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

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Abstract

Fresh beverages from fruits and herbal plants that contain antioxidants are able to enhance the immunity of the human body. However, such fresh beverage products generally have a short shelf life. As an alternative, the products must be converted into powdered drinks. Coating materials are thus needed to avoid the loss of antioxidant compounds during the drying process. This study aimed to scrutinize the effects of coating type and drying temperature on the quality of lemongrass and Malang apple powdered drinks. The study employed a completely randomized design (CRD) with two factors and two replications. The first factor was the coating type with 3 levels (maltodextrin, dextrin, gum arabic) and the second factor was the drying temperature with 3 levels (40°C, 45°C, 50°C). The data were analyzed using Analysis of variance one-way (ANOVA) test and Duncan's further test if the treatment was significantly different. The results showed that the type of coating significantly affected the parameters of stability, dissolution time, ash content, vitamin C, and antioxidants. Meanwhile, the drying time significantly affected the parameters of stability, dissolution time, water content, ash content, vitamin C, and antioxidants. There was an interaction between the coating type and drying time that affected the bulk density, stability, dissolution time, ash content, vitamin C, and antioxidants. The best result based on the high content of antioxidants was obtained on the dextrin coating type with a drying temperature of 45°C. Product characteristics included a solubility of 0.96 seconds, a bulk density of 0.58 g/mL, a stability of 89.19%, a water content of 2.38%, an ash content of 1.21%, a vitamin C content of 70.22%, an antioxidant inhibition percentage of 50.97%, an 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 (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℃ 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℃, 45℃ and 50℃ 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℃ 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℃	2.57±0.06	2.51±0.04	2.54±0.02	2.54±0.03^{c}
45℃	2.39±0.06	2.38±0.12	2.31±0.03	2.36±0.04^{b}
50℃	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℃. 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℃	$1.17±0.13^{ab}$	$1.46±0.11^{e}$	$1.06±0.07^{a}$	$1.23±0.21^{a}$
45℃	$1.26±0.01^{bcd}$	$1.21±0.03^{abc}$	$1.24±0.03^{bcd}$	$1.23±0.02^{a}$
50℃	$1.26±0.02^{bcd}$	$1.37±0.01^{cde}$	$1.38±0.09^{de}$	$1.33±0.07^{b}$
Mean±SD	$1.23±0.05^{a}$	$1.34±0.13^{b}$	$1.23±0.16^{a}$	

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

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

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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).

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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