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Food Research

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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/Weconfirm 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 onthe 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.

Sincerely,

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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 IC_{50} 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. Aftewards, 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 IC_{50} 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-lpicrylhydrazyl) 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 $BaCl_2.2H_2O$. 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 Multipe 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 (Yuliwaty 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 (Yuliwaty 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 (Pramitasari 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 (Pramitasari 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% (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 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), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates a strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates a weak activity. The results showed that the IC_{50} 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 IC_{50} 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 IC_{50} 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	

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 ± 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^{h}	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 IC_{50} 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	1.27 9 ± 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 IC_{50} 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. Aftewards, 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 IC_{50} 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-lpicrylhydrazyl) 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 $BaCl_2.2H_2O$. 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 Multipe 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 (Yuliwaty 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 (Yuliwaty 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 (Pramitasari 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 (Pramitasari 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% (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 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), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates a strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates a weak activity. The results showed that the IC_{50} 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 IC_{50} 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 IC_{50} 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

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 ± 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^{h}	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 IC_{50} 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	1.27 9 ± 0.08
50˚C	1.47 ± 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

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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 onthe 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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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 IC_{50} content of 1.29, and a water activity of 0.50.

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

1. Introduction

A brief literature review and previous relevant work with references. 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, 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.

2. Materials and methods

2.1 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".

2.2 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, that is, the making of fruit pulp and the drying process.

2.3 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 mins 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.

2.4 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 hrs . The dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3 mins 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.

2.5 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).

2.6 Analysis procedure of dissolution time testing

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.

2.7 Analysis procedure of stability testing

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 hrs. 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.

2.8 Analysis procedure of water content by oven drying method

An empty cup was dried in the oven for 15 mins and 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 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 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.

2.9 Analysis procedure of ash content by muffle furnace method

A porcelain cup was dried in the oven for 15 mins 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 hrs until white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

2.10 Analysis procedure of antioxidant content testing

A total of 1 mL of DPPH solution (10 mg/L) was added to 50 µL of sample solution and then added methanol pro analyzed 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.

2.10 Analysis procedure of IC_{50} antioxidant activity testing

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-lpicrylhydrazyl) 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 mins . All samples, extract samples that had been kept, were tested for measuring the absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

2.12 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 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.

2.13 Analysis procedure of vitamin C testing

Vitamin C analysis was performed by iodometric 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.

2.14 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 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 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 (Yuliwaty *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.

3.2 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 (Yuliwaty *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.

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 (%) 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. Dextrin's 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 (Pramitasari *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%.

3.4 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 hrs . 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 (Pramitasari *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.

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 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).

3.6 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).

3.7 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).

3.8 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 number 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.

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 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), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates a strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates a weak activity. The results showed that the IC_{50} 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 IC_{50} 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.

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 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 IC_{50} content of 1.29 ppm, and a water activity 0.50.

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

The authors declare no conflict of interest.

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

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	

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 ± 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^{h}	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}

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

Table 9. The mean value of IC_{50} 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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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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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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1. Appropriateness of Contents		√			
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1.	**Title** *It should reflect the article* Qualify	Thank you very much for your comments.
2.	**Abstract** *Background, Aim, Methodology and Conclusion* No Qualify	Thank you very much for your comments.
3.	**Keywords** *Min. 3 and Max. 6* Qualify	Thank you very much for your comments.
4.	**Introduction** *Concise with sufficient background* Qualify Please add a description of how the ability of maltodextrin and dextrin to trap volatile compounds	Thank you very much for your comments. We have explained about the maltodextrin and dextrin. Please see line 59-62 page 2.
5.	**Research design/Methodology** *Clearly described and reproducible* Minor revision 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	Thank you for your suggestion **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

	11. use common abbreviations: in a smoke c hamber 12. Replace with "radical scavenging activity" 13. Wrong order 14. Revised	**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: *2.5 Analysis procedure of bulk density* (Sandhu et al., 2007); *2.6 Analysis procedure of dissolution time testing* (Pentury et al., 2013); *2.7 Analysis procedure of stability testing* (Pentury et al., 2013); *2.8 Analysis procedure of water content by oven drying method* (AOAC, 2006); *2.9 Analysis procedure of ash content by muffle furnace method* (AOAC, 2006); 2.13 Analysis procedure of vitamin C testing (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 *radical scavenging activity* (Tristantini et al., 2016). Please see line 132 page 4. **13.** We have revised the sentence to be: 2.11 Analysis procedure of IC_{50} antioxidant activity (Tristantini et al., 2016). Please see line 143 page 4. **14.** We have revised the chemical formula writing to be: adding $BaCl_2.2H_2O$. Please see line 159, page 4.

6.	**Data Analysis** *Results well presented and discussed* Minor revision **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 dekxtrin. Please give the reason. 9. Can be added explanation why aw of all coating type was not significant? 10. Typo: *Salmonella yphimurium* 11. Replace with "radical scavenging activity" 12. Replace with radical scavenging activity 13. antioxidant content? 14. ppm or %?	Thank you for your suggestion 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: *Bulk density of lemongrass and Malang apple powder drinks.* 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 *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 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%. 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.

		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. 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. 9. We have revised the sentence to be: According to Morodi *et al*. (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. 10. We have revised the sentence to be: *Salmonella typhimurium.* Please see line 366-367, page 9 11. We have revised the sentence to be: 3.8 Radical scavenging activity. Please see line 378, page 9. 12. We have revised the sentence to be: Based on the *percent of radical scavenging activity* test. Please see line 381, page 9. 13. We have revised the sentence to be: Based on Table 8 it is also known that drying temperature affects *the percent of radical scavenging activity*. Please see line 384-385, page 9. 14. We have revised the sentence to be: The results showed that the IC_{50} value in the lemongrass and Malang apple powder drinks was 0.9 to 1.47 %. Please see line 427-428, page 10.
7.	**Conclusion** *A clear summary of the study* Qualify ppm or %?	Thank you for your suggestion We have revised the sentence to be: IC_{50} conte nt of 1.29 %. Please see line 444 page 11.
8.	**References** *References should follow the journal's format* Minor revision	Thank you for your suggestion We have revised the references base on authors' name alphabetically. Please see line 453-692 page 11-17.

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 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 IC_{50} antioxidant content for lemongrass and Malang apple powder drinks (%) on the best product. Please see line 728 page 20.

Overall Evaluation

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Physico-chemical properties of lemongrass and Malang apple powder drinks

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 IC_{50} content of 1.29, and a water activity of 0.50.

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

1. Introduction

A brief literature review and previous relevant work with references. 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, 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.

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

2. Materials and methods

Commented [A2]: Capital letter

2.1 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".

Commented [A3]: Repetitive

Commented [A4]: Repetitive

2.2 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, that is, the making of fruit pulp and the drying process.

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

2.3 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 mins 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 of fruit pulp separately. The pulp was stirred until homogeneous.

Commented [A6]: Without filtering process?

Commented [A7]: With apple peel?

Commented [A8]: delete

Commented [A9]:

2.4 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 hrs . The dried sheets of lemongrass and Malang apples were then crushed separately with a blender for 3 mins 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.

Commented [A10]: delete

Commented [A11]: use common abbreviations

2.5 Analysis procedure of bulk density

Commented [A12]: Please add the reference used

Complete for others analytical procedures too

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).

2.6 Analysis procedure of dissolution time testing

Commented [A13]:

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.

Commented [A14]: delete

2.7 Analysis procedure of stability testing

Commented [A15]:

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 hrs. 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.

2.8 Analysis procedure of water content by oven drying method

Commented [A16]:

An empty cup was dried in the oven for 15 mins and 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 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 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.

Commented [A17]: use common abbreviations

2.9 Analysis procedure of ash content by muffle furnace method

Commented [A18]:

A porcelain cup was dried in the oven for 15 mins 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 hrs until white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

Commented [A19]: use common abbreviations

Commented [A20]: ?

2.10 Analysis procedure of ~~antioxidant content testing~~

(….) A total of 1 mL of DPPH solution (10 mg/L) was added to 50 µL of sample solution and then added methanol pro analyzed 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.

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

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-lpicrylhydrazyl) 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 mins . All samples, extract samples that had been kept, were tested for measuring the absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

2.12 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 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.

2.13 Analysis procedure of vitamin C testing

Vitamin C analysis was performed by iodometric 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.

2.14 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 IBM SPSS Statistics 29 software. The significant level was set at α = 0.05.

3. Results and discussion

3.1 Bulk density of lemongrass and malang apple powder drinks

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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-lpicrylhydrazyl) 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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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 (Yuliwaty *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.

3.2 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 (Yuliwaty *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.

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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 ~~(%) 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.

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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. Dextrin's 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 (Pramitasari *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%.

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Please give more explanation

3.4 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 hrs . 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.

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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 (Pramitasari *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.

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

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 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

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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, 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).

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

3.7 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.

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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).

3.8 The percent of inhibition of antioxidant content

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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 number 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).

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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.

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 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), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates a strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates a weak activity. The results showed that the IC_{50} 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 IC_{50} 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.

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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 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 IC_{50} content of 1.29 ppm, and a water activity 0.50.

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

The authors declare no conflict of interest.

Acknowledgments

We wish to express our deep thanks to all the members of Food Technology Study Program for their helps to this research.

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

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

Drying Temperature	Coating Type			
	Maltodekstrin	Dekstrin	Gum Arabic	Mean ± SD
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	

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)

Coating Type	Mean

Drying Temperature				± 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.[illegible][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 ± 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[h]	53.66[g]	56.92 ± 3.24[c]
45˚C	45.73[c]	50.97[e]	48.17[d]	48.29 ± 2.6[illegible][b]
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

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

Table 9. The mean value of IC_{50} 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

> **Commented [A52]:** Change with "radical scavenging activity"
>
> **Commented [A53]:** ppm or %?

FOOD
RESEARCH

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			
4. Research Methodology			x		
5. Data Analysis			x		
6. Relevance to the Journal	x				

(REVIEWER'S SECTION) **REVIEWER'S COMMENTS/SUGGESTIONS**		**(AUTHOR'S SECTION)** **AUTHOR'S ACTION/RESPONSE** ***NOTE FOR AUTHOR: Please state your response to the reviewer's comments/suggestion below**
1.	**Title** *It should reflect the article* My suggest tittle: The effect of coating and drying temperature on the physicochemical properties of the mixture lemongrass and apple powder drink	Thank you for your suggestion. 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.
2.	**Abstract** *Background, Aim, Methodology and Conclusion* No See the comments in manuscript. 1. What beverage products have short shelf life?	Thank you for your suggestion. 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.
3.	**Keywords** *Min. 3 and Max. 6*	-
4.	**Introduction** *Concise with sufficient background* See the comments in manuscript! 1. What beverage products have short shel f life? 2. Berikan alasan lain yang lebih masuk a kal untuk diganti dengan minuman pow der, saat ini banyak berkembang minu man ready to drink yang lebih efisien d alam penggunaannya 3. Apakah campuran dua macam bahan in i pernah diteliti sebelumnya? Apa alasa n memilih dua macam bahan ini untuk digabungkan? 4. Apakah ada hasil pengukuran terhadap daya terima konsumen? 5. Untuk melihat hasil peningkatan imunit	Thank you for your suggestion 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. 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. 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

	as tubuh, indikator apa yang diuji?	their combination in making drinks in the introduction. Please see line 34-45, page 1-2. 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. 5. Indicators can increase body immunity by testing antioxidant activity and vitamin C levels.
5.	**Research design/Methodology** *Clearly described and reproducible* Write down the source of the literature for the measurement methods used! See the comments in manuscript! 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 kan 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	Thank you for your suggestion. 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 Analysis procedure of bulk density* (Sandhu et al., 2007); *2.6 Analysis procedure of dissolution time testing* (Pentury et al., 2013); *2.7 Analysis procedure of stability testing* (Pentury et al., 2013); *2.8 Analysis procedure of water content by oven drying method* (AOAC, 2006); *2.9 Analysis procedure of ash content by muffle furnace method* (AOAC, 2006); 2.13 Analysis procedure of vitamin C testing (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 Analysis procedure of *radical scavenging activity*. Please see line 133, page 4. 8. We have revised the chemical formula writin

		g to be: adding $BaCl_2.2H_2O$. Please see line 160, page 4. 9. We have added the formula for obtaining vitamin c. Please see line 173, page 5.
6.	**Data Analysis** *Results well presented and discussed* 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! 1. Bila dilihat dari data analisis, terjadi pengaruh interaksi antara suhu pengeringan dan jenis coating yang digunakan, sebaiknya dijelasnkan 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	Thank you for your suggestion. 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

		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. 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).
7.	**Conclusion** *A clear summary of the study*	Thank you very much for your comments.
8.	**References** *References should follow the journal's format*	Thank you for your suggestion. We have revised the references format. Please see line 454-696 page 11-18.
9.	**English Proficiency** Correct the writing for peer review	Thank you for your suggestion. We have corrected the writing.
10.	**Additional comments/suggestions by the reviewer about the article** Revise the manuscript according to the comments	Thank you for your suggestion. We have revised base on the reviewer comment.

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Physico-chemical properties of lemongrass and Malang apple powder drinks

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 IC_{50} content of 1.29, and a water activity of 0.50.

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,

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

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

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Deleted: the drying temperature with

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

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

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?

2. Materials and methods

2.1 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".

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

2.2 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, that is, the making of fruit pulp and the drying process.

2.3 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

Commented [A9]: Jelaskan perbandingan bahan yang digunakan 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.

2.4 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.

2.5 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).

2.6 Analysis procedure of dissolution time testing

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.

2.7 Analysis procedure of stability testing

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 hrs. 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.

2.8 Analysis procedure of water content by oven drying method

An empty cup was dried in the oven for 15 mins and 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 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 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.

2.9 Analysis procedure of ash content by muffle furnace method

A porcelain cup was dried in the oven for 15 mins 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 hrs until white ash was formed and had a constant weight. The ash formed in the cup was cooled in a desiccator and then weighed.

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 dihancurkan dengan blender

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

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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??

A total of 1 mL of DPPH solution (10 mg/L) was added to 50 µL of sample solution and then added methanol pro analyzed 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.

2.10 Analysis procedure of IC_{50} antioxidant activity testing

Commented [A15]: Sumber pustaka

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-lpicrylhydrazyl) 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 mins . All samples, extract samples that had been kept, were tested for measuring the absorbance values using a UV-visible spectrophotometer at a wavelength of 517 nm.

2.12 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 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.

Commented [A16]: Perbaiki cara penulisan rumus kimia

2.13 Analysis procedure of vitamin C testing

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

Vitamin C analysis was performed by iodometric 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.

2.14 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 IBM SPSS Statistics 29 software. The significant level was set at α = 0.05.

3. Results and discussion

3.1 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

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

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 (Yuliwaty *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.

3.2 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 (Yuliwaty *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.

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 (%) 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. Dextrin's 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 (Pramitasari *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%.

3.4 Water content

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

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 hrs . 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 (Pramitasari *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.

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 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).

3.6 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).

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

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).

3.7 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).

3.8 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 number 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.

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

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

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 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), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates a strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates a weak activity. The results showed that the IC_{50} 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 IC_{50} 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.

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 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 IC_{50} content of 1.29 ppm, and a water activity 0.50.

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

The authors declare no conflict of interest.

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

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	

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

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

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

Commented [A24]: sda

Coating Type	Mean

Drying Temperature	Maltodekstrin	Dekstrin	Gum Arabic	± SD
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.[illegible]^{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 ± 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^{h}	53.66^{g}	56.92 ± 3.24^{c}
45˚C	45.73^{c}	50.97^{e}	48.17^{d}	48.29 ± 2.6[illegible]^{b}
50˚C	37.45^{a}	43.98^{b}	37.53^{a}	39.65 ± 3.75^{a}

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

Table 9. The mean value of IC_{50} 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

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. The fresh beverage products generally have a short shelf life product, 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 IC_{50} content of 1.29, and a water activity of 0.50.

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 on an adequate diet and nutrion from foods and drinks (Iddir et al., 2020). The fresh 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

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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).

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). 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). 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 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 (Asiah 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. 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 have the potential to increase body immunity, are easy to carry, and have a relatively long shelf life.

2. Materials and Methods

2.1 Material

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 and Matrix ESJ210-4B scales, volumetric flasks, Erlenmeyer, burettes, measuring pipettes, suction ball, funnel pipette, beaker glass, filter paper, stative, Siever 60 mesh, and spectrophotometer UV2100 Spectrophotometer.

2.2 The process of making lemongrass and malang apple powder drinks

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

2.3 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 (1:1 w/w) 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 w/w. Furthermore, the coating materials (maltodextrin, dextrin, and gum Arabic) were added as much as 5% w/w fruit pulp separately. The pulp was stirred until homogeneous.

2.4 Drying

The 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, brown 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.

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

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).

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

A total of 5 g 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.

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

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 hrs. 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.

2.8 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 mins 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.

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

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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 crucibles 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.

2.10 Analysis procedure of *radical scavenging activity* (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-lpicrylhydrazyl) 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. A total of 1 mL of DPPH solution (10 mg/L) was added to 50 µL of sample solution and then added methanol pro analyzed 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.

2.11 Analysis procedure of IC_{50} antioxidant activity (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-lpicrylhydrazyl) 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-visible spectrophotometer at a wavelength of 517 nm.

2.12 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 $BaCl_2.2H_2O$. It was then closed and kept for 3 mins 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.

2.13 Analysis procedure of vitamin C testing (AOAC, 2006)

Vitamin C analysis was performed by iodometric 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

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

$$\text{Vitamin C (mg/100 g)} = \frac{V\,I2 \times 0{,}88 \times fp \times 100}{W\ (g)}$$

$V\ I_2$ = Iodine volume (mL)
0.88 = 0.88 mg ascorbic acid equivalent to 1 ml I_2 0.01 N solution
Fp = dilution factor
W = sample mass (gram)

2.14 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 IBM SPSS Statistics 29 software. The significant level was set at α = 0.05.

3. Results and Discussion

3.1 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 findings revealed that the drying temperature and coating type had an effect on the bulk density value of the 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. 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 and Abdullah, 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 (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 (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

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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. Dari uraian di atas tergambar bahwa suhu pengeringan dan jenis pelapis sama-sama memengaruhi nilai densitas kamba. Hal ini menunjukkan ada interaksi di antara keduanya dalam memengaruhi nilai denistas kamba.

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3.2 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 and Rekna, 2019).

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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 (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 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.

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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*., 2016). 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.

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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 powder drinks made. The stability of

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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. Dextrin's 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 (Pramitasari *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%.

3.4 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 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 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. 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 (Pramitasari *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).

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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.

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 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 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 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).

3.6 Vitamin C

The results of the vitamin C test are presented in Table 6, showing an average value of vitamin C between 72.69 mg/100g to 53.15 mg/100g. 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 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 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. 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. In addition, according to Aretzy *et al*. (2018), maltodextrin can protect volatile compounds and protect compounds that are sensitive to oxidation. According to Morodi *et al*. (2022), gum arabic alone or combined with other biopolymers has been successfully applied on

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tomato slices and grapefruit slices to preserve the dried products' quality. 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).

3.7 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 and Hersoelistyorini (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 typhimurium* and *Staphylococcus aureus*; this indicates 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, 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).

3.8 Radical scavenging activity

The percent of radical scavenging activity 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 *percent of 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 it is also known that drying temperature affects *the percent of 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 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 condition 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

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the antioxidant content. The highest antioxidant content is 50.55%. The high antioxidant content in lemongrass is due to the large number 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 and Abdullah, 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.

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 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), IC_{50} value < 10 ppm indicates a very strong activity. IC_{50} 10-50 ppm indicates a strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates a weak activity. The results showed that the IC_{50} value in the lemongrass and Malang apple powder 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 zanthorrihiza L. 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.

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

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

The authors declare no conflict of interest.

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

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	

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 ± 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)

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]	

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	

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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 ± 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)

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.[illegible]^{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)

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	

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 powder 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 ± 2.6[illegible]
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 IC_{50} 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

Page 18: [1] Deleted **Author**

The effects of coating type and drying temperature on the physicochemical properties of the mixture of lemongrass and apple powder 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 powder 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 powder 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 the 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 IC_{50} content of 1.29, and a water activity of 0.50.

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

1. Introduction

The COVID-19 pandemic has forced people to maintain their health through increasing their body's immunity. Body immunity can be enhanced through an adequate diet and nutrion from drinks (Iddir *et al*., 2020). Powder drinks are a processed food product 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, powder 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 contain antioxidants is lemongrass. Lemongrass contains compounds including *geraniol, citronellol, lemonen, kadinen, eugenol, dipentene, citral* (Wibisono, 2011). Acting as anticancer and antioxidants, 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, 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 a powder form (Sari *et al.*, 2021) with both ingredients are necessary to be made. In order to function as nutritional drinks, the making of powder 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 in 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 at maintaining the stability of volatile compounds and trapping 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 at investigating the effects 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. 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 immunity. This research has yielded a product with the following characteristics: easy to carry, having a potential to boost the body immunity, and having a relatively long shelf life.

2. Materials and methods

2.1 Material

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 powder drinks

The process of making powder drinks was a modification of the research of Susanti and Putri (2014). The process of making powder 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. Afterwards, 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 powder 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 h 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-lpicrylhydrazyl) 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. 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 through 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-lpicrylhydrazyl) 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 $BaCl_2.2H_2O$. 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 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 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:

$$\text{Vitamin C (mg/100 g)} = \frac{V\ I2X\ 0.88\ X\ Fp\ X\ 100}{W(g)}$$

$V\ I_2$ = iodine volume (mL)
0.88 = 0.88 mg ascorbic acid equivalent to 1 ml I_2 0.01 N solution
Fp = dilution factor
W = sample mass (gram)

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 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.*, 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 powder 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. It 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 body, inhibit crystallization, and quickly disperse. Dextrin also has high solubility, hygroscopic properties, low browning properties, 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 that 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 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 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. 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 evaporated on the powder 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 powder 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 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. Dextrin is not viscous and 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. 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. It is due to the characteristic of maltodextrin that 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 be used as the 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.

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 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 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 the 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 in it, so that 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 showed 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 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 h. The results reveal that the drying temperature has an effect on the water content of lemongrass and Malang apple powder 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 powder 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 the 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 in the high temperature (Wiyono, 2011). The increase of 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 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 (Pramitasari *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 powder drinks was a maximum of 3% (BSN, 1996). The powder drink products meet the requirements of SNI number 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 composition depending on the type and source in 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, 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 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 powder 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 the 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 type of coating in determining the vitamin C content of powder drinks. The vitamin C content tends to decrease along with the increase of the drying temperature. A decrease in vitamin C can occur due to the unstable nature of vitamin C that can be easily degraded, especially by heat (Parfiyanti *et al*., 2016). It shows that the drying process at high temperature can reduce the vitamin C content in powder drinks. Vitamin C is classified as a natural antioxidant. Vitamin C contains ascorbic acid which is easily oxidized to dehydroascorbic acid that 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 more 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 powder 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 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/100 g - 550 mg/100 g, higher than lemongrass and Malang apple powder drinks (Minah, *et al.*, 2021).

3.7 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 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 of 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 a 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 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, 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 the drying temperature of 45˚C (0.44).

3.8 The percent of radical scavenging activity

The percent of radical scavenging activity shows the radical scavenging activity possessed by antioxidant compounds. The plants that have potential as antioxidants are lemongrass (Wibisono, 2011) and apples (Yudhianto *et al*., 2013). Based on the percent of 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 percent of 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 powder 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 condition, 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 the 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 activitiy 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 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 the 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 a strong activity, IC_{50} > 50-100 ppm indicates moderate activity, and IC_{50} > 100-250 ppm indicates a weak activity. The results showed that the IC_{50} value in the lemongrass and Malang apple powder 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 zanthorrihiza* 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 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 IC_{50} 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 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	

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±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)

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}	

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	

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±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)

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±6.01^{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)

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	

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 powder 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)

Table 9. The mean value of IC_{50} 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

FOOD
RESEARCH

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

Gmail

Rahmawati Farasara <rahmafarasara@gmail.com>

Re: FR-2023-077 Upcoming Process

Dede Saputra <ddsaputra2020@gmail.com> Thu, Jul 11, 2024 at 1:58 PM
To: Food Research <foodresearch.my@outlook.com>
Cc: rahmafarasara@gmail.com, foodstandardconsultant@gmail.com

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
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>
> 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 (revison)

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 12:39 AM Food Research <foodresearch.my@outlook.com> wrote:

> Dear Saputra,
> Please see attached files.
>
> 1. The Letter of Acceptance for your manuscript.
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> 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 (revison)

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

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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℃, 45℃, 50℃). 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℃. 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 IC_{50} content of 1.29, and a water activity of 0.50.

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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,

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-lpicrylhydrazyl) 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-lpicrylhydrazyl) 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 $BaCl_2.2H_2O$. 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:

$$\text{Vitamin C (mg/100 g)} = \frac{V\ I2 \times 0.88 \times Fp \times 100}{W(g)}$$

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 α = 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 (Pramitasari *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 (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 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 zanthorrihiza* 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 IC_{50} 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	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)

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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	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)

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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 Maltodekstrin	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	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)

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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	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)

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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	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]	

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	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)

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	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)

Table 9. The mean value of IC_{50} 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℃, 45℃, 50℃). 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℃. 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 IC_{50} content of 1.29, and a water activity of 0.50.

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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,

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-lpicrylhydrazyl) 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-lpicrylhydrazyl) 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 $BaCl_2.2H_2O$. 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:

$$\text{Vitamin C (mg/100 g)} = \frac{V\ I2 \times 0.88 \times Fp \times 100}{W(g)}$$

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 α = 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 (Pramitasari *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 (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 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 zanthorrihiza* 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 IC_{50} 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			
	Maltodekstrin	Dekstrin	Gum Arabic	Mean±SD
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]	

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

Commented [A7]: Please change to English.

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 ($P < 0.05$)

Commented [A8]: Please change to English.

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 IC_{50} 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

Commented [A10]: Please change to English.

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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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Commented [A1]: I have added the affiliate because Mr. Saputra is a lecturer too in our university

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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℃, 45℃, 50℃). 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℃. 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 IC_{50} content of 1.29, and a water activity of 0.50.

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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,

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-lpicrylhydrazyl) 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-lpicrylhydrazyl) 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 $BaCl_2.2H_2O$. 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:

$$\text{Vitamin C (mg/100 g)} = \frac{V\ I2 \times 0.88 \times Fp \times 100}{W(g)}$$

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 (Pramitasari *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 (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 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 zanthorrihiza* 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 IC_{50} 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	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)

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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	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)

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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 Maltodekstrin	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	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)

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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	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)

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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	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]	

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	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
	Maltodextrin Maltodekstrin	Dextrin 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 IC_{50} 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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RESEARCH PAPER

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 IC_{50} 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

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(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-lpicrylhydrazyl) 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-lpicrylhydrazyl) 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 $BaCl_2.2H_2O$. 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

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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:

$$\text{Vitamin C (mg/100 g)} = \frac{V\,I2 \times 0.88 \times Fp \times 100}{W(g)}$$

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 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

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^{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}	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

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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 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 (Pramitasari *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).

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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	$1.17{\pm}0.13^{ab}$	$1.46{\pm}0.11^{e}$	$1.06{\pm}0.07^{a}$	$1.23{\pm}0.21^{a}$
45°C	$1.26{\pm}0.01^{bcd}$	$1.21{\pm}0.03^{abc}$	$1.24{\pm}0.03^{bcd}$	$1.23{\pm}0.02^{a}$
50°C	$1.26{\pm}0.02^{bcd}$	$1.37{\pm}0.01^{cde}$	$1.38{\pm}0.09^{de}$	$1.33{\pm}0.07^{b}$
Mean±SD	$1.23{\pm}0.05^{a}$	$1.34{\pm}0.13^{b}$	$1.23{\pm}0.16^{a}$	

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	$68.11{\pm}1.74^{d}$	$72.69{\pm}2.74^{e}$	$61.95{\pm}0.50^{c}$	$67.58\ {\pm}5.39^{c}$
45°C	$63.36{\pm}1.49^{c}$	$70.22{\pm}1.24^{de}$	$58.26{\pm}1.24^{b}$	$63.95{\pm}6.01^{b}$
50°C	$54.91{\pm}0.50^{a}$	$63.36{\pm}1.49^{c}$	$53.15{\pm}0.50^{a}$	$57.14{\pm}5.46^{a}$
Mean±SD	$62.13{\pm}6.69^{a}$	$68.76{\pm}4.83^{b}$	$57.79{\pm}4.42^{c}$	

Values are presented as mean±SD. Values with different superscripts within the same column are statistically significantly different (P<0.05).

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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).

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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℃, 45℃ and 50℃. 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 zanthorrihiza* 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.

Table 9. The mean value of IC_{50} antioxidant content for lemongrass and Malang apple powdered drinks (%) on the best product.

Drying temperature	Coating type
	Dextrin
40℃	0.9±0.01
45℃	1.279±0.08
50℃	1.47±0.01

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℃ 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 IC_{50} 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℃	56.96±1.13^{f}	60.13±0.05^{h}	53.66±0.14^{g}	56.92±3.24^{c}
45℃	45.73±0.67^{c}	50.97±0.11^{e}	48.17±0.18^{d}	48.29±2.62^{b}
50℃	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).

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Conflict of interest

The authors declare no conflict of interest.

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