). Dextrin has a dextrose equivalent (DE) value of 3-5 and has the ability to form

layers (Tyanjani and Yunianta, 2015). With the addition of dextrin, the solubility of powdered drinks increases. This is because dextrin is easily soluble in water. This is in accordance with Nurhidayah *et al.* (2014), who state that dextrin is easily soluble in water, and disperses more quickly. Dextrin is not viscous and more stable than starch.

According to Wulansari *et al.* (2012), the dextrose equivalent (DE) of maltodextrin is 3-20. The higher the DE value, the higher the monosaccharide content. It causes the binding power to be greater. Thus, compared to dextrin, the use of maltodextrin allows the water content to be higher. Maltodextrin is a filler that has a high level of solubility. This is due to the characteristic of maltodextrin which is soluble in water (Hofman *et al.*, 2016). Gum Arabic has a longer dissolution time than maltodextrin and dextrin. However, according to Herawati (2018), gum Arabic has a high solubility in water, making it better to use as the coating material in making powdered drinks. The DE value of gum Arabic is 6 (Soottitantawat *et al.*, 2006). According to Hofman *et al.* (2016), the factor that affects the level of solubility in water is the DE value. The higher the DE value, the better the solubility level.

3.3 Stability

Beverage products will be stable if the particles acting as the dispersed phase can be retained without changing for a long time, or without experiencing grouping with each other (Anjani *et al.*, 2011). The stability testing is expressed in the percentage of stability of the powdered drinks made. The stability of lemongrass and Malang apple powdered drinks obtained an average of 63.89% to 93.33% (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The higher the drying temperature, the lower the powder water content. It causes the product to absorb water more easily so that the product becomes more stable when rehydrated. This is in line with Kryzhska *et al.* (2020) who state that the high water content in powder products would seriously disrupt the product stability. It would also cause the product to agglomerate when stored. The high water content in a product can cause damage due to the activity of microorganisms.

The type of coating also affects the stability value. Of the three types of coating used, dextrin has the most stable results compared to the other types of coating. Dextrin can wrap the active ingredient particles from oxidation reactions during storage, thereby increasing product stability (Septevani *et al.*, 2013). Belong to a group of polysaccharides, dextrin has a stronger ability to bind water because it has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). The addition of maltodextrin can increase the stability of the drink, reducing the precipitate formed (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the product does not precipitate too much (Pramitasari *et*

al., 2011). Gum arabic has a more complex molecular structure than dextrin and contains starch so it is more hygroscopic (Sutardi *et al.*, 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin treatment with a drying temperature of 50 °C is the coating material with the highest stability value of 93.33%.

3.4 Water content

The average water content of lemongrass and Malang apple powdered drinks ranged from 2.06% to 2.57% (Table 4). In the manufacturing process, powdered drinks are made by drying separately at 40 °C, 45 °C and 50 °C for 18 h. The results reveal that the drying temperature has an effect on the water content of lemongrass and Malang apple powdered drinks. Meanwhile, the type of coating had no effect on the water content. Similarly, there was no interaction between the drying temperature and coating type affecting the moisture content of the powdered drinks. The higher the drying temperature, the lower the water content of the powder. Drying causes the water content in the lemongrass and Malang apple powder to evaporate. The higher temperature allows the powder to have a lower water content. According to Wiyono (2011), the drying temperature factor is important. The water content can be removed quickly when the material is dried at a high temperature (Wiyono, 2011). The increase in the heating temperature tends to reduce the water content. There are more water molecules that evaporate from the dried raw materials. Thus, the water content obtained is lower.

The type of coating has a relatively similar effect on the value of the water content. Of the three types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic as it easily absorbs water. But when it is dried, the absorbed water is released (Wulansari *et al.*, 2012). The water content absorbed by the coating material will evaporate more easily than the water content in the material tissue so that the evaporation process of water in powdered drinks becomes easier (Paramita *et al.*, 2015). Maltodextrin has a low molecular weight and a simple structure so that water is easily evaporated during the drying process (Prमितasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic. The water in the material coated with gum arabic is difficult to evaporate. Containing a large amount of starch, gum arabic has a high molecular weight and a complex molecular structure (Sutardi *et al.*, 2010). Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50 °C dextrin. It was in accordance with the SNI number 01-4320-1996 in which the water content of powdered drinks was a

maximum of 3% (BSN, 1996). The powdered drink products meet the requirements of the Indonesian National Standard for powdered drinks (SNI No. 01-4320-1996). The products have a small possibility of being contaminated with microorganisms.

3.5 Ash content

According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of minerals in a food. Ash is composed of various types of minerals with varying compositions depending on the type and source of food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher the ash content. The increase in ash content is related to the higher drying temperature. It causes more water in the material to evaporate. Thus, the water content is lower. It causes the percentage of mineral content in the material to increase. The results of the study are in line with Shadri *et al.* (2018).

Dextrin is a polysaccharide group that has a simpler chemical structure than gum arabic. Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile, gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin coating with a drying temperature of 45 °C. In general, the ash content of the product was still within the limits of SNI 01-4320-1996 regarding the quality requirements for powdered drinks, namely a maximum of 1.5% (BSN, 1996). Malang apples have a fairly high nutritional content, especially vitamins and minerals such as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2, and vitamin C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A, vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

3.6 Vitamin C

The results of the vitamin C test are presented in Table 6. It shows an average value of vitamin C between 72.69 mg/100 g to 53.15 mg/100 g. The results demonstrated that the drying temperature and type of coating affected the vitamin C content. There was an interaction between the drying temperature and the type of coating in determining the vitamin C content of powdered drinks. The vitamin C content tends to decrease along with the increase in the drying temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C which can be easily degraded, especially by heat (Parfiyanti *et al.*, 2016). It

shows that the drying process at high temperatures can reduce the vitamin C content in powdered drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid and plays a role in inhibiting excessive oxidation reactions (Susanti and Putri, 2014).

The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin produces the highest content of vitamin C compared to other types of coating. Dextrin can protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the addition of more dextrin helps maintain the vitamin C content in the product. Dextrin can protect vitamin C and compounds sensitive to heat or oxidation. It is because the molecules of dextrin are stable to heat and oxidation. In addition, according to Aretzy *et al.* (2018), maltodextrin can protect volatile compounds and protect compounds sensitive to oxidation. According to Morodi *et al.* (2022), GA alone or combined with other biopolymers has been successfully applied on tomato slices and grapefruit slices to preserve the dried products' quality. The highest content of vitamin C was produced in powdered drinks dried at 40 °C with the dextrin coating (72.68 mg/100 g) and the lowest was produced at 50 °C with the gum arabic coating (53.15 mg/100 g). The vitamin C content of mixed fruit powdered drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and tween 80 dried at 50 °C produces a vitamin C content between 425 mg/100 g - 550 mg/100 g, higher than lemongrass and Malang apple powdered drinks (Minah, *et al.*, 2021).

3.7 Water activity

Table 7 shows the mean value of water activity (a_w) of lemongrass and Malang apple powdered drinks, namely 0.44 to 0.50. The a_w value of lemongrass and Malang apple powdered drinks is lower than the a_w value for the bacterial growth requirement at 0.90. The a_w value for yeast growth is 0.80-0.90, and the a_w value for mold growth is 0.60-0.70. The a_w value is relatively decreased along with the increase in drying temperature. In the drying process, the free water in the material will evaporate. The higher temperature causes more water to evaporate. The lower the water content, the lower the water activity (Martins *et al.*, 2019). According to Adri and Hersoelistyorini (2013), the composition of water in foodstuffs, such as free water and bound water, can affect the duration of food drying. The relatively small a_w value does not allow the growth of bacteria, molds, and yeasts in the product. The lemongrass extract has great potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella typhimurium* and *Staphylococcus aureus*, indicating the possibility of using medicinal plants as natural antibacterial agents (Ibrahim and Salem, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying is to reduce water content so that it is not easy for mold and bacteria to grow. The drying process also eliminates the

activity of enzymes that can decompose the active substance content. It also facilitates further processing so that the product can be more compact, durable, and easy to store.

The use of various coatings in this study relatively produces the same aw value. The use of maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray drying can protect protein, calcium, and lactose powder (Martins *et al.*, 2019). The lowest water activity value of lemongrass and Malang apple powdered drinks was obtained for products with gum arabic coating at the drying temperature of 45 °C (0.44).

3.8 Radical scavenging activity

Plants that have potential as antioxidants are lemongrass (Wibisono, 2011) and apples (Yudhianto *et al.*, 2013). Based on the radical scavenging activity test in Table 8, the average inhibition value was 37.45% to 60.13%. Dextrin protects volatile chemicals and molecules vulnerable to heat or oxidation. Gum arabic can help increase the stability of the coating component. Gum arabic is another sort of heat-resistant coating (Dauqan and Abdullah, 2013). Based on Table 8, the drying temperature affects the radical scavenging activity. The higher the drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant activity in the lemongrass and Malang apple powdered drinks is related to the damage to the antioxidant compounds due to high temperatures. According to Patras *et al.* (2010), antioxidant compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat. Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna *et al.* (2013) that antioxidant bioactive components have heat-resistant characteristics. If the sample is extracted in hot conditions, it will reduce the value of its antioxidant activity. The results of the research by Widiastuti *et al.* (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content in lemongrass is due to its large number of phenolic compounds. The high content of phenolic compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential oil in lemongrass stems is very high, with an effective inhibition of 89% and 89.63%. In lemongrass leaves, it is slightly lower with the antioxidant and antidiabetic activity ranging from 78.89% and 79.26% respectively (Mirghani, *et al.*, 2012).

The use of dextrin coating with a drying temperature of 40 °C produced the highest inhibition value compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explain that dextrin is composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the

oxidation process can be prevented. Dextrin protects volatile compounds and compounds sensitive to heat or oxidation. Gum arabic can maintain the stability of the compounds being coated. Gum arabic is also resistant to heat (Dauqan and Abdullah, 2013). Meanwhile, maltodextrin can protect volatile compounds and compounds sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high oxidation resistance. It can reduce the viscosity of the emulsion. Combined with other coatings that have better emulsifying properties, it causes the antioxidant compounds in the microencapsulants to be well protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural antioxidants and anti-inflammatories that can prevent free radicals in the human body. Antioxidants in lemongrass are able to inhibit the release of arachidonic acid. It is through the mechanism of inhibiting kinase protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants that are very good for skin health. The very high antioxidant content is also the reason for the high consumption of apples by the public. It is an effort to prevent diseases and other dysfunctions of body health.

3.9 Antioxidant content with inhibition concentration value of 50% (IC_{50})

The IC_{50} value is the concentration of the antioxidant source to neutralize 50% of the radical compounds. The lower the IC_{50} value, the better the antioxidant activity of the sample. IC_{50} antioxidant content is determined from the 3 best samples based on the highest inhibition percentage, namely on lemongrass and Malang apple powders coated with dextrin with drying temperatures of 40 °C, 45 °C and 50 °C. According to Phongpaichit *et al.* (2007), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates weak activity. The results showed that the IC_{50} value in the lemongrass and Malang apple powdered drinks was 0.9 to 1.47 % (Table 9), which indicated a very strong activity. The results of research by Andriyani *et al.* (2015) show that the IC_{50} value of *Curcuma zanthorrhiza* L. and red ginger powder functional drinks made using the spray drying method has the highest average value of 0.62 ppm at 4% maltodextrin concentration, and the lowest or weakest value of 1.00 ppm at 0% maltodextrin concentration.

4. Conclusion

The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the

parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the type of coating and the drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was determined based on the antioxidant content and high stability. The fast dissolution time was found in the lemongrass and Malang apple powder dried at 45 °C with the dextrin coating. The best lemongrass and Malang apple powdered drinks had the following characteristics: a solubility of 0.96 seconds, a bulk density of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 %, and a water activity 0.50.

Conflict of interest

The authors declare no conflict of interest.

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Table 1. The mean value of bulk density for lemongrass and Malang apple powdered drinks.

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	0.58±0.04 ^a		0.63±0.03 ^{bcd}	0.62±0.03
45 °C	0.67±0.03 ^{ab}		0.58±0.05 ^{abc}	0.63±0.05
50 °C	0.58±0.06 ^{abc}		0.67±0.02 ^{cd}	0.59±0.08
Mean±SD	0.61±0.05		0.63±0.05	0.60±0.60

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 2. The mean value of dissolution time for lemongrass and Malang apple powdered drinks (seconds).

Drying temperature	Coating type			Mean ± SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	1.06±0.04 ^{bc}		1.11±0.01 ^{ab}	1.15±0.12 ^c
45 °C	1.04±0.00 ^{abc}		0.96±0.07 ^a	1.02±0.05 ^b
50 °C	1.07±0.00 ^{bc}		1.01±0.02 ^{cd}	1.08±0.08 ^a
Mean±SD	1.05±0.01 ^a		1.03±0.08 ^a	1.17±0.12 ^b

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 3. The mean value of stability for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Dextrin	Gum Arabic	
	Maltodekstrin	Dekstrin		
40 °C	65.30±0.65 ^{ab}	87.32±0.45 ^e	63.89±2.66 ^a	72.17±13.14 ^c
45 °C	73.01±0.57 ^d	89.19±0.43 ^e	69.69±0.59 ^c	77.30±10.43 ^b
50 °C	78.74±1.00 ^d	93.33±0.40 ^f	80.19 ±0.00 ^e	84.09±8.03 ^a
Mean±SD	72.35±6.74 ^a	89.95±3.07 ^a	71.26±8.26 ^b	

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Table 4. The mean value of water content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	2.57±0.06		2.51±0.04	2.54±0.03 ^c
45 °C	2.39±0.06		2.38±0.12	2.36±0.04 ^b
50 °C	2.07±0.02		2.16±0.02	2.10±0.05 ^a
Mean±SD	2.34±0.25		2.35±0.18	2.30±0.24

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 5. The mean value of ash content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	1.17±0.13 ^{ab}		1.46±0.11 ^e	1.23±0.21 ^a
45 °C	1.26±0.01 ^{bcd}		1.21±0.03 ^{abc}	1.23±0.02 ^a
50 °C	1.26±0.02 ^{bcd}		1.37±0.01 ^{cde}	1.33±0.07 ^b
Mean±SD	1.23±0.05 ^a		1.34±0.13 ^b	1.23±0.16 ^a

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 6. The mean value of vitamin C content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	68.11±1.74 ^d		72.69±2.74 ^e	61.95±0.50 ^c 67.58 ±5.39 ^c
45 °C	63.36±1.49 ^c		70.22±1.24 ^{de}	58.26±1.24 ^b 63.95±6.01 ^b
50 °C	54.91±0.50 ^a		63.36±1.49 ^c	53.15±0.50 ^a 57.14±5.46 ^a
Mean±SD	62.13±6.69 ^a		68.76±4.83 ^b	57.79±4.42 ^c

Note:

the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 7. The mean value of water activity for lemongrass and Malang apple powdered drinks.

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	0.48±0.00		0.48±0.02	0.51±0.00
45 °C	0.51±0.03		0.50±0.01	0.44±0.02
50 °C	0.49±0.04		0.46±0.05	0.46±0.01
Mean±SD	0.49±0.02		0.48±0.02	0.47±0.03

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Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

Table 8. The mean value of radical scavenging activity content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	56.96±1.13 ^f		60.13±0.05 ^h	53.66±0.14 ^g
45 °C	45.73±0.67 ^c		50.97±0.11 ^e	48.17±0.18 ^d
50 °C	37.45±1.07 ^a		43.98±0.71 ^b	39.65±3.75 ^a

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Note: the mean value followed by different letters indicates a significant difference (P<0.05)

Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powdered drinks (%) on the best product.

Drying temperature	Coating type	
	Dextrin	Dekstrin
40 °C	0.9±0.01	
45 °C	1.279±0.08	
50 °C	1.47±0.01	

Commented [A11]: Please change to English.

The effects of coating type and drying temperature on the physicochemical properties of the mixture of lemongrass and apple powdered drinks

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Abstract

Fresh beverages from fruits and herbal plants that contain antioxidants are able to enhance the immunity of the human body. However, such fresh beverage products generally have a short shelf life. As an alternative, the products must be converted into powdered drinks. Coating materials are thus needed to avoid the loss of antioxidant compounds during the drying process. This study aimed to scrutinize the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The study employed a completely randomized design (CRD) with two factors and two replications. The first factor was

the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). The data were analyzed using ANAVA test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the coating type and drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of 1.29, and a water activity of 0.50.

Keywords: Apples, Dextrin, Powdered drinks, Drying, Lemongrass

1. Introduction

The COVID-19 pandemic has forced people to maintain their health by increasing their body's immunity. Body immunity can be enhanced through an adequate diet and nutrition from drinks (Iddir *et al.*, 2020). Powdered drinks are processed food products in the form of a powder. Having a relatively long shelf life, the product is easy to serve and can be rapidly dissolved in water. In addition, powdered drinks are easy to carry and ship (Tangkeallo *et al.*, 2014), making the product to be liked by the public. One of the ingredients that can boost the body's immunity is herbal plants. The plants are known to contain antioxidant compounds. Antioxidants are able to capture free radicals to enhance the immunity of the body (Cakmakci *et al.*, 2015). One of the popular herbal plants that contains antioxidants is lemongrass. Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*, *eugenol*, *dipentene*, *citral* (Wibisono, 2011). Acting as an anticancer and antioxidant, these compounds can stabilize blood pressure, treat constipation, help the digestive system, tighten the body after childbirth (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). In addition to lemongrass, Malang apples, a famous fruit typical of the city of Malang, also belong to the food ingredient that can enhance the body's immunity. Being small in size, Malang apples have low economic value because they are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019), Malang apples contain lots of vitamins such as vitamins A, B,

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and C, minerals, and fiber. The apples also contain flavonoid compounds, including quercetin. Vitamin C and quercetin act as antioxidants, antivirals, and anti-inflammatories that protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free radicals and reduce free radicals (Suparni dan Wulandari, 2012).

However, although containing beneficial antioxidants, lemongrass and Malang apples are rarely used as ingredients to make powdered beverages. Due to its practicality, ready-to-serve drinks in powder form (Sari *et al.*, 2021) with both ingredients are necessary to be made. In order to function as a nutritional drink, the making of powdered drinks from lemongrass and Malang apples should pay special attention to the drying process (Naibaho *et al.*, 2015). It is because the active ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures for a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the amount of antioxidants present, it is necessary to find the right drying temperature. In addition, coating materials are needed to maintain the existing volatile compounds. The commonly used coating material is gum Arabic because this material has the ability to form good emulsions and films. Compared to modified starch, gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the highest volatile components (Santoso *et al.*, 2013). Gum arabic can preserve the flavor of dried materials by coating the flavor particles, protecting them from oxidation, absorption, and evaporation of water from the air (Herawati, 2018). According to Harahap *et al.* (2021), maltodextrin has a high solubility, a strong binding power, and low browning properties. In addition, being able to disperse quickly, maltodextrin can inhibit crystallization and form low hygroscopic properties. Meanwhile, dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity (Asiah *et al.*, 2012).

Based on the description above, this study aimed to investigate the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The quality of the powdered drinks was determined based on physical tests in the form of bulk density, dissolution time, and stability tests. These tests were required to determine packaging. In addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity, water activity, and vitamin C. These tests would indirectly determine the shelf life of the product and its ability to enhance the body's immunity. This research has yielded a product with the following characteristics: easy to carry, having the potential to boost the body's immunity, and having a relatively long shelf life.

2. Materials and methods

2.1 Materials and equipment

The materials used in the study were lemongrass stems and seedless Malang apples, maltodextrin, dextrin, gum Arabic powder, water, and brown sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a Mitzui blender, cutting boards, measuring cups, knives, WTC Binder 78532 blower ovens, baking sheets, spoons, Matrix ESJ210-4B scales, volumetric flasks, Erlenmeyer, burettes, measuring pipettes, a suction ball, a funnel pipette, a beaker glass, a filter paper, a burette, a stative, a Siever 60 mesh, and a UV2100 spectrophotometer.

2.2 The process of making lemongrass and malang apple powdered drinks

The process of making powdered drinks was a modification of the research of Susanti and Putri (2014). The process of making powdered drinks consisted of two stages including the making of fruit pulp and the drying process.

2.2.1 Making fruit pulp

The making of fruit pulp began with the sorting of the lemongrass and Malang apples. The ingredients sorted were washed and cut (1:1 w/w), and then crushed with a blender for 5 mins at speed number 2. The pulp was added with water in a ratio of 1:1 w/w. The coating materials (maltodextrin, dextrin, and gum Arabic) were then added as much as 5% w/w of the fruit pulp separately. The pulp was stirred until homogeneous.

2.2.2 Drying

Each homogeneous fruit pulp was placed on a 60 × 40 × 2 cm baking sheet as much as 250 mL. It was then dried with a blower oven at a predetermined temperature (40 °C, 45 °C, and 50 °C) separately for 18 h. Afterwards, the dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3 mins at speed number 2. Then, brown sugar was added at 10% w/w of the dry powder. After that, the powder was sieved using a 60-mesh sieve. Lemongrass powdered drinks were packaged in aluminum foil zip lock with a size of 7 × 13 cm.

2.3. Analysis procedure of bulk density

The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring cup containing the powder sample was tapped 30 times until there were no more cavities when the powder

sample was adjusted to 10 mL. The measuring cup containing the powder sample was then weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its volume (10 mL).

2.4 Analysis procedure of dissolution time testing

A total of 5 g sample was weighed. The sample was then dissolved in 50 mL of warm water and stirred 20 times until homogeneous. The dissolving time of the sample was recorded.

2.5 Analysis procedure of stability testing

A total of 5 g of powder was weighed and brewed in 50 mL of water. It was then put into a 10 mL measuring cup and kept for 24 h. Afterwards, the solution was measured for the volume of the precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

2.6 Analysis procedure of water content by oven drying method

An empty cup was dried in the oven for 15 mins. The cup was then cooled in a desiccator (10 mins for an aluminum cup and 20 mins for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2-3 g and then put in the dry cup. After that, the cup containing the sample was put in the oven at 105°C for 6 h. Next, it was cooled in a desiccator and then weighed. The drying process was repeated until a constant weight was obtained. The water content was calculated based on the loss of weight, by calculating the difference between the initial weight of the sample before the drying and the final weight after the drying.

2.7 Analysis procedure of ash content by muffle furnace method

A porcelain cup was dried in the oven for 15 mins. The cup was cooled in a desiccator and then weighed. The sample was weighed as much as 3 g in a cup that had been dried. Afterwards, it was burned in a crucible until it no longer emitted smoke. Next, the ashing process was carried out using an electric furnace at a temperature of 400-600°C for 4-6 hrs until the white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

2.8 Analysis procedure of radical scavenging activity

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free

radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 mL of the sample in 100 mL of methanol PA. A total of 1 mL of DPPH solution (10 mg/L) was added to 50 μ L of sample solution. Afterwards, methanol pro analyzed was added up to 5 mL, then incubated for 30 mins at 37°C. The absorbance was measured at a wavelength of 513 nm. The antioxidant activity of the sample was determined by the magnitude of the DPPH radical uptake inhibition by calculating the percentage of DPPH uptake inhibition.

2.9 Analysis procedure of IC_{50} antioxidant activity

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenylpicrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 mL of the sample in 100 mL of methanol PA. Furthermore, dilution was carried out using the methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was prepared by dissolving 5 mg of solid DPPH in 100 mL of methanol PA. Then a comparison solution was prepared, namely a control solution containing 2 mL of methanol PA and 1 mL of 50 ppm DPPH solution. For the test sample, 2 mL of the sample solution and 2 mL of the DPPH solution were prepared. Then, the solution was kept for 30 mins. All samples, the extract samples that had been kept, were tested for measuring the absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

2.10 Analysis procedure of water activity testing

The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated by adding $BaCl_2 \cdot 2H_2O$. It was then closed and kept for 3 mins until the number on the scale became 0.9. The aw-meter was then opened and the sample was inserted. Afterwards, the tool was closed and waited until the aw scale was read. The temperature scale and the correction factor were observed. When the temperature scale was above 20°C, the aw scale reading was added as much as the excess of the temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.

2.11 Analysis procedure of vitamin C testing

The analysis of vitamin C was performed by the iodometric method. The crushed sample was weighed as much as 5 g. The sample was put into a 100 mL measuring flask. Distilled water was then added up to

the line mark. The sample was then shaken until homogeneous. Afterwards, the solution was filtered and the filtrate was pipetted as much as 25 mL, and put into an Erlenmeyer flask. A few drops of the starch indicator were added, then titrated rapidly using 0.01 N iodine solution until a blue color appeared. The vitamin C content was obtained from the following formula:

$$\text{Vitamin C (mg/100 g)} = \frac{V I_2 \times 0.88 \times Fp \times 100}{W(g)}$$

Where $V I_2$ = iodine volume (mL), 0.88 = 0.88 mg ascorbic acid equivalent to 1 ml I_2 0.01 N solution, Fp = dilution factor and W = sample mass (g).

2.12 Statistical analysis

The data obtained were analyzed using the analysis of variance (ANOVA). When the data showed that there was a significant effect, the Duncan Multiple Range Test was carried out. The testing was done using the IBM SPSS Statistics 29 software. The significant level was set at $\alpha = 0.05$.

3. Results and discussion

3.1 Bulk density of lemongrass and Malang apple powdered drinks

The bulk density value indicates void space, namely the number of empty cavities between the material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2008). The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The findings revealed that the drying temperature and coating type had an effect on the density value of the Kamba powdered drink. Furthermore, the density value of Kamba is affected by a relationship between the drying temperature and coating type. The higher the drying temperature causes the bulk density value to decrease. This is because the higher the drying temperature causes more water in the material to be evaporated. Therefore, the resulting water content is lower, causing the weight of the powder to become lighter. According to Andriyani *et al.* (2015), as the drying temperature rises, the bulk density falls. The bulk density is influenced by the type of material, the water content, and the shape and size of the material. The smaller the bulk density, the more porous the product is (Widowati *et al.*, 2010).

Of the three types of coating used, gum Arabic has the lowest bulk density compared to other coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan and Abdullah, 2013). Meanwhile, according to Purbasari (2019), dextrin is able to form films, form the body, inhibit crystallization, and quickly disperse. Dextrin also has high solubility, hygroscopic properties, low browning properties, and strong binding power. The dextrin film layer has a higher proportion of solids than

gum arabic since the DE value of dextrin is lower than gum arabic. Therefore, the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*, 2010). Maltodextrin is a coating material that has a high level of solubility. It is due to the nature of maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has the ability to absorb water) so the water in the material is more retained and difficult to evaporate (Yuliwati and Susanto, 2015).

According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space needed for that material. The greater the bulk density, the smaller the space needed, and vice versa. The smaller the size of the molecule, the more easily the product will be compressed. The smaller the gaps between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum Arabic with a drying temperature of 50 °C resulted in the lowest bulk density value of 0.52. According to Palijama *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact (non-voluminous). It means that in the same certain volume, the product is available in more weight. According to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small. It means that lightweight requires a large space. The smaller the bulk density, the more porous the product is. Sadeghi *et al.* (2010) state that the higher sphericity of the corn kernels results in a more regular arrangement of the kernels. Therefore, the cavities between the kernels were smaller, resulting in a higher bulk density. According to the preceding description, the drying temperature and the type of coating both affect the density value of Kamba. It demonstrates that the two interact in altering the value of Kamba density.

3.2 Dissolution time

Dissolution time is a time for all beverage powder to dissolve in water perfectly. The testing of dissolution time was carried out to determine the speed of solubility of the drinks. The higher the solubility value of the powder product, the better the product is. It is because the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang *et al.*, 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 s (Table 2). The results showed that the higher the drying temperature, the faster the dissolution time (Table 2). It is because the powder produced is drier. The higher the drying temperature, the more water evaporates on the powdered drinks so that the water content is lower. The lower the water content, the more hygroscopic, the dissolution time is faster (Paramita *et al.*, 2015 and Sakdiyah and Rekna, 2019).

The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin has the fastest dissolution time (Table 2). When powdered drinks are dissolved in water, especially warm water, the hydroxyl groups in the coating substance will interact with the water, increasing the powder's solubility (Yuliwati and Susanto, 2015). Dextrin has a dextrose equivalent (DE) value of 3-5 and has the ability to form

layers (Tyanjani and Yunianta, 2015). With the addition of dextrin, the solubility of powdered drinks increases. This is because dextrin is easily soluble in water. This is in accordance with Nurhidayah *et al.* (2014), who state that dextrin is easily soluble in water, and disperses more quickly. Dextrin is not viscous and more stable than starch.

According to Wulansari *et al.* (2012), the dextrose equivalent (DE) of maltodextrin is 3-20. The higher the DE value, the higher the monosaccharide content. It causes the binding power to be greater. Thus, compared to dextrin, the use of maltodextrin allows the water content to be higher. Maltodextrin is a filler that has a high level of solubility. This is due to the characteristic of maltodextrin which is soluble in water (Hofman *et al.*, 2016). Gum Arabic has a longer dissolution time than maltodextrin and dextrin. However, according to Herawati (2018), gum Arabic has a high solubility in water, making it better to use as the coating material in making powdered drinks. The DE value of gum Arabic is 6 (Soottitantawat *et al.*, 2006). According to Hofman *et al.* (2016), the factor that affects the level of solubility in water is the DE value. The higher the DE value, the better the solubility level.

3.3 Stability

Beverage products will be stable if the particles acting as the dispersed phase can be retained without changing for a long time, or without experiencing grouping with each other (Anjani *et al.*, 2011). The stability testing is expressed in the percentage of stability of the powdered drinks made. The stability of lemongrass and Malang apple powdered drinks obtained an average of 63.89% to 93.33% (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The higher the drying temperature, the lower the powder water content. It causes the product to absorb water more easily so that the product becomes more stable when rehydrated. This is in line with Kryzhska *et al.* (2020) who state that the high water content in powder products would seriously disrupt the product stability. It would also cause the product to agglomerate when stored. The high water content in a product can cause damage due to the activity of microorganisms.

The type of coating also affects the stability value. Of the three types of coating used, dextrin has the most stable results compared to the other types of coating. Dextrin can wrap the active ingredient particles from oxidation reactions during storage, thereby increasing product stability (Septevani *et al.*, 2013). Belong to a group of polysaccharides, dextrin has a stronger ability to bind water because it has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). The addition of maltodextrin can increase the stability of the drink, reducing the precipitate formed (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the product does not precipitate too much (Pramitasari *et*

et al., 2011). Gum arabic has a more complex molecular structure than dextrin and contains starch so it is more hygroscopic (Sutardi *et al.*, 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin treatment with a drying temperature of 50 °C is the coating material with the highest stability value of 93.33%.

3.4 Water content

The average water content of lemongrass and Malang apple powdered drinks ranged from 2.06% to 2.57% (Table 4). In the manufacturing process, powdered drinks are made by drying separately at 40 °C, 45 °C and 50 °C for 18 h. The results reveal that the drying temperature has an effect on the water content of lemongrass and Malang apple powdered drinks. Meanwhile, the type of coating had no effect on the water content. Similarly, there was no interaction between the drying temperature and coating type affecting the moisture content of the powdered drinks. The higher the drying temperature, the lower the water content of the powder. Drying causes the water content in the lemongrass and Malang apple powder to evaporate. The higher temperature allows the powder to have a lower water content. According to Wiyono (2011), the drying temperature factor is important. The water content can be removed quickly when the material is dried at a high temperature (Wiyono, 2011). The increase in the heating temperature tends to reduce the water content. There are more water molecules that evaporate from the dried raw materials. Thus, the water content obtained is lower.

The type of coating has a relatively similar effect on the value of the water content. Of the three types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic as it easily absorbs water. But when it is dried, the absorbed water is released (Wulansari *et al.*, 2012). The water content absorbed by the coating material will evaporate more easily than the water content in the material tissue so that the evaporation process of water in powdered drinks becomes easier (Paramita *et al.*, 2015). Maltodextrin has a low molecular weight and a simple structure so that water is easily evaporated during the drying process (Prमितasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic. The water in the material coated with gum arabic is difficult to evaporate. Containing a large amount of starch, gum arabic has a high molecular weight and a complex molecular structure (Sutardi *et al.*, 2010). Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50 °C dextrin. It was in accordance with the SNI number 01-4320-1996 in which the water content of powdered drinks was a

maximum of 3% (BSN, 1996). The powdered drink products meet the requirements of the Indonesian National Standard for powdered drinks (SNI No. 01-4320-1996). The products have a small possibility of being contaminated with microorganisms.

3.5 Ash content

According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of minerals in a food. Ash is composed of various types of minerals with varying compositions depending on the type and source of food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher the ash content. The increase in ash content is related to the higher drying temperature. It causes more water in the material to evaporate. Thus, the water content is lower. It causes the percentage of mineral content in the material to increase. The results of the study are in line with Shadri *et al.* (2018).

Dextrin is a polysaccharide group that has a simpler chemical structure than gum arabic. Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile, gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alfren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin coating with a drying temperature of 45 °C. In general, the ash content of the product was still within the limits of SNI 01-4320-1996 regarding the quality requirements for powdered drinks, namely a maximum of 1.5% (BSN, 1996). Malang apples have a fairly high nutritional content, especially vitamins and minerals such as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2, and vitamin C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A, vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

3.6 Vitamin C

The results of the vitamin C test are presented in Table 6. It shows an average value of vitamin C between 72.69 mg/100 g to 53.15 mg/100 g. The results demonstrated that the drying temperature and type of coating affected the vitamin C content. There was an interaction between the drying temperature and the type of coating in determining the vitamin C content of powdered drinks. The vitamin C content tends to decrease along with the increase in the drying temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C which can be easily degraded, especially by heat (Parfiyanti *et al.*, 2016). It

shows that the drying process at high temperatures can reduce the vitamin C content in powdered drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid and plays a role in inhibiting excessive oxidation reactions (Susanti and Putri, 2014).

The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin produces the highest content of vitamin C compared to other types of coating. Dextrin can protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the addition of more dextrin helps maintain the vitamin C content in the product. Dextrin can protect vitamin C and compounds sensitive to heat or oxidation. It is because the molecules of dextrin are stable to heat and oxidation. In addition, according to Aretzy *et al.* (2018), maltodextrin can protect volatile compounds and protect compounds sensitive to oxidation. According to Morodi *et al.* (2022), GA alone or combined with other biopolymers has been successfully applied on tomato slices and grapefruit slices to preserve the dried products' quality. The highest content of vitamin C was produced in powdered drinks dried at 40 °C with the dextrin coating (72.68 mg/100 g) and the lowest was produced at 50 °C with the gum arabic coating (53.15 mg/100 g). The vitamin C content of mixed fruit powdered drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and tween 80 dried at 50 °C produces a vitamin C content between 425 mg/100 g - 550 mg/100 g, higher than lemongrass and Malang apple powdered drinks (Minah, *et al.*, 2021).

3.7 Water activity

Table 7 shows the mean value of water activity (*aw*) of lemongrass and Malang apple powdered drinks, namely 0.44 to 0.50. The *Aw* value of lemongrass and Malang apple powdered drinks is lower than the *Aw* value for the bacterial growth requirement at 0.90. The *Aw* value for yeast growth is 0.80-0.90, and the *Aw* value for mold growth is 0.60-0.70. The *Aw* value is relatively decreased along with the increase in drying temperature. In the drying process, the free water in the material will evaporate. The higher temperature causes more water to evaporate. The lower the water content, the lower the water activity (Martins *et al.*, 2019). According to Adri and Hersoelistyorini (2013), the composition of water in foodstuffs, such as free water and bound water, can affect the duration of food drying. The relatively small *aw* value does not allow the growth of bacteria, molds, and yeasts in the product. The lemongrass extract has great potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella typhimurium* and *Staphylococcus aureus*, indicating the possibility of using medicinal plants as natural antibacterial agents (Ibrahim and Salem, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying is to reduce water content so that it is not easy for mold and bacteria to grow. The drying process also eliminates the

activity of enzymes that can decompose the active substance content. It also facilitates further processing so that the product can be more compact, durable, and easy to store.

The use of various coatings in this study relatively produces the same a_w value. The use of maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray drying can protect protein, calcium, and lactose powder (Martins *et al.*, 2019). The lowest water activity value of lemongrass and Malang apple powdered drinks was obtained for products with gum arabic coating at the drying temperature of 45 °C (0.44).

3.8 Radical scavenging activity

Plants that have potential as antioxidants are lemongrass (Wibisono, 2011) and apples (Yudhianto *et al.*, 2013). Based on the radical scavenging activity test in Table 8, the average inhibition value was 37.45% to 60.13%. Dextrin protects volatile chemicals and molecules vulnerable to heat or oxidation. Gum arabic can help increase the stability of the coating component. Gum arabic is another sort of heat-resistant coating (Dauqan and Abdullah, 2013). Based on Table 8, the drying temperature affects the radical scavenging activity. The higher the drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant activity in the lemongrass and Malang apple powdered drinks is related to the damage to the antioxidant compounds due to high temperatures. According to Patras *et al.* (2010), antioxidant compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat. Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna *et al.* (2013) that antioxidant bioactive components have heat-resistant characteristics. If the sample is extracted in hot conditions, it will reduce the value of its antioxidant activity. The results of the research by Widiastuti *et al.* (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content in lemongrass is due to its large number of phenolic compounds. The high content of phenolic compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential oil in lemongrass stems is very high, with an effective inhibition of 89% and 89.63%. In lemongrass leaves, it is slightly lower with the antioxidant and antidiabetic activity ranging from 78.89% and 79.26% respectively (Mirghani, *et al.*, 2012).

The use of dextrin coating with a drying temperature of 40 °C produced the highest inhibition value compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explain that dextrin is composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the

oxidation process can be prevented. Dextrin protects volatile compounds and compounds sensitive to heat or oxidation. Gum arabic can maintain the stability of the compounds being coated. Gum arabic is also resistant to heat (Dauqan and Abdullah, 2013). Meanwhile, maltodextrin can protect volatile compounds and compounds sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high oxidation resistance. It can reduce the viscosity of the emulsion. Combined with other coatings that have better emulsifying properties, it causes the antioxidant compounds in the microencapsulants to be well protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural antioxidants and anti-inflammatories that can prevent free radicals in the human body. Antioxidants in lemongrass are able to inhibit the release of arachidonic acid. It is through the mechanism of inhibiting kinase protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants that are very good for skin health. The very high antioxidant content is also the reason for the high consumption of apples by the public. It is an effort to prevent diseases and other dysfunctions of body health.

3.9 Antioxidant content with inhibition concentration value of 50% (IC_{50})

The IC_{50} value is the concentration of the antioxidant source to neutralize 50% of the radical compounds. The lower the IC_{50} value, the better the antioxidant activity of the sample. IC_{50} antioxidant content is determined from the 3 best samples based on the highest inhibition percentage, namely on lemongrass and Malang apple powders coated with dextrin with drying temperatures of 40 °C, 45 °C and 50 °C. According to Phongpaichit *et al.* (2007), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates weak activity. The results showed that the IC_{50} value in the lemongrass and Malang apple powdered drinks was 0.9 to 1.47 % (Table 9), which indicated a very strong activity. The results of research by Andriyani *et al.* (2015) show that the IC_{50} value of *Curcuma zanthorrhiza* L. and red ginger powder functional drinks made using the spray drying method has the highest average value of 0.62 ppm at 4% maltodextrin concentration, and the lowest or weakest value of 1.00 ppm at 0% maltodextrin concentration.

4. Conclusion

The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the

parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the type of coating and the drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was determined based on the antioxidant content and high stability. The fast dissolution time was found in the lemongrass and Malang apple powder dried at 45 °C with the dextrin coating. The best lemongrass and Malang apple powdered drinks had the following characteristics: a solubility of 0.96 seconds, a bulk density of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 %, and a water activity 0.50.

Conflict of interest

The authors declare no conflict of interest.

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Table 1. The mean value of bulk density for lemongrass and Malang apple powdered drinks.

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40 ° C	0.58±0.04 ^a	0.63±0.03 ^{bcd}	0.64±0.01 ^{bcd}	0.62±0.03
45 ° C	0.67±0.03 ^{ab}	0.58±0.05 ^{abc}	0.64±0.03 ^{bcd}	0.63±0.05
50 ° C	0.58±0.06 ^{abc}	0.67±0.02 ^{cd}	0.52±0.00 ^a	0.59±0.08
Mean±SD	0.61±0.05	0.63±0.05	0.60±0.60	

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

Commented [A2]: Please change to English.

Table 2. The mean value of dissolution time for lemongrass and Malang apple powdered drinks (seconds).

Drying temperature	Coating type			Mean ± SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40 ° C	1.06±0.04 ^{bc}	1.11±0.01 ^{ab}	1.29±0.07 ^d	1.15±0.12 ^c
45 ° C	1.04±0.00 ^{abc}	0.96±0.07 ^a	1.05±0.03 ^{abc}	1.02±0.05 ^b
50 ° C	1.07±0.00 ^{bc}	1.01±0.02 ^{cd}	1.17±0.03 ^e	1.08±0.08 ^a
Mean±SD	1.05±0.01 ^a	1.03±0.08 ^a	1.17±0.12 ^b	

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

Commented [A3]: Please change to English.

Table 3. The mean value of stability for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40 ° C	65.30±0.65 ^{ab}	87.32±0.45 ^e	63.89±2.66 ^a	72.17±13.14 ^c
45 ° C	73.01±0.57 ^d	89.19±0.43 ^e	69.69±0.59 ^c	77.30±10.43 ^b
50 ° C	78.74±1.00 ^d	93.33±0.40 ^f	80.19 ±0.00 ^e	84.09±8.03 ^a
Mean±SD	72.35±6.74 ^a	89.95±3.07 ^a	71.26±8.26 ^b	

Commented [A4]: Please change to English.

Table 4. The mean value of water content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40 °C	2.57±0.06	2.51±0.04	2.54±0.02	2.54±0.03 ^c
45 °C	2.39±0.06	2.38±0.12	2.31±0.03	2.36±0.04 ^b
50 °C	2.07±0.02	2.16±0.02	2.06±0.02	2.10±0.05 ^a
Mean±SD	2.34±0.25	2.35±0.18	2.30±0.24	

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

Commented [A5]: Please change to English.

Table 5. The mean value of ash content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40 °C	1.17±0.13 ^{ab}	1.46±0.11 ^e	1.06±0.07 ^a	1.23±0.21 ^a
45 °C	1.26±0.01 ^{bcd}	1.21±0.03 ^{abc}	1.24±0.03 ^{bcd}	1.23±0.02 ^a
50 °C	1.26±0.02 ^{bcd}	1.37±0.01 ^{cde}	1.38±0.09 ^{de}	1.33±0.07 ^b
Mean±SD	1.23±0.05 ^a	1.34±0.13 ^b	1.23±0.16 ^a	

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

Commented [A6]: Please change to English.

Table 6. The mean value of vitamin C content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40 °C	68.11±1.74 ^d	72.69±2.74 ^e	61.95±0.50 ^c	67.58 ±5.39 ^c
45 °C	63.36±1.49 ^c	70.22±1.24 ^{de}	58.26±1.24 ^b	63.95±6.01 ^b
50 °C	54.91±0.50 ^a	63.36±1.49 ^c	53.15±0.50 ^a	57.14±5.46 ^a
Mean±SD	62.13±6.69 ^a	68.76±4.83 ^b	57.79±4.42 ^c	

followed by different letters indicates a significant difference (P<0.05)

Note: the mean value

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Table 7. The mean value of water activity for lemongrass and Malang apple powdered drinks.

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40 °C	0.48±0.00	0.48±0.02	0.51±0.00	0.49±0.02
45 °C	0.51±0.03	0.50±0.01	0.44±0.02	0.49±0.04
50 °C	0.49±0.04	0.46±0.05	0.46±0.01	0.47±0.02
Mean±SD	0.49±0.02	0.48±0.02	0.47±0.03	

Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

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Table 8. The mean value of radical scavenging activity content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodekstrin	Dekstrin	Gum Arabic	
40 °C	56.96±1.13 ^f	60.13±0.05 ^h	53.66±0.14 ^g	56.92±3.24 ^c
45 °C	45.73±0.67 ^c	50.97±0.11 ^e	48.17±0.18 ^d	48.29±2.62 ^b
50 °C	37.45±1.07 ^a	43.98±0.71 ^b	37.53±0.21 ^a	39.65±3.75 ^a

Note: the mean value followed by different letters indicates a significant difference ($P < 0.05$)

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Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powdered drinks (%) on the best product.

Drying temperature	Coating type
	Dekstrin
40 °C	0.9±0.01
45 °C	1.279±0.08
50 °C	1.47±0.01

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Dear Dr Dede,

Received with thanks.

Thanks & Regards,

Dr Vivian New, PhD

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Dear Dr Vivian New, PhD
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Manuscript ID: FR-2023-077

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I have just added some information to the manuscript, namely:

1. In the affiliation of Mr. Saputra, D, I added him as a Sahid University member, because he is our lecturer.
 2. In the title of table 1, I have added the unit of measurement
- Hopefully this addition can be accepted. Thank you.

King regards,
Rahmawati Rahmawati

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The effects of coating type and drying temperature on the physicochemical properties of the mixture of lemongrass and apple powdered drinks

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Abstract

Fresh beverages from fruits and herbal plants that contain antioxidants are able to enhance the immunity of the human body. However, such fresh beverage products generally have a short shelf life. As an alternative, the products must be converted into powdered drinks. Coating materials are thus needed to avoid the loss of antioxidant compounds during the drying process. This study aimed to scrutinize the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The study employed a completely randomized design (CRD) with two factors and two replications. The first factor was

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the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). The data were analyzed using Analysis of variance one-way (ANAVA) test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the coating type and drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of 1.29, and a water activity of 0.50.

Keywords: Apples, Dextrin, Powdered drinks, Drying, Lemongrass

1. Introduction

The COVID-19 pandemic has forced people to maintain their health by increasing their body's immunity. Body immunity can be enhanced through an adequate diet and nutrition from drinks (Iddir *et al.*, 2020). Powdered drinks are processed food products in the form of a powder. Having a relatively long shelf life, the product is easy to serve and can be rapidly dissolved in water. In addition, powdered drinks are easy to carry and ship (Tangkeallo *et al.*, 2014), making the product to be liked by the public. One of the ingredients that can boost the body's immunity is herbal plants. The plants are known to contain antioxidant compounds. Antioxidants are able to capture free radicals to enhance the immunity of the body (Cakmakci *et al.*, 2015). One of the popular herbal plants that contains antioxidants is lemongrass. Lemongrass contains compounds including *geraniol*, *citronellol*, *lemonen*, *kadinen*, *eugenol*, *dipentene*, *citral* (Wibisono, 2011). Acting as an anticancer and antioxidant, these compounds can stabilize blood pressure, treat constipation, help the digestive system, tighten the body after childbirth (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). In addition to lemongrass, Malang apples, a famous fruit typical of the city of Malang, also belong to the food ingredient that can enhance the body's immunity. Being small in size, Malang apples have low economic value because they are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019), Malang apples contain lots of vitamins such as vitamins A, B,

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and C, minerals, and fiber. The apples also contain flavonoid compounds, including quercetin. Vitamin C and quercetin act as antioxidants, antivirals, and anti-inflammatories that protect the body's reproductive system. Flavonoids as antioxidants have the ability to act as anti-free radicals and reduce free radicals (Suparni dan Wulandari, 2012).

However, although containing beneficial antioxidants, lemongrass and Malang apples are rarely used as ingredients to make powdered beverages. Due to its practicality, ready-to-serve drinks in powder form (Sari *et al.*, 2021) with both ingredients are necessary to be made. In order to function as a nutritional drink, the making of powdered drinks from lemongrass and Malang apples should pay special attention to the drying process (Naibaho *et al.*, 2015). It is because the active ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures for a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the amount of antioxidants present, it is necessary to find the right drying temperature. In addition, coating materials are needed to maintain the existing volatile compounds. The commonly used coating material is gum Arabic because this material has the ability to form good emulsions and films. Compared to modified starch, gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the highest volatile components (Santoso *et al.*, 2013). Gum arabic can preserve the flavor of dried materials by coating the flavor particles, protecting them from oxidation, absorption, and evaporation of water from the air (Herawati, 2018). According to Harahap *et al.* (2021), maltodextrin has a high solubility, a strong binding power, and low browning properties. In addition, being able to disperse quickly, maltodextrin can inhibit crystallization and form low hygroscopic properties. Meanwhile, dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity (Asiah *et al.*, 2012).

Based on the description above, this study aimed to investigate the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The quality of the powdered drinks was determined based on physical tests in the form of bulk density, dissolution time, and stability tests. These tests were required to determine packaging. In addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity, water activity, and vitamin C. These tests would indirectly determine the shelf life of the product and its ability to enhance the body's immunity. This research has yielded a product with the following characteristics: easy to carry, having the potential to boost the body's immunity, and having a relatively long shelf life.

2. Materials and methods

2.1 Materials and equipment

The materials used in the study were lemongrass stems and seedless Malang apples, maltodextrin, dextrin, gum Arabic powder, water, and brown sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a Mitzui blender, cutting boards, measuring cups, knives, WTC Binder 78532 blower ovens, baking sheets, spoons, Matrix ESJ210-4B scales, volumetric flasks, Erlenmeyer, burettes, measuring pipettes, a suction ball, a funnel pipette, a beaker glass, a filter paper, a burette, a stative, a Siever 60 mesh, and a UV2100 spectrophotometer.

2.2 The process of making lemongrass and malang apple powdered drinks

The process of making powdered drinks was a modification of the research of Susanti and Putri (2014). The process of making powdered drinks consisted of two stages including the making of fruit pulp and the drying process.

2.2.1 Making fruit pulp

The making of fruit pulp began with the sorting of the lemongrass and Malang apples. The ingredients sorted were washed and cut (1:1 w/w), and then crushed with a blender for 5 mins at speed number 2. The pulp was added with water in a ratio of 1:1 w/w. The coating materials (maltodextrin, dextrin, and gum Arabic) were then added as much as 5% w/w of the fruit pulp separately. The pulp was stirred until homogeneous.

2.2.2 Drying

Each homogeneous fruit pulp was placed on a 60 × 40 × 2 cm baking sheet as much as 250 mL. It was then dried with a blower oven at a predetermined temperature (40 °C, 45 °C, and 50 °C) separately for 18 h. Afterwards, the dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3 mins at speed number 2. Then, brown sugar was added at 10% w/w of the dry powder. After that, the powder was sieved using a 60-mesh sieve. Lemongrass powdered drinks were packaged in aluminum foil zip lock with a size of 7 × 13 cm.

2.3. Analysis procedure of bulk density

The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring cup containing the powder sample was tapped 30 times until there were no more cavities when the powder

sample was adjusted to 10 mL. The measuring cup containing the powder sample was then weighed. The bulk density (g/mL) can be calculated by dividing the weight of the powder sample by its volume (10 mL).

2.4 Analysis procedure of dissolution time testing

A total of 5 g sample was weighed. The sample was then dissolved in 50 mL of warm water and stirred 20 times until homogeneous. The dissolving time of the sample was recorded.

2.5 Analysis procedure of stability testing

A total of 5 g of powder was weighed and brewed in 50 mL of water. It was then put into a 10 mL measuring cup and kept for 24 h. Afterwards, the solution was measured for the volume of the precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

2.6 Analysis procedure of water content by oven drying method

An empty cup was dried in the oven for 15 mins. The cup was then cooled in a desiccator (10 mins for an aluminum cup and 20 mins for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2-3 g and then put in the dry cup. After that, the cup containing the sample was put in the oven at 105°C for 6 h. Next, it was cooled in a desiccator and then weighed. The drying process was repeated until a constant weight was obtained. The water content was calculated based on the loss of weight, by calculating the difference between the initial weight of the sample before the drying and the final weight after the drying.

2.7 Analysis procedure of ash content by muffle furnace method

A porcelain cup was dried in the oven for 15 mins. The cup was cooled in a desiccator and then weighed. The sample was weighed as much as 3 g in a cup that had been dried. Afterwards, it was burned in a crucible until it no longer emitted smoke. Next, the ashing process was carried out using an electric furnace at a temperature of 400-600°C for 4-6 hrs until the white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

2.8 Analysis procedure of radical scavenging activity

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free

radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 mL of the sample in 100 mL of methanol PA. A total of 1 mL of DPPH solution (10 mg/L) was added to 50 μ L of sample solution. Afterwards, methanol pro analyzed was added up to 5 mL, then incubated for 30 mins at 37°C. The absorbance was measured at a wavelength of 513 nm. The antioxidant activity of the sample was determined by the magnitude of the DPPH radical uptake inhibition by calculating the percentage of DPPH uptake inhibition.

2.9 Analysis procedure of IC_{50} antioxidant activity

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenylpicrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 mL of the sample in 100 mL of methanol PA. Furthermore, dilution was carried out using the methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was prepared by dissolving 5 mg of solid DPPH in 100 mL of methanol PA. Then a comparison solution was prepared, namely a control solution containing 2 mL of methanol PA and 1 mL of 50 ppm DPPH solution. For the test sample, 2 mL of the sample solution and 2 mL of the DPPH solution were prepared. Then, the solution was kept for 30 mins. All samples, the extract samples that had been kept, were tested for measuring the absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

2.10 Analysis procedure of water activity testing

The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated by adding $BaCl_2 \cdot 2H_2O$. It was then closed and kept for 3 mins until the number on the scale became 0.9. The aw-meter was then opened and the sample was inserted. Afterwards, the tool was closed and waited until the aw scale was read. The temperature scale and the correction factor were observed. When the temperature scale was above 20°C, the aw scale reading was added as much as the excess of the temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.

2.11 Analysis procedure of vitamin C testing

The analysis of vitamin C was performed by the iodometric method. The crushed sample was weighed as much as 5 g. The sample was put into a 100 mL measuring flask. Distilled water was then added up to

the line mark. The sample was then shaken until homogeneous. Afterwards, the solution was filtered and the filtrate was pipetted as much as 25 mL, and put into an Erlenmeyer flask. A few drops of the starch indicator were added, then titrated rapidly using 0.01 N iodine solution until a blue color appeared. The vitamin C content was obtained from the following formula:

$$\text{Vitamin C (mg/100 g)} = \frac{V I_2 \times 0.88 \times Fp \times 100}{W(g)}$$

Where $V I_2$ = iodine volume (mL), 0.88 = 0.88 mg ascorbic acid equivalent to 1 ml I_2 0.01 N solution, Fp = dilution factor and W = sample mass (g).

2.12 Statistical analysis

The data obtained were analyzed using the analysis of variance (ANOVA). When the data showed that there was a significant effect, the Duncan Multiple Range Test was carried out. The testing was done using the IBM SPSS Statistics 29 software. The significant level was set at $\alpha = 0.05$.

3. Results and discussion

3.1 Bulk density of lemongrass and Malang apple powdered drinks

The bulk density value indicates void space, namely the number of empty cavities between the material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2008). The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The findings revealed that the drying temperature and coating type had an effect on the density value of the Kamba powdered drink. Furthermore, the density value of Kamba is affected by a relationship between the drying temperature and coating type. The higher the drying temperature causes the bulk density value to decrease. This is because the higher the drying temperature causes more water in the material to be evaporated. Therefore, the resulting water content is lower, causing the weight of the powder to become lighter. According to Andriyani *et al.* (2015), as the drying temperature rises, the bulk density falls. The bulk density is influenced by the type of material, the water content, and the shape and size of the material. The smaller the bulk density, the more porous the product is (Widowati *et al.*, 2010).

Of the three types of coating used, gum Arabic has the lowest bulk density compared to other coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan and Abdullah, 2013). Meanwhile, according to Purbasari (2019), dextrin is able to form films, form the body, inhibit crystallization, and quickly disperse. Dextrin also has high solubility, hygroscopic properties, low browning properties, and strong binding power. The dextrin film layer has a higher proportion of solids than

gum arabic since the DE value of dextrin is lower than gum arabic. Therefore, the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*, 2010). Maltodextrin is a coating material that has a high level of solubility. It is due to the nature of maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has the ability to absorb water) so the water in the material is more retained and difficult to evaporate (Yuliwati and Susanto, 2015).

According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space needed for that material. The greater the bulk density, the smaller the space needed, and vice versa. The smaller the size of the molecule, the more easily the product will be compressed. The smaller the gaps between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum Arabic with a drying temperature of 50 °C resulted in the lowest bulk density value of 0.52. According to Palijama *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact (non-voluminous). It means that in the same certain volume, the product is available in more weight. According to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small. It means that lightweight requires a large space. The smaller the bulk density, the more porous the product is. Sadeghi *et al.* (2010) state that the higher sphericity of the corn kernels results in a more regular arrangement of the kernels. Therefore, the cavities between the kernels were smaller, resulting in a higher bulk density. According to the preceding description, the drying temperature and the type of coating both affect the density value of Kamba. It demonstrates that the two interact in altering the value of Kamba density.

3.2 Dissolution time

Dissolution time is a time for all beverage powder to dissolve in water perfectly. The testing of dissolution time was carried out to determine the speed of solubility of the drinks. The higher the solubility value of the powder product, the better the product is. It is because the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang *et al.*, 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 s (Table 2). The results showed that the higher the drying temperature, the faster the dissolution time (Table 2). It is because the powder produced is drier. The higher the drying temperature, the more water evaporates on the powdered drinks so that the water content is lower. The lower the water content, the more hygroscopic, the dissolution time is faster (Paramita *et al.*, 2015 and Sakdiyah and Rekna, 2019).

The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin has the fastest dissolution time (Table 2). When powdered drinks are dissolved in water, especially warm water, the hydroxyl groups in the coating substance will interact with the water, increasing the powder's solubility (Yuliwati and Susanto, 2015). Dextrin has a dextrose equivalent (DE) value of 3-5 and has the ability to form

layers (Tyanjani and Yunianta, 2015). With the addition of dextrin, the solubility of powdered drinks increases. This is because dextrin is easily soluble in water. This is in accordance with Nurhidayah *et al.* (2014), who state that dextrin is easily soluble in water, and disperses more quickly. Dextrin is not viscous and more stable than starch.

According to Wulansari *et al.* (2012), the dextrose equivalent (DE) of maltodextrin is 3-20. The higher the DE value, the higher the monosaccharide content. It causes the binding power to be greater. Thus, compared to dextrin, the use of maltodextrin allows the water content to be higher. Maltodextrin is a filler that has a high level of solubility. This is due to the characteristic of maltodextrin which is soluble in water (Hofman *et al.*, 2016). Gum Arabic has a longer dissolution time than maltodextrin and dextrin. However, according to Herawati (2018), gum Arabic has a high solubility in water, making it better to use as the coating material in making powdered drinks. The DE value of gum Arabic is 6 (Soottitantawat *et al.*, 2006). According to Hofman *et al.* (2016), the factor that affects the level of solubility in water is the DE value. The higher the DE value, the better the solubility level.

3.3 Stability

Beverage products will be stable if the particles acting as the dispersed phase can be retained without changing for a long time, or without experiencing grouping with each other (Anjani *et al.*, 2011). The stability testing is expressed in the percentage of stability of the powdered drinks made. The stability of lemongrass and Malang apple powdered drinks obtained an average of 63.89% to 93.33% (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The higher the drying temperature, the lower the powder water content. It causes the product to absorb water more easily so that the product becomes more stable when rehydrated. This is in line with Kryzhska *et al.* (2020) who state that the high water content in powder products would seriously disrupt the product stability. It would also cause the product to agglomerate when stored. The high water content in a product can cause damage due to the activity of microorganisms.

The type of coating also affects the stability value. Of the three types of coating used, dextrin has the most stable results compared to the other types of coating. Dextrin can wrap the active ingredient particles from oxidation reactions during storage, thereby increasing product stability (Septevani *et al.*, 2013). Belong to a group of polysaccharides, dextrin has a stronger ability to bind water because it has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). The addition of maltodextrin can increase the stability of the drink, reducing the precipitate formed (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the product does not precipitate too much (Pramitasari *et*

et al., 2011). Gum arabic has a more complex molecular structure than dextrin and contains starch so it is more hygroscopic (Sutardi *et al.*, 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin treatment with a drying temperature of 50 °C is the coating material with the highest stability value of 93.33%.

3.4 Water content

The average water content of lemongrass and Malang apple powdered drinks ranged from 2.06% to 2.57% (Table 4). In the manufacturing process, powdered drinks are made by drying separately at 40 °C, 45 °C and 50 °C for 18 h. The results reveal that the drying temperature has an effect on the water content of lemongrass and Malang apple powdered drinks. Meanwhile, the type of coating had no effect on the water content. Similarly, there was no interaction between the drying temperature and coating type affecting the moisture content of the powdered drinks. The higher the drying temperature, the lower the water content of the powder. Drying causes the water content in the lemongrass and Malang apple powder to evaporate. The higher temperature allows the powder to have a lower water content. According to Wiyono (2011), the drying temperature factor is important. The water content can be removed quickly when the material is dried at a high temperature (Wiyono, 2011). The increase in the heating temperature tends to reduce the water content. There are more water molecules that evaporate from the dried raw materials. Thus, the water content obtained is lower.

The type of coating has a relatively similar effect on the value of the water content. Of the three types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic as it easily absorbs water. But when it is dried, the absorbed water is released (Wulansari *et al.*, 2012). The water content absorbed by the coating material will evaporate more easily than the water content in the material tissue so that the evaporation process of water in powdered drinks becomes easier (Paramita *et al.*, 2015). Maltodextrin has a low molecular weight and a simple structure so that water is easily evaporated during the drying process (Prमितasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic. The water in the material coated with gum arabic is difficult to evaporate. Containing a large amount of starch, gum arabic has a high molecular weight and a complex molecular structure (Sutardi *et al.*, 2010). Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50 °C dextrin. It was in accordance with the SNI number 01-4320-1996 in which the water content of powdered drinks was a

maximum of 3% (BSN, 1996). The powdered drink products meet the requirements of the Indonesian National Standard for powdered drinks (SNI No. 01-4320-1996). The products have a small possibility of being contaminated with microorganisms.

3.5 Ash content

According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of minerals in a food. Ash is composed of various types of minerals with varying compositions depending on the type and source of food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher the ash content. The increase in ash content is related to the higher drying temperature. It causes more water in the material to evaporate. Thus, the water content is lower. It causes the percentage of mineral content in the material to increase. The results of the study are in line with Shadri *et al.* (2018).

Dextrin is a polysaccharide group that has a simpler chemical structure than gum arabic. Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile, gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alfren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin coating with a drying temperature of 45 °C. In general, the ash content of the product was still within the limits of SNI 01-4320-1996 regarding the quality requirements for powdered drinks, namely a maximum of 1.5% (BSN, 1996). Malang apples have a fairly high nutritional content, especially vitamins and minerals such as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2, and vitamin C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A, vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

3.6 Vitamin C

The results of the vitamin C test are presented in Table 6. It shows an average value of vitamin C between 72.69 mg/100 g to 53.15 mg/100 g. The results demonstrated that the drying temperature and type of coating affected the vitamin C content. There was an interaction between the drying temperature and the type of coating in determining the vitamin C content of powdered drinks. The vitamin C content tends to decrease along with the increase in the drying temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C which can be easily degraded, especially by heat (Parfiyanti *et al.*, 2016). It

shows that the drying process at high temperatures can reduce the vitamin C content in powdered drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid and plays a role in inhibiting excessive oxidation reactions (Susanti and Putri, 2014).

The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin produces the highest content of vitamin C compared to other types of coating. Dextrin can protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the addition of more dextrin helps maintain the vitamin C content in the product. Dextrin can protect vitamin C and compounds sensitive to heat or oxidation. It is because the molecules of dextrin are stable to heat and oxidation. In addition, according to Aretzy *et al.* (2018), maltodextrin can protect volatile compounds and protect compounds sensitive to oxidation. According to Morodi *et al.* (2022), GA alone or combined with other biopolymers has been successfully applied on tomato slices and grapefruit slices to preserve the dried products' quality. The highest content of vitamin C was produced in powdered drinks dried at 40 °C with the dextrin coating (72.68 mg/100 g) and the lowest was produced at 50 °C with the gum arabic coating (53.15 mg/100 g). The vitamin C content of mixed fruit powdered drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and tween 80 dried at 50 °C produces a vitamin C content between 425 mg/100 g - 550 mg/100 g, higher than lemongrass and Malang apple powdered drinks (Minah, *et al.*, 2021).

3.7 Water activity

Table 7 shows the mean value of water activity (*aw*) of lemongrass and Malang apple powdered drinks, namely 0.44 to 0.50. The *Aw* value of lemongrass and Malang apple powdered drinks is lower than the *Aw* value for the bacterial growth requirement at 0.90. The *Aw* value for yeast growth is 0.80-0.90, and the *Aw* value for mold growth is 0.60-0.70. The *Aw* value is relatively decreased along with the increase in drying temperature. In the drying process, the free water in the material will evaporate. The higher temperature causes more water to evaporate. The lower the water content, the lower the water activity (Martins *et al.*, 2019). According to Adri and Hersoelistyorini (2013), the composition of water in foodstuffs, such as free water and bound water, can affect the duration of food drying. The relatively small *aw* value does not allow the growth of bacteria, molds, and yeasts in the product. The lemongrass extract has great potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella typhimurium* and *Staphylococcus aureus*, indicating the possibility of using medicinal plants as natural antibacterial agents (Ibrahim and Salem, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying is to reduce water content so that it is not easy for mold and bacteria to grow. The drying process also eliminates the

activity of enzymes that can decompose the active substance content. It also facilitates further processing so that the product can be more compact, durable, and easy to store.

The use of various coatings in this study relatively produces the same a_w value. The use of maltodextrin and gum arabic as coating materials in the process of drying milk into milk powder by spray drying can protect protein, calcium, and lactose powder (Martins *et al.*, 2019). The lowest water activity value of lemongrass and Malang apple powdered drinks was obtained for products with gum arabic coating at the drying temperature of 45 °C (0.44).

3.8 Radical scavenging activity

Plants that have potential as antioxidants are lemongrass (Wibisono, 2011) and apples (Yudhianto *et al.*, 2013). Based on the radical scavenging activity test in Table 8, the average inhibition value was 37.45% to 60.13%. Dextrin protects volatile chemicals and molecules vulnerable to heat or oxidation. Gum arabic can help increase the stability of the coating component. Gum arabic is another sort of heat-resistant coating (Dauqan and Abdullah, 2013). Based on Table 8, the drying temperature affects the radical scavenging activity. The higher the drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant activity in the lemongrass and Malang apple powdered drinks is related to the damage to the antioxidant compounds due to high temperatures. According to Patras *et al.* (2010), antioxidant compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat. Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna *et al.* (2013) that antioxidant bioactive components have heat-resistant characteristics. If the sample is extracted in hot conditions, it will reduce the value of its antioxidant activity. The results of the research by Widiastuti *et al.* (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content in lemongrass is due to its large number of phenolic compounds. The high content of phenolic compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential oil in lemongrass stems is very high, with an effective inhibition of 89% and 89.63%. In lemongrass leaves, it is slightly lower with the antioxidant and antidiabetic activity ranging from 78.89% and 79.26% respectively (Mirghani, *et al.*, 2012).

The use of dextrin coating with a drying temperature of 40 °C produced the highest inhibition value compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explain that dextrin is composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the

oxidation process can be prevented. Dextrin protects volatile compounds and compounds sensitive to heat or oxidation. Gum arabic can maintain the stability of the compounds being coated. Gum arabic is also resistant to heat (Dauqan and Abdullah, 2013). Meanwhile, maltodextrin can protect volatile compounds and compounds sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high oxidation resistance. It can reduce the viscosity of the emulsion. Combined with other coatings that have better emulsifying properties, it causes the antioxidant compounds in the microencapsulants to be well protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural antioxidants and anti-inflammatories that can prevent free radicals in the human body. Antioxidants in lemongrass are able to inhibit the release of arachidonic acid. It is through the mechanism of inhibiting kinase protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants that are very good for skin health. The very high antioxidant content is also the reason for the high consumption of apples by the public. It is an effort to prevent diseases and other dysfunctions of body health.

3.9 Antioxidant content with inhibition concentration value of 50% (IC_{50})

The IC_{50} value is the concentration of the antioxidant source to neutralize 50% of the radical compounds. The lower the IC_{50} value, the better the antioxidant activity of the sample. IC_{50} antioxidant content is determined from the 3 best samples based on the highest inhibition percentage, namely on lemongrass and Malang apple powders coated with dextrin with drying temperatures of 40 °C, 45 °C and 50 °C. According to Phongpaichit *et al.* (2007), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates weak activity. The results showed that the IC_{50} value in the lemongrass and Malang apple powdered drinks was 0.9 to 1.47 % (Table 9), which indicated a very strong activity. The results of research by Andriyani *et al.* (2015) show that the IC_{50} value of *Curcuma zanthorrhiza* L. and red ginger powder functional drinks made using the spray drying method has the highest average value of 0.62 ppm at 4% maltodextrin concentration, and the lowest or weakest value of 1.00 ppm at 0% maltodextrin concentration.

4. Conclusion

The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the

parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the type of coating and the drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was determined based on the antioxidant content and high stability. The fast dissolution time was found in the lemongrass and Malang apple powder dried at 45 °C with the dextrin coating. The best lemongrass and Malang apple powdered drinks had the following characteristics: a solubility of 0.96 seconds, a bulk density of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 %, and a water activity 0.50.

Conflict of interest

The authors declare no conflict of interest.

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Table 1. The mean value of bulk density (gr/mL) for lemongrass and Malang apple powdered drinks.

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	0.58±0.04 ^a	0.63±0.03 ^{bcd}	0.64±0.01 ^{bcd}	0.62±0.03
45 °C	0.67±0.03 ^{ab}	0.58±0.05 ^{abc}	0.64±0.03 ^{bcd}	0.63±0.05
50 °C	0.58±0.06 ^{abc}	0.67±0.02 ^{cd}	0.52±0.00 ^a	0.59±0.08
Mean±SD	0.61±0.05	0.63±0.05	0.60±0.60	

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 2. The mean value of dissolution time for lemongrass and Malang apple powdered drinks (seconds).

Drying temperature	Coating type			Mean ± SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	1.06±0.04 ^{bc}	1.11±0.01 ^{ab}	1.29±0.07 ^d	1.15±0.12 ^c
45 °C	1.04±0.00 ^{abc}	0.96±0.07 ^a	1.05±0.03 ^{abc}	1.02±0.05 ^b
50 °C	1.07±0.00 ^{bc}	1.01±0.02 ^{cd}	1.17±0.03 ^e	1.08±0.08 ^a
Mean±SD	1.05±0.01 ^a	1.03±0.08 ^a	1.17±0.12 ^b	

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 3. The mean value of stability for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Dextrin Dekstrin	Gum Arabic	
40 °C	65.30±0.65 ^{ab}	87.32±0.45 ^e	63.89±2.66 ^a	72.17±13.14 ^c
45 °C	73.01±0.57 ^d	89.19±0.43 ^e	69.69±0.59 ^c	77.30±10.43 ^b
50 °C	78.74±1.00 ^d	93.33±0.40 ^f	80.19 ±0.00 ^e	84.09±8.03 ^a
Mean±SD	72.35±6.74 ^a	89.95±3.07 ^a	71.26±8.26 ^b	

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Table 4. The mean value of water content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 ° C	2.57±0.06		2.51±0.04	2.54±0.03 ^c
45 ° C	2.39±0.06		2.38±0.12	2.36±0.04 ^b
50 ° C	2.07±0.02		2.16±0.02	2.10±0.05 ^a
Mean±SD	2.34±0.25		2.35±0.18	2.30±0.24

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 5. The mean value of ash content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 ° C	1.17±0.13 ^{ab}		1.46±0.11 ^e	1.23±0.21 ^a
45 ° C	1.26±0.01 ^{bcd}		1.21±0.03 ^{abc}	1.23±0.02 ^a
50 ° C	1.26±0.02 ^{bcd}		1.37±0.01 ^{cde}	1.33±0.07 ^b
Mean±SD	1.23±0.05 ^a		1.34±0.13 ^b	1.23±0.16 ^a

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 6. The mean value of vitamin C content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 ° C	68.11±1.74 ^d		72.69±2.74 ^e	67.58 ±5.39 ^c
45 ° C	63.36±1.49 ^c		70.22±1.24 ^{de}	63.95±6.01 ^b
50 ° C	54.91±0.50 ^a		63.36±1.49 ^c	57.14±5.46 ^a
Mean±SD	62.13±6.69 ^a		68.76±4.83 ^b	57.79±4.42 ^c

Note:

the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 7. The mean value of water activity for lemongrass and Malang apple powdered drinks.

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	0.48±0.00	0.48±0.02	0.51±0.00	0.49±0.02
45 °C	0.51±0.03	0.50±0.01	0.44±0.02	0.49±0.04
50 °C	0.49±0.04	0.46±0.05	0.46±0.01	0.47±0.02
Mean±SD	0.49±0.02	0.48±0.02	0.47±0.03	

Note: the mean value followed by different letters indicates a significant difference (P < 0.05)

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Table 8. The mean value of radical scavenging activity content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Mean±SD
	Maltodextrin	Maltodekstrin	Dextrin Dekstrin	
40 °C	56.96±1.13 ^f	60.13±0.05 ⁿ	53.66±0.14 ^g	56.92±3.24 ^c
45 °C	45.73±0.67 ^c	50.97±0.11 ^e	48.17±0.18 ^d	48.29±2.62 ^b
50 °C	37.45±1.07 ^a	43.98±0.71 ^b	37.53±0.21 ^a	39.65±3.75 ^a

Note: the mean value followed by different letters indicates a significant difference (P<0.05)

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Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powdered drinks (%) on the best product.

Drying temperature	Coating type	
	Dextrin	Dekstrin
40 °C	0.9±0.01	
45 °C	1.279±0.08	
50 °C	1.47±0.01	

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The effects of coating type and drying temperature on the physicochemical properties of the mixture of lemongrass and apple powdered drinks

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Abstract

Fresh beverages from fruits and herbal plants that contain antioxidants are able to enhance the immunity of the human body. However, such fresh beverage products generally have a short shelf life. As an alternative, the products must be converted into powdered drinks. Coating materials are thus needed to avoid the loss of antioxidant compounds during the drying process. This study aimed to scrutinize the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The study employed a completely randomized design (CRD) with two factors and two replications. The first factor was the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). The data were analyzed using Analysis of variance one-way (ANOVA) test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the coating type and drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an IC₅₀ content of 1.29, and a water activity of 0.50.

1. Introduction

The COVID-19 pandemic has forced people to maintain their health by increasing their body's immunity. Body immunity can be enhanced through an adequate diet and nutrition from drinks (Iddir *et al.*, 2020). Powdered drinks are processed food products in the form of a powder. Having a relatively long shelf life, the product is easy to serve and can be rapidly dissolved in water. In addition, powdered drinks are easy to carry and ship (Tangkeallo *et al.*, 2014), making the product to be liked by the public. One of the ingredients that can boost the body's immunity is herbal plants. The plants are known to contain antioxidant compounds. Antioxidants are able to capture free radicals to enhance the immunity of the body (Cakmakci *et al.*, 2015). One of the popular herbal plants that contains antioxidants is lemongrass. Lemongrass contains compounds including

geraniol, *citronellol*, *lemonen*, *kadinen*, *eugenol*, *dipentene*, *citral* (Wibisono, 2011). Acting as an anticancer and antioxidant, these compounds can stabilize blood pressure, treat constipation, help the digestive system, tighten the body after childbirth (Poeloengan, 2009), and reduce pain (Royhanaty *et al.*, 2018). In addition to lemongrass, Malang apples, a famous fruit typical of the city of Malang, also belong to the food ingredient that can enhance the body's immunity. Being small in size, Malang apples have low economic value because they are less attractive to consumers (Pramanta *et al.*, 2017). Meanwhile, according to Rusita *et al.* (2019), Malang apples contain lots of vitamins such as vitamins A, B, and C, minerals, and fiber. The apples also contain flavonoid compounds, including quercetin. Vitamin C and quercetin act as antioxidants, antivirals, and anti-inflammatories that protect the body's reproductive system. Flavonoids as

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antioxidants have the ability to act as anti-free radicals and reduce free radicals (Suparni dan Wulandari, 2012).

However, although containing beneficial antioxidants, lemongrass and Malang apples are rarely used as ingredients to make powdered beverages. Due to its practicality, ready-to-serve drinks in powder form (Sari *et al.*, 2021) with both ingredients are necessary to be made. In order to function as a nutritional drink, the making of powdered drinks from lemongrass and Malang apples should pay special attention to the drying process (Naibaho *et al.*, 2015). It is because the active ingredients contained in lemongrass and Malang apples are volatile. Drying at high temperatures for a long time can reduce the antioxidant activity of the dried material (Yamin *et al.*, 2017). To maintain the amount of antioxidants present, it is necessary to find the right drying temperature. In addition, coating materials are needed to maintain the existing volatile compounds. The commonly used coating material is gum Arabic because this material has the ability to form good emulsions and films. Compared to modified starch, gum arabic as a coating material is able to maintain the stability of volatile compounds and trap the highest volatile components (Santoso *et al.*, 2013). Gum arabic can preserve the flavor of dried materials by coating the flavor particles, protecting them from oxidation, absorption, and evaporation of water from the air (Herawati, 2018). According to Harahap *et al.* (2021), maltodextrin has a high solubility, a strong binding power, and low browning properties. In addition, being able to disperse quickly, maltodextrin can inhibit crystallization and form low hygroscopic properties. Meanwhile, dextrin has a high solubility, but it has a relatively low ability to bind water and a relatively low viscosity (Asiah *et al.*, 2012).

Based on the description above, this study aimed to investigate the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The quality of the powdered drinks was determined based on physical tests in the form of bulk density, dissolution time, and stability tests. These tests were required to determine packaging. In addition, chemical tests were carried out in the form of water content, ash content, antioxidant activity, water activity, and vitamin C. These tests would indirectly determine the shelf life of the product and its ability to enhance the body's immunity. This research has yielded a product with the following characteristics: easy to carry, having the potential to boost the body's immunity, and having a relatively long shelf life.

2. Materials and methods

2.1 Materials and equipment

The materials used in the study were lemongrass stems and seedless Malang apples, maltodextrin, dextrin, gum Arabic powder, water, and brown sugar. The materials for chemical analysis were distilled water, starch indicator, 0.1 N NaOH, 50 mg/L DPPH, methanol p.a, and ascorbic acid. The tools used in the study were a Mitzui blender, cutting boards, measuring cups, knives, WTC Binder 78532 blower ovens, baking sheets, spoons, Matrix ESJ210-4B scales, volumetric flasks, Erlenmeyer, burettes, measuring pipettes, a suction ball, a funnel pipette, a beaker glass, a filter paper, a burette, a stative, a Siever 60 mesh, and a UV2100 spectrophotometer.

2.2 The process of making lemongrass and malang apple powdered drinks

The process of making powdered drinks was a modification of the research of Susanti and Putri (2014). The process of making powdered drinks consisted of two stages including the making of fruit pulp and the drying process.

2.2.1 Fruit pulp production

The making of fruit pulp began with the sorting of the lemongrass and Malang apples. The ingredients sorted were washed and cut (1:1 w/w), and then crushed with a blender for 5 mins at speed number 2. The pulp was added with water in a ratio of 1:1 w/w. The coating materials (maltodextrin, dextrin, and gum Arabic) were then added as much as 5% w/w of the fruit pulp separately. The pulp was stirred until homogeneous.

2.2.2 Drying

Each homogeneous fruit pulp was placed on a 60×40×2 cm baking sheet as much as 250 mL. It was then dried with a blower oven at a predetermined temperature (40°C, 45°C, and 50°C) separately for 18 hrs. Afterwards, the dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3 mins at speed number 2. Then, brown sugar was added at 10% w/w of the dry powder. After that, the powder was sieved using a 60-mesh sieve. Lemongrass powdered drinks were packaged in aluminum foil zip lock with a size of 7×13 cm.

2.3. Analysis procedure of bulk density

The powder sample was put into a 10 mL measuring cup whose weight was known. The measuring cup containing the powder sample was tapped 30 times until there were no more cavities when the powder sample was adjusted to 10 mL. The measuring cup containing the powder sample was then weighed. The bulk density

(g/mL) can be calculated by dividing the weight of the powder sample by its volume (10 mL).

2.4 Analysis procedure of dissolution time testing

A total of 5 g sample was weighed. The sample was then dissolved in 50 mL of warm water and stirred 20 times until homogeneous. The dissolving time of the sample was recorded.

2.5 Analysis procedure of stability testing

A total of 5 g of powder was weighed and brewed in 50 mL of water. It was then put into a 10 mL measuring cup and kept for 24 hrs. Afterwards, the solution was measured for the volume of the precipitate and the height of the solution volume as the percentage of stability of the drink obtained.

2.6 Analysis procedure of water content by oven drying method

An empty cup was dried in the oven for 15 mins. The cup was then cooled in a desiccator (10 mins for an aluminum cup and 20 mins for a porcelain cup). The dry cup was weighed. The sample was weighed as much as 2-3 g and then put in the dry cup. After that, the cup containing the sample was put in the oven at 105°C for 6 hrs. Next, it was cooled in a desiccator and then weighed. The drying process was repeated until a constant weight was obtained. The water content was calculated based on the loss of weight, by calculating the difference between the initial weight of the sample before the drying and the final weight after the drying.

2.7 Analysis procedure of ash content by muffle furnace method

A porcelain cup was dried in the oven for 15 mins. The cup was cooled in a desiccator and then weighed. The sample was weighed as much as 3 g in a cup that had been dried. Afterwards, it was burned in a crucible until it no longer emitted smoke. Next, the ashing process was carried out using an electric furnace at a temperature of 400-600°C for 4-6 hrs until the white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

2.8 Analysis procedure of radical scavenging activity

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by

dissolving 0.01 mL of the sample in 100 mL of methanol PA. A total of 1 mL of DPPH solution (10 mg/L) was added to 50 µL of sample solution. Afterwards, methanol pro analyzed was added up to 5 mL, then incubated for 30 mins at 37°C. The absorbance was measured at a wavelength of 513 nm. The antioxidant activity of the sample was determined by the magnitude of the DPPH radical uptake inhibition by calculating the percentage of DPPH uptake inhibition.

2.9 Analysis procedure of IC_{50} antioxidant activity

Antioxidant activity was analyzed based on its ability to capture free radicals (radical scavenging activity) of DPPH. The analysis of antioxidant activity in this study used the DPPH (2,2-diphenyl-1-picrylhydrazyl) method. The DPPH method aimed to determine the concentration used to inhibit free radicals in a sample. A sample macerated with methanol was prepared. A mother liquor for each sample of 100 ppm was made by dissolving 0.01 mL of the sample in 100 mL of methanol PA. Furthermore, dilution was carried out using the methanol PA solvent by varying the concentration of 5 ppm, 6 ppm, 7 ppm, 8 ppm and 9 ppm for each sample. The next step was to prepare a 50 ppm DPPH stock solution. The DPPH stock solution was prepared by dissolving 5 mg of solid DPPH in 100 mL of methanol PA. Then a comparison solution was prepared, namely a control solution containing 2 mL of methanol PA and 1 mL of 50 ppm DPPH solution. For the test sample, 2 mL of the sample solution and 2 mL of the DPPH solution were prepared. Then, the solution was kept for 30 mins. All samples, the extract samples that had been kept, were tested for measuring the absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

2.10 Analysis procedure of water activity testing

The measurement of water activity was conducted using an aw-meter tool. The tool was calibrated by adding $BaCl_2 \cdot 2H_2O$. It was then closed and kept for 3 mins until the number on the scale became 0.9. The aw-meter was then opened and the sample was inserted. Afterwards, the tool was closed and waited until the aw scale was read. The temperature scale and the correction factor were observed. When the temperature scale was above 20°C, the aw scale reading was added as much as the excess of the temperature multiplied by a correction factor of 0.002°, as well as for temperatures below 20°C.

2.11 Analysis procedure of vitamin C testing

The analysis of vitamin C was performed by the iodometric method. The crushed sample was weighed as much as 5 g. The sample was put into a 100 mL measuring flask. Distilled water was then added up to the line mark. The sample was then shaken until

homogeneous. Afterwards, the solution was filtered and the filtrate was pipetted as much as 25 mL, and put into an Erlenmeyer flask. A few drops of the starch indicator were added, then titrated rapidly using 0.01 N iodine solution until a blue color appeared. The vitamin C content was obtained from the following formula:

$$\text{Vitamin C (mg/100 g)} = \frac{V I_2 \times 0.88 \times Fp \times 100}{W(g)}$$

Where $V I_2$ = iodine volume (mL), 0.88 = 0.88 mg ascorbic acid equivalent to 1 ml I_2 0.01 N solution, Fp = dilution factor and W = sample mass (g).

2.12 Statistical analysis

The data obtained were analyzed using the analysis of variance (ANOVA). When the data showed that there was a significant effect, the Duncan Multiple Range Test was carried out. The testing was done using the IBM SPSS Statistics 29 software. The significant level was set at $\alpha = 0.05$.

3. Results and discussion

3.1 Bulk density of lemongrass and Malang apple powdered drinks

The bulk density value indicates void space, namely the number of empty cavities between the material particles. The greater the bulk density of an object, the less void space it has (Hui *et al.*, 2008). The bulk density obtained in the study was 0.52 g/mL to 0.67 g/mL (Table 1). The findings revealed that the drying temperature and coating type had an effect on the density value of the Kamba powdered drink. Furthermore, the density value of Kamba is affected by a relationship between the drying temperature and coating type. The higher the drying temperature causes the bulk density value to decrease. This is because the higher the drying temperature causes more water in the material to be evaporated. Therefore, the resulting water content is lower, causing the weight of the powder to become lighter. According to Andriyani *et al.* (2015), as the drying temperature rises, the bulk density falls. The bulk density is influenced by the type of material, the water content, and the shape and size of the material. The smaller the bulk density, the more porous the product is

(Widowati *et al.*, 2010).

Of the three types of coating used, gum Arabic has the lowest bulk density compared to other coatings. It is because gum arabic contains a complex mixture of hydrophilic carbohydrates and hydrophobic protein components so that the solution can dissolve very well in water (up to 50%) (Dauqan and Abdullah, 2013). Meanwhile, according to Purbasari (2019), dextrin is able to form films, form the body, inhibit crystallization, and quickly disperse. Dextrin also has high solubility, hygroscopic properties, low browning properties, and strong binding power. The dextrin film layer has a higher proportion of solids than gum arabic since the DE value of dextrin is lower than gum arabic. Therefore, the drying process using dextrin is faster and the particle size is smaller than gum arabic (Sutardi *et al.*, 2010). Maltodextrin is a coating material that has a high level of solubility. It is due to the nature of maltodextrin which is soluble in water and has a fast dispersion process. Maltodextrin is hygroscopic (has the ability to absorb water) so the water in the material is more retained and difficult to evaporate (Yuliwaty and Susanto, 2015).

According to Setiawati *et al.* (2014), the amount of bulk density of a material affects the space needed for that material. The greater the bulk density, the smaller the space needed, and vice versa. The smaller the size of the molecule, the more easily the product will be compressed. The smaller the gaps between molecules, the greater the bulk density (Stranzinger *et al.*, 2017). The treatment using gum Arabic with a drying temperature of 50°C resulted in the lowest bulk density value of 0.52. According to Palijama *et al.* (2020), foodstuffs that have a high bulk density indicate that the product is more compact (non-voluminous). It means that in the same certain volume, the product is available in more weight. According to Widowati *et al.* (2010), a material is considered 'bulk' if the bulk density is small. It means that lightweight requires a large space. The smaller the bulk density, the more porous the product is. Sadeghi *et al.* (2010) state that the higher sphericity of the corn kernels results in a more regular arrangement of the kernels. Therefore, the cavities between the kernels were smaller, resulting in a higher bulk density. According to the preceding description, the drying

Table 1. The mean value of bulk density for lemongrass and Malang apple powdered drinks.

Drying temperature	Coating type			Average
	Maltodextrin	Dextrin	Gum Arabic	
40°C	0.58±0.04 ^a	0.63±0.03 ^{bcd}	0.64±0.01 ^{bcd}	0.62±0.03
45°C	0.67±0.03 ^{ab}	0.58±0.05 ^{abc}	0.64±0.03 ^{bcd}	0.63±0.05
50°C	0.58±0.06 ^{abc}	0.67±0.02 ^{cd}	0.52±0.00 ^a	0.59±0.08
Mean±SD	0.61±0.05	0.63±0.05	0.60±0.60	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different ($P < 0.05$).

temperature and the type of coating both affect the density value of Kamba. It demonstrates that the two interact in altering the value of Kamba density.

3.2 Dissolution time

Dissolution time is a time for all beverage powder to dissolve in water perfectly. The testing of dissolution time was carried out to determine the speed of solubility of the drinks. The higher the solubility value of the powder product, the better the product is. It is because the perfect solubility will produce products that do not float on the surface of the water (Phoungchandang *et al.*, 2009). The dissolution time of lemongrass and Malang apple powder was 0.96 to 1.29 s (Table 2). The results showed that the higher the drying temperature, the faster the dissolution time (Table 2). It is because the powder produced is drier. The higher the drying temperature, the more water evaporates on the powdered drinks so that the water content is lower. The lower the water content, the more hygroscopic, the dissolution time is faster (Paramita *et al.*, 2015 and Sakdiyah and Rekna, 2019).

The type of coating also affects the dissolution time. Of the three types of coatings used, dextrin has the fastest dissolution time (Table 2). When powdered drinks are dissolved in water, especially warm water, the hydroxyl groups in the coating substance will interact with the water, increasing the powder's solubility (Yuliwaty and Susanto, 2015). Dextrin has a dextrose equivalent (DE) value of 3-5 and has the ability to form layers (Tyanjani and Yuniarta, 2015). With the addition of dextrin, the solubility of powdered drinks increases. This is because dextrin is easily soluble in water. This is in accordance with Nurhidayah *et al.* (2014), who state that dextrin is easily soluble in water, and disperses more quickly. Dextrin is not viscous and more stable than

starch.

According to Wulansari *et al.* (2012), the dextrose equivalent (DE) of maltodextrin is 3-20. The higher the DE value, the higher the monosaccharide content. It causes the binding power to be greater. Thus, compared to dextrin, the use of maltodextrin allows the water content to be higher. Maltodextrin is a filler that has a high level of solubility. This is due to the characteristic of maltodextrin which is soluble in water (Hofman *et al.*, 2016). Gum Arabic has a longer dissolution time than maltodextrin and dextrin. However, according to Herawati (2018), gum Arabic has a high solubility in water, making it better to use as the coating material in making powdered drinks. The DE value of gum Arabic is 6 (Soottitantawat *et al.*, 2006). According to Hofman *et al.* (2016), the factor that affects the level of solubility in water is the DE value. The higher the DE value, the better the solubility level.

3.3 Stability

Beverage products will be stable if the particles acting as the dispersed phase can be retained without changing for a long time, or without experiencing grouping with each other (Anjani *et al.*, 2011). The stability testing is expressed in the percentage of stability of the powdered drinks made. The stability of lemongrass and Malang apple powdered drinks obtained an average of 63.89% to 93.33% (Table 3). The results show that the higher the drying temperature, the higher the resulting stability. The higher the drying temperature, the lower the powder water content. It causes the product to absorb water more easily so that the product becomes more stable when rehydrated. This is in line with Kryzhska *et al.* (2020) who state that the high water content in powder products would seriously disrupt the

Table 2. The mean value of dissolution time for lemongrass and Malang apple powdered drinks (seconds).

Drying temperature	Coating type			Average
	Maltodextrin	Dextrin	Gum Arabic	
40°C	1.06±0.04 ^{bc}	1.11±0.01 ^{ab}	1.29±0.07 ^d	1.15±0.12 ^c
45°C	1.04±0.00 ^{abc}	0.96±0.07 ^a	1.05±0.03 ^{abc}	1.02±0.05 ^b
50°C	1.07±0.00 ^{bc}	1.01±0.02 ^{cd}	1.17±0.03 ^e	1.08±0.08 ^a
Mean±SD	1.05±0.01 ^a	1.03±0.08 ^a	1.17±0.12 ^b	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

Table 3. The mean value of stability for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Average
	Maltodextrin	Dextrin	Gum Arabic	
40°C	65.30±0.65 ^{ab}	87.32±0.45 ^c	63.89±2.66 ^a	72.17±13.14 ^c
45°C	73.01±0.57 ^d	89.19±0.43 ^c	69.69±0.59 ^c	77.30±10.43 ^b
50°C	78.74±1.00 ^d	93.33±0.40 ^f	80.19±0.00 ^c	84.09±8.03 ^a
Mean±SD	72.35±6.74 ^a	89.95±3.07 ^a	71.26±8.26 ^b	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

product stability. It would also cause the product to agglomerate when stored. The high water content in a product can cause damage due to the activity of microorganisms.

The type of coating also affects the stability value. Of the three types of coating used, dextrin has the most stable results compared to the other types of coating. Dextrin can wrap the active ingredient particles from oxidation reactions during storage, thereby increasing product stability (Septevani *et al.*, 2013). Belong to a group of polysaccharides, dextrin has a stronger ability to bind water because it has a simpler chemical structure consisting of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). The addition of maltodextrin can increase the stability of the drink, reducing the precipitate formed (Paramita *et al.*, 2015). Maltodextrin has a high solubility so that the product does not precipitate too much (Prमितasari *et al.*, 2011). Gum arabic has a more complex molecular structure than dextrin and contains starch so it is more hygroscopic (Sutardi *et al.*, 2010). Gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Anggraini *et al.* (2016), the presence of sediment in beverage products can be caused by the presence of pectin. Table 3 shows that the dextrin treatment with a drying temperature of 50°C is the coating material with the highest stability value of 93.33%.

3.4 Water content

The average water content of lemongrass and Malang apple powdered drinks ranged from 2.06% to 2.57% (Table 4). In the manufacturing process, powdered drinks are made by drying separately at 40°C, 45°C and 50°C for 18 hrs. The results reveal that the drying temperature has an effect on the water content of lemongrass and Malang apple powdered drinks. Meanwhile, the type of coating had no effect on the water content. Similarly, there was no interaction between the drying temperature and coating type affecting the moisture content of the powdered drinks. The higher the drying temperature, the lower the water content of the powder. Drying causes the water content

in the lemongrass and Malang apple powder to evaporate. The higher temperature allows the powder to have a lower water content. According to Wiyono (2011), the drying temperature factor is important. The water content can be removed quickly when the material is dried at a high temperature (Wiyono, 2011). The increase in the heating temperature tends to reduce the water content. There are more water molecules that evaporate from the dried raw materials. Thus, the water content obtained is lower.

The type of coating has a relatively similar effect on the value of the water content. Of the three types of coating used, dextrin produced the highest average powder water content of 2.35%, followed by maltodextrin (2.34%) and gum arabic (2.30%). According to Wulansari *et al.* (2012), dextrin is hygroscopic as it easily absorbs water. But when it is dried, the absorbed water is released (Wulansari *et al.*, 2012). The water content absorbed by the coating material will evaporate more easily than the water content in the material tissue so that the evaporation process of water in powdered drinks becomes easier (Paramita *et al.*, 2015). Maltodextrin has a low molecular weight and a simple structure so that water is easily evaporated during the drying process (Prमितasari *et al.*, 2011). Meanwhile, gum arabic is hygroscopic. The water in the material coated with gum arabic is difficult to evaporate. Containing a large amount of starch, gum arabic has a high molecular weight and a complex molecular structure (Sutardi *et al.*, 2010). Based on the water content testing carried out, the lowest water content was 2.06%, namely at 50°C dextrin. It was in accordance with the Indonesian National Standard No: 01-4320-1996 in which the water content of powdered drinks was a maximum of 3% (Badan Standarisasi Nasional [BSN], 1996). The powdered drink products meet the requirements of the Indonesian National Standard for powdered drinks (SNI No. 01-4320-1996). The products have a small possibility of being contaminated with microorganisms.

3.5 Ash content

According to Leggli *et al.* (2011), ash content testing is carried out to determine the amount of minerals in a

Table 4. The mean value of water content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Average
	Maltodextrin	Dextrin	Gum Arabic	
40°C	2.57±0.06	2.51±0.04	2.54±0.02	2.54±0.03 ^c
45°C	2.39±0.06	2.38±0.12	2.31±0.03	2.36±0.04 ^b
50°C	2.07±0.02	2.16±0.02	2.06±0.02	2.10±0.05 ^a
Mean±SD	2.34±0.25	2.35±0.18	2.30±0.24	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

food. Ash is composed of various types of minerals with varying compositions depending on the type and source of food (Andarwulan *et al.*, 2011). Based on Table 5, the mean value of the ash content was 1.06% to 1.46%. It shows that the higher the drying temperature, the higher the ash content. The increase in ash content is related to the higher drying temperature. It causes more water in the material to evaporate. Thus, the water content is lower. It causes the percentage of mineral content in the material to increase. The results of the study are in line with Shadri *et al.* (2018).

Dextrin is a polysaccharide group that has a simpler chemical structure than gum arabic. Dextrin consists of 1,6 α -glycosidic and 1,4 α -glycosidic bonds (Xu *et al.*, 2012). Meanwhile, gum arabic has a more complex chemical structure, consisting of D-galactose, L-arabinose, D-glucuronic acid, and L-rhamnose (Alftren *et al.*, 2012). According to Sediaoetama (2010), ash content describes the amount of minerals that are not burnt into substances that can evaporate. Ash content is the residue left when a sample of a food ingredient is completely burned. The highest ash content is obtained in the dextrin coating with a drying temperature of 45°C. In general, the ash content of the product was still within the limits of SNI 01-4320-1996 regarding the quality requirements for powdered drinks, namely a maximum of 1.5% (BSN, 1996). Malang apples have a fairly high nutritional content, especially vitamins and minerals such as calcium, phosphorus, iron, potassium, carbohydrates, fat, protein, niacin, riboflavin, vitamins A, B1, B2, and vitamin C (Wahyuningtyas *et al.*, 2017). Lemongrass contains several minerals such as vitamin A, vitamin C, potassium, calcium, iron, magnesium, and selenium (Shadri *et al.*, 2018).

3.6 Vitamin C

The results of the vitamin C test are presented in Table 6. It shows an average value of vitamin C between 72.69 mg/100 g to 53.15 mg/100 g. The results demonstrated that the drying temperature and type of coating affected the vitamin C content. There was an interaction between the drying temperature and the type of coating in determining the vitamin C content of powdered drinks. The vitamin C content tends to decrease along with the increase in the drying temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C which can be easily degraded, especially by heat (Parfiyanti *et al.*, 2016). It shows that the drying process at high temperatures can reduce the vitamin C content in powdered drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid and plays a role in inhibiting excessive oxidation reactions (Susanti and Putri, 2014).

The type of coating also affects the vitamin C content. Of the three types of coatings used, dextrin produces the highest content of vitamin C compared to other types of coating. Dextrin can protect the volatile components of materials such as vitamin C from damage due to heat. Thus, the addition of more dextrin helps maintain the vitamin C content in the product. Dextrin can protect vitamin C and compounds sensitive to heat or oxidation. It is because the molecules of dextrin are stable to heat and oxidation. In addition, according to Aretzy *et al.* (2018), maltodextrin can protect volatile compounds and protect compounds sensitive to oxidation. According to Morodi *et al.* (2022), GA alone or combined with other biopolymers has been

Table 5. The mean value of ash content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Average
	Maltodextrin	Dextrin	Gum Arabic	
40°C	1.17±0.13 ^{ab}	1.46±0.11 ^c	1.06±0.07 ^a	1.23±0.21 ^a
45°C	1.26±0.01 ^{bcd}	1.21±0.03 ^{abc}	1.24±0.03 ^{bcd}	1.23±0.02 ^a
50°C	1.26±0.02 ^{bcd}	1.37±0.01 ^{cde}	1.38±0.09 ^{dc}	1.33±0.07 ^b
Mean±SD	1.23±0.05 ^a	1.34±0.13 ^b	1.23±0.16 ^a	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

Table 6. The mean value of vitamin C content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Average
	Maltodextrin	Dextrin	Gum Arabic	
40°C	68.11±1.74 ^d	72.69±2.74 ^c	61.95±0.50 ^c	67.58 ±5.39 ^c
45°C	63.36±1.49 ^c	70.22±1.24 ^{dc}	58.26±1.24 ^b	63.95±6.01 ^b
50°C	54.91±0.50 ^a	63.36±1.49 ^c	53.15±0.50 ^a	57.14±5.46 ^a
Mean±SD	62.13±6.69 ^a	68.76±4.83 ^b	57.79±4.42 ^c	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

successfully applied on tomato slices and grapefruit slices to preserve the dried products' quality. The highest content of vitamin C was produced in powdered drinks dried at 40°C with the dextrin coating (72.68 mg/100 g) and the lowest was produced at 50°C with the gum arabic coating (53.15 mg/100 g). The vitamin C content of mixed fruit powdered drinks (red guava, papaya, apple, and tomato) coated with maltodextrin and tween 80 dried at 50°C produces a vitamin C content between 425 mg/100 g - 550 mg/100 g, higher than lemongrass and Malang apple powdered drinks (Minah, *et al.*, 2021).

3.7 Water activity

Table 7 shows the mean value of water activity (aw) of lemongrass and Malang apple powdered drinks, namely 0.44 to 0.50. The Aw value of lemongrass and Malang apple powdered drinks is lower than the Aw value for the bacterial growth requirement at 0.90. The Aw value for yeast growth is 0.80-0.90, and the Aw value for mold growth is 0.60-0.70. The Aw value is relatively decreased along with the increase in drying temperature. In the drying process, the free water in the material will evaporate. The higher temperature causes more water to evaporate. The lower the water content, the lower the water activity (Martins *et al.*, 2019). According to Adri and Hersoelistyorini (2013), the composition of water in foodstuffs, such as free water and bound water, can affect the duration of food drying. The relatively small aw value does not allow the growth of bacteria, molds, and yeasts in the product. The lemongrass extract has great potential as an antibacterial agent that can suppress the activity of *Bacillus cereus*, *Salmonella enterica* serovar Typhimurium and *Staphylococcus aureus*, indicating the possibility of using medicinal plants as natural antibacterial agents (Ibrahim and Salem, 2013). According to Parfiyanti *et al.* (2016), the purpose of drying is to reduce water content so that it is not easy for mold and bacteria to grow. The drying process also eliminates the activity of enzymes that can decompose the active substance content. It also facilitates further processing so that the product can be more compact, durable, and easy to store.

The use of various coatings in this study relatively produces the same aw value. The use of maltodextrin and

gum arabic as coating materials in the process of drying milk into milk powder by spray drying can protect protein, calcium, and lactose powder (Martins *et al.*, 2019). The lowest water activity value of lemongrass and Malang apple powdered drinks was obtained for products with gum arabic coating at the drying temperature of 45°C (0.44).

3.8 Radical scavenging activity

Plants that have potential as antioxidants are lemongrass (Wibisono, 2011) and apples (Yudhianto *et al.*, 2013). Based on the radical scavenging activity test in Table 8, the average inhibition value was 37.45% to 60.13%. Dextrin protects volatile chemicals and molecules vulnerable to heat or oxidation. Gum arabic can help increase the stability of the coating component. Gum arabic is another sort of heat-resistant coating (Dauqan and Abdullah, 2013). Based on Table 8, the drying temperature affects the radical scavenging activity. The higher the drying temperature, the lower the antioxidant activity value. The decrease in the value of antioxidant activity in the lemongrass and Malang apple powdered drinks is related to the damage to the antioxidant compounds due to high temperatures. According to Patras *et al.* (2010), antioxidant compounds are easily degraded when exposed to heat. Heat accelerates the oxidation reaction of these compounds. The degradation process occurs due to an increase in the rate of oxidation reactions by heat. Antioxidant compounds that have been oxidized will be damaged. It is confirmed by Husna *et al.* (2013) that antioxidant bioactive components have heat-resistant characteristics. If the sample is extracted in hot conditions, it will reduce the value of its antioxidant activity. The results of the research by Widiastuti *et al.* (2019) show that the more addition of lemongrass in lemongrass syrup with stevia sweetener, the higher the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content in lemongrass is due to its large number of phenolic compounds. The high content of phenolic compounds also results in antidiabetic and antihypertensive activity. The antioxidant activity of essential oil in lemongrass stems is very high, with an effective inhibition of 89% and 89.63%. In lemongrass leaves, it is slightly lower with the antioxidant and

Table 7. The mean value of water activity for lemongrass and Malang apple powdered drinks.

Drying temperature	Coating type			Average
	Maltodextrin	Dextrin	Gum Arabic	
40°C	0.48±0.00	0.48±0.02	0.51±0.00	0.49±0.02
45°C	0.51±0.03	0.50±0.01	0.44±0.02	0.49±0.04
50°C	0.49±0.04	0.46±0.05	0.46±0.01	0.47±0.02
Mean±SD	0.49±0.02	0.48±0.02	0.47±0.03	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

antidiabetic activity ranging from 78.89% and 79.26% respectively (Mirghani, *et al.*, 2012).

The use of dextrin coating with a drying temperature of 40°C produced the highest inhibition value compared to maltodextrin and gum arabic (Table 8). Goncalves *et al.* (2015) explain that dextrin is composed of glucose units that can bind water so that dissolved oxygen can be reduced. As a result, the oxidation process can be prevented. Dextrin protects volatile compounds and compounds sensitive to heat or oxidation. Gum arabic can maintain the stability of the compounds being coated. Gum arabic is also resistant to heat (Dauqan and Abdullah, 2013). Meanwhile, maltodextrin can protect volatile compounds and compounds sensitive to oxidation (Aretzy *et al.*, 2018). The maltodextrin coating has high oxidation resistance. It can reduce the viscosity of the emulsion. Combined with other coatings that have better emulsifying properties, it causes the antioxidant compounds in the microencapsulants to be well protected (Purnomo *et al.*, 2014). According to Godwin *et al.* (2014), lemongrass contains natural antioxidants and anti-inflammatories that can prevent free radicals in the human body. Antioxidants in lemongrass are able to inhibit the release of arachidonic acid. It is through the mechanism of inhibiting kinase protein that can affect the activity of phospholipase enzymes. Thus, the inhibition of arachidonic acid synthesis will reduce the production of prostaglandins. The antioxidants found in lemongrass are citronellal and geraniol compounds. According to Baskara (2010), apples contain antioxidants that are very good for skin health. The very high antioxidant content is also the reason for the high consumption of apples by the public. It is an effort to prevent diseases and other dysfunctions of body health.

3.9 Antioxidant content with inhibition concentration value of 50% (IC₅₀)

The IC₅₀ value is the concentration of the antioxidant source to neutralize 50% of the radical compounds. The lower the IC₅₀ value, the better the antioxidant activity of the sample. IC₅₀ antioxidant content is determined from the 3 best samples based on the highest inhibition percentage, namely on lemongrass and Malang apple powders coated with dextrin with drying temperatures of 40°C, 45°C and 50°C. According to Phongpaichit *et al.*

(2007), IC₅₀ value < 10 ppm indicates a very strong activity. IC₅₀ 10-50 ppm indicates strong activity, IC₅₀ > 50-100 ppm indicates moderate activity, and IC₅₀ > 100-250 ppm indicates weak activity. The results showed that the IC₅₀ value in the lemongrass and Malang apple powdered drinks was 0.9 to 1.47% (Table 9), which indicated a very strong activity. The results of research by Andriyani *et al.* (2015) show that the IC₅₀ value of *Curcuma zanthorhiza* L. and red ginger powder functional drinks made using the spray drying method has the highest average value of 0.62 ppm at 4% maltodextrin concentration, and the lowest or weakest

Table 9. The mean value of IC₅₀ antioxidant content for lemongrass and Malang apple powdered drinks (%) on the best product.

Drying temperature	Coating type
	Dextrin
40°C	0.9±0.01
45°C	1.279±0.08
50°C	1.47±0.01

value of 1.00 ppm at 0% maltodextrin concentration.

4. Conclusion

The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the type of coating and the drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best quality was determined based on the antioxidant content and high stability. The fast dissolution time was found in the lemongrass and Malang apple powder dried at 45°C with the dextrin coating. The best lemongrass and Malang apple powdered drinks had the following characteristics: a solubility of 0.96 seconds, a bulk density of 0.58 gr/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition of 50.97%, an IC₅₀ content of 1.29 %, and a water activity 0.50.

Table 8. The mean value of radical scavenging activity content for lemongrass and Malang apple powdered drinks (%).

Drying temperature	Coating type			Average
	Maltodextrin	Dextrin	Gum Arabic	
40°C	56.96±1.13 ^f	60.13±0.05 ^h	53.66±0.14 ^g	56.92±3.24 ^c
45°C	45.73±0.67 ^c	50.97±0.11 ^e	48.17±0.18 ^d	48.29±2.62 ^b
50°C	37.45±1.07 ^a	43.98±0.71 ^b	37.53±0.21 ^a	39.65±3.75 ^a

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

Conflict of interest

The authors declare no conflict of interest.

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Dr. Rahmawati, ST, M.Si. <rahmafarasara@usahid.ac.id>

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To: "Dr. Rahmawati, ST, M.Si." <rahmafarasara@usahid.ac.id>

Wed, Dec 4, 2024 at 9:23 AM

Dear Dr Rahmawati

Kindly be informed that your manuscript has been published and assigned to Food Research 2024, Vol. 8, Issue 6 (December). Your manuscript is currently available online and in press on our website <https://www.myfoodresearch.com>. Alternatively, you can download a copy of the manuscript by clicking on the following link:
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Thanks & Regards,
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From: Food Research Production <fr.production@outlook.com>

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