Original Article
Food Science and Technology

ISSN 0101-2061 (Print)
ISSN 1678-457X (Online)

DOI: https://doi.org/10.5327/fst.00344

Effect of maltodextrin concentration and temperature process on physicochemical characteristics of instant lemon (*Citrus limon l*) powder minute using crystallization machine

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Abstract

The purpose of this study was to determine the effect of maltodextrin concentration and drying temperature on the physicochemical characteristics of instant lemon powder drinks. The research used the randomized design group with a 3x3 factorial pattern consisting of two factors with two repeats so that 18 experimental units were obtained. There is a T factor which is a concentration of maltodextrin consisting of three levels, namely t1 (10%), t2 (15%), and t3 (20%), and a K factor that is a variation of the process temperature also consisting of three levels, namely k1 (50°C), k2 (60°C), and k3 (70°C). In this study, physical responses include solubility, dissolving time, amount of yield, hygroscopicity, bulk density, and scanning electron microscopy. Chemical responses correspond to water content, antioxidant activity, pH value, and vitamin C. The results showed that maltodextrin concentration can affect solubility, dissolving time, amount of yield, hygroscopicity, bulk density, water content, pH value, and vitamin C. Variations in process temperature affect solubility, dissolving time, amount of yield, hygroscopicity, bulk density, moisture content, pH value, and vitamin C. The interaction of maltodextrin concentration and process temperature variations affects hygroscopicity but not solubility response, dissolving time, yield amount, bulk density, water content, pH value, and vitamin C.

Keywords: maltodextrin; process temperature; lemon powder.

Practical Application: This article is relevant for use in the food and beverage industries, particularly beverage products with the addition of lemon extract used as a fortifier.

1 INTRODUCTION

The development of lemons in Indonesia is very fast. According to the Ministry of Agriculture, lemons production on Java Island reached up to 30 tons per month in 2016. In recent years, imported citrus fruits such as lemons have become more dominant in supermarkets with very attractive varieties. This is due to the difficulty of finding local suppliers or farmers to produce lemons in bulk. Meanwhile, the ability to produce fruit all year round and high productivity is the dominant advantage of lemons. The lemon tree can bear fruit throughout the year, so there is no such thing as a bumper crop, hence prices are always stable (Bahri et al., 2020).

Lemon fruit has an important economic value for being highly nutritious, especially its content of vitamin C, known as a very strong antioxidant, so it is used as an ingredient in beverages manufacture. Vitamin C is a strong reducing agent that can act as an antioxidant effective in overcoming free radicals that damage cells or tissues, including protecting lenses from oxidative damage caused by radiation (Geri et al., 2019). Lemon is one of the most popular citrus fruits in the world, both for consumption and non-consumption purposes. It contains 6% citric acid, which makes the taste sour, and a great quantity of vitamin C, vitamin B-6, calcium, iron, magnesium, potassium, carbohydrates, and even protein. By consuming one lemon a day, your daily vitamin C needs will be met. The amount of nutrients contained in lemon makes this fruit beneficial for health (Muaris, 2013).

The processing of drinks from lemons is currently varied. People get nutrients from the fruit easily or instantly, one of which is served in powder. Instant powder drinks can be drunk by boiling with water, either cold or hot directly. Efforts to utilize abundant local foods such as lemon, so that it lasts longer, are made by processing it into powdered drink, which in addition to lasting longer, can also increase the sales value of community consumption (Husniati, 2009). Processing fruits into powder products requires additional ingredients (fillers) in order to make the drying process faster. One of the many fillers that is widely used in food processing is maltodextrin (Suryanto, 2012).

Maltodextrin is a white powdery polysaccharide, slightly viscous and hygroscopic, with a nearly acceptable taste, with none or little sweetness. Additives are used in food processing

Received: 24 May, 2024.
Accepted: 25 June, 2024.
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Conflict of interest: nothing to declare.
Funding: This article is a collaboration between National Research and Innovation Agency and PT Duta Selera Pertiwi, and the research was funded by PT Duta Selera Pertiwi.

as preservatives and thickeners to increase food absorption; one example of a modified starch product is tapioca. As with starch, maltodextrin is a thickening agent that can be used as an emulsifier (Suryanto, 2012).

The processing of lemon fruit into powdered beverages can be performed with different types of drying. Lemon drying has two main objectives: to extend its shelf life by reducing the moisture content, preventing the growth of microorganisms, and to minimize the distribution once the weight and size become lower. Powder drying itself aims to extend shelf life by reducing the moisture content and prevent food from being overgrown by spoilage microorganisms. The drying process regulates temperature, humidity, and air flow. Changes in the moisture content of the food are caused by changes in the energy in the drying system (Permana, 2008).

Instant powdered beverages can be processed using several types of drying machines, one of which is the rotary vacuum. A rotary vacuum is a type of dryer in which the material is dried at low pressure and low temperature in conjunction with the suction of water vapor (vacuum) from the heating of the material. This type of drying is suitable for materials that are sensitive to high temperature and the drying time is relatively faster. This machine is also equipped with paddles so that the material is continuously rotated and the paddle helps the co-crystallization process (Parikh, 2015).

Based on this, it is necessary to conduct a study to determine the effect of maltodextrin concentration as filler and drying temperature using rotary vacuum on the physicochemical characteristics of lemon fruit instant powder.

2 MATERIALS AND METHODS

2.1 Materials

The material used in the production of instant lemon fruit drink powder was lemon fruit purchased from CV Gumelar Sejahtera Kp. Cibeunying Rt 03/10, Cibodas, Kec. Lembang, West Bandung Regency. West, West Java. Other ingredients used in the production of beverage powders were fillers, namely maltodextrin produced in Cihanjuang Village, Jalan Cihanjuang nº 138, Kec. Parongpong, Bandung. The other materials used for analysis in this study were distilled water, filter paper, charcoal band, methanol p.a., and DPPH (2,2-diphenyl-1-picrylhydrazyl).

2.2 Preparation of product

The first step was to prepare the raw materials. The lemons suitable for consumption were separated from those damaged. Washing was carried out to avoid the dirt that was still found after sorting the ingredients. Lemons were trimmed with a proper knife and the peels were separated. The already-skinned lemons were cut into smaller pieces in order to facilitate compression in the next process. They were squeezed to get juice and filtered in a next stage. Then the juice was weighed according to a pre-determined formula. Filtering was conducted to separate the lemon juice from the seeds and put them in different containers. This filtering was done with a filter cloth in order to obtain juice free of residues. The filtered lemon juice was mixed with maltodextrin bulking agent which was placed in a crystallization machine. This blending was conducted with a formulation of lemon juice and maltodextrin bulking agents. The mixed maltodextrin had percentage levels of 10, 15, and 20%. This stage was done by stirring the lemon juice with maltodextrin until it was evenly distributed for the next stage, which was Brix level analysis and hydrogen potential (pH) level measurement. The Brix analysis of the dry solids dissolved in the solution (g/100 g solution) was calculated as sucrose and other solids using a refractophotometer, and the pH of the solution was measured using a pH meter before the crystallization process. The ingredients were mixed and then placed in a crystallization machine. This machine is made of stainless steel, has a material tank with a diameter of 60 cm and a capacity of 25 liters, has a gas fuel heater, and an electric motor drive. The working principle of this machine is to stir the material continuously while it is heated. The crystallization process was carried out at temperatures of 50, 60, and 70°C in approximately 8–10 hours. Then, grinding was done by crushing after the product had been dried into powder. The crushing is done first in case there are still products that have not become powder using a chopper tool to make the product size uniform and facilitate the next step, sifting. After the sifting of the lemon powder, the instant drinks were placed in plastic packaging in the form of aluminum foil standing pouches. Another weighing was done to get the final weight of the product that had been determined.

2.3 Physical characteristics

2.3.1 Solubility analysis

Dispersibility measurement was performed to determine the solubility of the instant powder. The solubility was measured by dissolving 5 grams of the powder sample in 100 mL of water and filtering with filter paper. Afterward, the filter paper and the residue were dried in an oven at 105°C for three hours, then cooled in a desiccator, and weighed.

2.3.2 Dissolution time analysis

Dissolution duration test was conducted to determine the optimal brewing time for spinach milk powder. The dissolution duration is the time required for the sample to dilute completely in water within seconds. This analysis was carried out by dissolving 5 grams of the sample in 50 mL of water and stirring until the mixture became homogeneous; it was then recorded how long it took for the sample to dilute perfectly in water (Widiatmoko & Hartomo, 1993).

2.3.3 Yield analysis

Yield is the final result calculated based on the input and output processes. It is the ratio of the weight of dried powder to the total weight of solids in suspension (AOAC, 1995).

2.3.4 Bulk density analysis

Bulk density was measured by pouring the sample into a measuring cup to a certain volume without compacting, and then weighing the sample. The densities of the cups were calculated by dividing the weight of the sample by the volume of the space occupied by the sample, and expressed in units of kg/m^3 or g/mL (Khalil, 1999).

2.3.5 Scanning electron microscopy analysis

Scanning electron microscopy (SEM) is an instrument that uses a high beam of electrons to scan an object and produce its image. Two types of images are most commonly produced by SEM, namely sample surface mapping and sample composition mapping. The SEM is generally used to visualize very small objects (nanoscale). Before the sample was placed in the specimen chamber, it was first prepared by applying the powder to the double carbon tape attached to the holder. Then, a blower was used to blow air onto the powder to ensure that it was firmly attached to the carbon tape. It is feared that powder that is not firmly attached will be sucked in during the SEM vaporization process (Hoten, 2020).

2.3.6 Hygroscopicity analysis

Regarding the procedure for testing and calculating the level of hygroscopicity, first, the desiccant in the form of a saturated solution of ammonium chloride was placed in a desiccator. Then the sample in the form of pigment powder was weighed and placed in a desiccator. The increase in sample weight was recorded every ten minutes for the first 30–40 minutes and then every 20 minutes for four hours. The weight increase commonly reaches a maximum and then decreases to a stable level. When the maximum weight is reached, the analysis can be stopped, which, usually, does not take more than four hours.

2.4 Chemical characteristics

2.4.1 Gravimetric moisture analysis

To analyze the moisture content of the gravimetric method, an empty cup was heated in an oven at 105°C for 30 minutes, then placed in an exicator for 15 minutes, and weighed (W0). A sample of 2 grams was placed in this cup, which was weighed again (W1), then dried in an oven at 105°C for two hours. Next, the cup and its contents were put into an applicator for 10 minutes and reheated for 15 minutes. Drying was carried out until a constant W2 was obtained.

2.4.2 pH analysis

The procedure for measuring pH began by turning on the pH meter and preparing the sample to be measured. Next, the pH meter was calibrated by immersing the electrode in pH buffer 7, then pressing the "Read" button, and leaving the electrode in pH buffer 7. Electrodes immersed in pH 7 buffer were rinsed with distilled water and dried with tissue paper. The dried electrode was dipped back into pH 4 buffer. The button was pressed again and left until the scale on the pH meter was read. The electrode was rinsed again with distilled water, dried with tissue paper, and then dipped into the concentrated extract sample to be measured. The pH of the sample was indicated by an unchanged number on the monitor and subsequently the word "Ready" appeared. The pH of the sample was recorded on the monitor of the pH meter tool. The electrode on the instrument was rinsed for the third time with distilled water, dried with tissue paper, and then stored in a closed state. After all measurements were completed, the instrument was turned off (AOAC, 2006).

2.4.3 Vitamin C analysis by UV-Vis spectrophotometric method

Vitamin C was determined by the UV-Vis spectrophotometric method. The bottled beverage was filtered and pipetted 0.5 mL. This filtrate was placed in a 100 mL volumetric flask, where distilled water was added to the limit mark. It was then homogenized. The absorbance was measured at the maximum wavelength of 265 nm, repeated up to 15 times (Damayanti & Kurniawati, 2017).

2.4.4 Antioxidant activity by DPPH method

Around 7.88 mg of 2,2-diphenyl-1-picrylhydrazyl (DPPH) powder was dissolved in 100 mL of methanol. The solution was stirred until homogeneous and the absorbance was measured using a UV-Vis spectrophotometer. A total of 2.0 mL of the 0.2 mM DPPH solution was then added to a test tube and 2 mL of methanol p.a. was added. The solution was homogenized and incubated in the dark for 30 minutes. This process was repeated three times. The solution was prepared by making a 1,000 μg/mL mother solution. The mother solution was pipetted 0.5 mL, 1.25 mL, 2.0 mL, 2.75 mL, and 3.5 mL into a 10 mL volumetric flask to obtain test solutions with concentrations of 50 μg/mL, 125 μg/mL, 200 μg/mL, 275 μg/mL, and 350 μg/mL. Each test solution was pipetted up to 2.0 mL into a test tube, and 2 mL of 0.2 mM DPPH was added. The solution was homogenized and incubated at room temperature for 30 minutes in the dark, then the absorbance was measured by a UV-Vis spectrophotometer at a wavelength of 515 nm. The test solution was prepared three times. The percentage inhibition of each solution was calculated using Equation 1:

$$\% \text{ Inhibition} = \frac{\text{blank absorbance} - \text{sample absorbance}}{\text{blank absorbance}} \times 100\% \quad (1)$$

The half maximal inhibitory concentration (IC50) value was determined using a linear regression equation formula with percent inhibition as the ordinate (y) and concentration as the abscissa (x) (Molyneux, 2004).

2.4.5 Statistical analysis

This experimental design was conducted to make instant drink with the effect of maltodextrin concentration and drying temperature on lemon fruit powder drink. In the present study, a randomized design group was used with 3x3 factorial pattern and two replications, obtaining 18 trials. This analysis design was carried out to determine the effect of treatment on the observed response and was arranged in the analysis of variation (ANOVA) table to get a conclusion.

3 RESULTS AND DISCUSSION

3.1 Solubility analysis

Based on the results of ANOVA calculations (Table 1), it is observed that the factors of maltodextrin concentration (T) and drying temperature (K) had a significant effect on solubility. The effect of maltodextrin on each treatment caused significantly different results—the lowest result was obtained in the t1 treatment (10%) of 95.99% and the highest in the t3 treatment (20%) of 99.03%. This is because the higher the concentration of maltodextrin added, the lower the value of water content obtained in lemon instant powder. This is due to the influence of maltodextrin which has water soluble properties, so the higher the concentration between treatments, the faster the drying process will be and more water will evaporate. According to Ayu et al. (2016), the higher the concentration of maltodextrin, the higher the solubility value obtained. This happens because maltodextrin has properties that can bind hydrophobic substances. Besides, maltodextrin is a polysaccharide that is very soluble in water, so it can form a solution system that is evenly dispersed.

Table 2 reveals that the drying temperature gave significantly different results in each treatment: the lowest result was obtained in treatment k1 (50°C) of 97.09% and the highest in treatment k3 (70°C) of 97.85%. This is because the more the drying temperature is increased between treatments, the faster the drying process, and the lower the water content obtained in the lemon instant powder drink. These results are also supported by Amanto et al. (2015) who stated that with increasing temperature and drying time, the solubility increases. The increased solubility is due to the fact that during the heating process, the bonds in the amylopectin branches are broken into straight chains (amylose), which increases the proportion of amylose that is polar.

3.2 Dissolution time

Concerning dissolution time, the effect of maltodextrin on each treatment produced significantly different results—the longest dissolving time was obtained in the t1 (10%) treatment in 57.18 seconds and the fastest in the t3 (20%) in 49.57 seconds, as indicated in Table 3. Giving higher levels of maltodextrin produces lemon instant powder drink products that have the shortest dissolution time. This is because maltodextrin is an oligosaccharide that is very soluble in water and can form a uniformly dispersed system. The results obtained are consistent with Winarno's (2012) statement that the higher the maltodextrin added to the lemon leaf powder, the faster the dissolution time.

Based on the results of the research, it can be seen from Table 4 that the drying temperature using a rotary vacuum machine obtained the longest average result in treatment k2 (60°C) in 55.65 seconds and the fastest result in treatment k3 (70°C) in 55.37 seconds. We can conclude that the higher the temperature carried out between treatments in the drying process, the lower the water content obtained in the lemon powder product, and therefore, the faster the dissolving time by stirring.

3.3 Yield analysis

The variation of maltodextrin concentration proved to be significantly different in each treatment (Table 5) concerning yield. The highest yield was obtained at temperature t3 (70°C) of 17.97% and the lowest was at t1 (50°C) of 11.81%. This is because maltodextrin has high water-binding power, so the higher the concentration of maltodextrin, the greater the bond with the lemon powder. This is consistent with Kumalla et al.'s (2013) assertion that the higher the concentration of maltodextrin added, the higher the yield of coconut milk powder obtained. The resulting increase in total yield indicates that maltodextrin can act as a mass enhancer. The greater the amount of maltodextrin added, the higher the product yield. This is because the use of maltodextrin in instant beverage products serves to increase the volume and total solids of the ingredients, resulting in a higher yield.

Table 6 reveals that in the treatment of drying temperature variations, the highest yield at K3 (70°C) amounted to 15.85% and the lowest at K1 (50°C) corresponded to 14.83%. It can be seen that each drying temperature in each treatment is significantly

Table 1. Maltodextrin concentration on solubility.

Maltodextrin Concentration	Solubility (%)
t1 (10%)	95.99 ± 0.281[a]
t2 (15%)	97.46 ± 0.580[b]
t3 (20%)	99.03 ± 0.374[c]

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 2. Temperature process on solubility.

Temperature Process	Solubility (%)
k1 (50°C)	97.09 ± 1.432[a]
k2 (60°C)	97.53 ± 1.693[b]
k3 (70°C)	97.85 ± 1.453[b]

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 3. Maltodextrin concentration on dissolving time.

Maltodextrin Concentration	Rate Dissolving Time (seconds)
t1 (10%)	57.18 ± 2.412[c]
t2 (15%)	53.68 ± 1.644[b]
t3 (20%)	49.57 ± 1.350[a]

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 4. Drying temperature on dissolving time.

Temperature Process	Rate Dissolving Time (seconds)
k1 (50°C)	55.42 ± 4.451[b]
k2 (60°C)	55.65 ± 4.264[a]
k3 (70°C)	55.37 ± 2.726[a]

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 5. Maltodextrin concentration on yield.

Maltodextrin Concentration	Yield (%)
t1 (10%)	11.81 ± 0.581[a]
t2 (15%)	16.24 ± 0.801[b]
t3 (20%)	17.97 ± 0.284[c]

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

different—the more the drying temperature increased, the greater the yield produced in lemon powder. The drying process will be more efficient because there is no material that sticks to the walls of the drying machine (Yamin et al., 2017).

3.4 Bulk density

Based on the results of the present research (Table 7), the variation of maltodextrin concentration showed significantly differences in each treatment referring to bulk density. The highest yield was obtained at temperature t1 (50°C) of 0.76% and the lowest t1 (50°C) of 0.67%. A high bulk density value in a product indicates that the product is dense. A material is called a slurry when the bulk density value is low so that the material is light for a large volume. The increase in the bulk density value is influenced by the addition of higher concentrations of maltodextrin. This is because maltodextrin can increase the level of solids in food with a light final product weight. High concentrations of maltodextrin can also provide small values of bulk density due to the presence of air voids formed during homogenization, so that the air trapped in the product will be smaller, resulting in a small particle size (Widyasanti et al., 2020).

The results of bulk density can be found in Table 8. Bulk density is the ratio of the weight of the material to the volume it occupies, including the empty space between the grains of the material. It is a physical property that is influenced by material size and moisture content. In the variation of drying temperature, the highest bulk density was obtained at level k1 (50°C) of 0.72, while the lowest was obtained at level k3 (70°C) of 0.69. The bulk density of the lemon instant powder drink decreased as the drying temperature increased. This was due to the decrease in water content that occurred during the drying process with the increase in temperature. The low water content causes the weight of lemon powder drink to be lower in the same volume of the container; thus, the bulk density of lemon instant powder drink decreases with the increase in the temperature of its drying (Fitriani, 2008). Purwitasari (2014) found that the smaller particle size causes the weight of the measured material to be larger than the volume of the container it occupies.

3.5 Hygroscopicity analysis

Based on Table 9, it can be concluded that maltodextrin (T), drying temperature factor (K), and their interaction (TK) significantly affected the level of hygroscopicity. This is consistent with the opinion of Wang et al. (2011) that the higher the concentration of maltodextrin used, the stronger the hygroscopicity. According to Ferrari et al. (2012), a low moisture content indicates a high hygroscopicity value. Products with low moisture content have a greater ability to absorb environmental moisture, which is related to the high water concentration gradient between the product and the environment. In other words, products with low moisture content have high hygroscopicity. The results of the hygroscopicity analysis showed that the lemon instant powder drink with the addition of maltodextrin and variations in drying temperature had a significant effect on the hygroscopicity rate.

3.6 Moisture analysis

Regarding moisture analysis, the variation of maltodextrin concentration was significantly different in each treatment (Table 10). The highest percentage water content was obtained at t1 (10%) of 5.37% and the lowest at t3 (20%) of 3.55%. It is suggested that the addition of a high concentration of maltodextrin causes the water content to increase (Yuliawaty & Susanto, 2015). This is due to the nature of maltodextrin which is hygroscopic (able to absorb water). According to Putra (2013), the addition of more maltodextrin affects the water content so that it decreases. Thus, the addition of maltodextrin decreases the binding power

Table 6. Temperature process on yield.

Temperature Process	Yield (%)
k1 (50°C)	14.83 ± 3.157^{a}
k2 (60°C)	15.33 ± 3.436^{a}
k3 (70°C)	15.85 ± 2.967^{b}

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 7. Maltodextrin concentration on bulk density.

Maltodextrin Concentration	Bulk Density Level (g/mL)
t1 (10%)	0.76 ± 0.028^{c}
t2 (15%)	0.70 ± 0.013^{b}
t3 (20%)	0.67 ± 0.010^{a}

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 8. Temperature process on bulk density.

Temperature Process	Bulk Density (g/mL)
k1 (50°C)	0.72 ± 0.056^{b}
k2 (60°C)	0.71 ± 0.051^{b}
k3 (70°C)	0.69 ± 0.038^{a}

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 9. Effect of interaction of maltodextrin concentration and temperature process on hygroscopicity.

Maltodextrin Concentration	Temperature Process on Hygroscopicity (%)		
	k1 (50°C)	k2 (60°C)	k3 (70°C)
	B	C	C
t1 (10%)	2.05 ± 0.07^{f}	1.55 ± 0.21^{e}	1.30 ± 0.14^{d}
	c	b	a
	A	B	B
t2 (15%)	1.15 ± 0.07^{cd}	1.10 ± 0.28^{c}	1.05 ± 0.07^{bc}
	b	a	a
	A	A	A
t3 (20%)	1.05 ± 0.07^{b}	0.85 ± 0.07^{a}	0.8 ± 0.28^{a}
	b	a	a

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

(interaction) of the mixture of ingredients with water, allowing it to evaporate more easily during the heating process.

According to the research findings, Table 11 shows that drying temperature variations differed significantly between treatments. The highest percentage water content was obtained in k1 (50°C) of 4.63% and the lowest was k3 (70°C) of 4.2%. This is because the more the drying temperature is increased, the higher the temperature difference between the heating medium and the food material, the faster the reaction of the heat transfer process to the material, the faster the evaporation of water from the food and the fruit drying. If the air is used as heating media, other factors need to be considered such as the speed of air movement (Saputra et al., 2023). This is in line with the research conducted by Pratiwi and Suharto (2015), who stated that the high drying of moisture content is due to high temperature; the more water molecules evaporate, the lower the resulting moisture content. The moisture content of each sample is highly variable, meaning that temperature and drying time significantly affect the moisture content of lemon instant powdered beverages.

3.7 Hydrogen potential analysis

Based on Table 12, we can observe that the variation of the effect of maltodextrin on the pH of lemon instant powder drink had a real effect. The higher the addition of maltodextrin, the higher the pH of instant powder drink. The lowest pH was detected in the treatment using maltodextrin as much as 20%, which was of 3.49. Acidity or pH is an indicator that determines the alkalinity of food ingredients. The addition of different concentrations of maltodextrin has a significant effect on the pH, which is the degree of acidity in the solution used to express the level of acids and bases (Karangan et al., 2019). The higher the concentration, the lower the pH of the Tapak Dara flower corolla coloring powder. This is because the addition of a higher percentage of maltodextrin decreases the pH, as maltodextrin has a lower pH of 4–7 (Yuliawaty & Susanto, 2015).

Table 13 indicates that the increasing variation in drying temperature resulted in a significant decrease in pH in treatment k1 to k2 to k3. The higher the drying temperature used, the lower the pH value of the lemon instant powder drink. This is corroborated by Lagawa (2020), who supported that the higher the drying temperature used, the lower the pH value produced as evidenced by research results using phenol and flavonoid compounds increase at high temperatures.

3.8 Vitamin C value

Each treatment from t1 to t3 was significantly different from one another, as seen in Table 14. Treatment t1, with 10% of maltodextrin added hadthe lowest average vitamin C content of 0.008%. The higher the concentration of maltodextrin added, the less damage to vitamin C in the sample. According to Visita and Putri (2013), vitamin C is oxidized and becomes damaged during the heating process; however, maltodextrin can maintain some vitamin C content in the resulting product so that it is not completely damaged.

Based on Table 15, it can be concluded that the increasing variation of drying temperature caused a significant decrease in vitamin C content in treatments k1, k2, and k3. The higher the drying temperature, the lower the vitamin C content. This happens because the nature of vitamin C is unstable and easily degraded, especially by temperature (Parfiyanti et al., 2016). Winarno (2018) stated that the content of ascorbic acid is easily damaged by heat and light but the addition of maltodextrin can at least maintain the vitamin C content in the resulting product so that it is not completely damaged. Adding up to 20% maltodextrin can protect the material it is wrapped in.

Table 10. Maltodextrin concentration against moisture content.

Maltodextrin concentration	Moisture Content Level (%)
t1 (10%)	5.37 ± 0.161^{c}
t2 (15%)	4.28 ± 0.225^{b}
t3 (20%)	3.55 ± 0.278^{a}

Different letters indicate that there is a significantly different effect on each treatment (p<0.05) according to Duncan's test.

Table 11. Temperature process on moisture content.

Temperature Process	Moisture Content Level (%)
k1 (50°C)	4.63 ± 0.858^{b}
k2 (60°C)	4.37 ± 0.902^{ab}
k3 (70°C)	4.20 ± 0.984^{a}

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 12. Maltodextrin concentration on pH.

Maltodextrin Concentration	pH
t1 (10%)	3.78 ± 0.039^{c}
t2 (15%)	3.67 ± 0.035^{b}
t3 (20%)	3.49 ± 0.035^{a}

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 13. Temperature process to pH.

Temperature Process	pH
k1 (50°C)	3.68 ± 0.144^{c}
k2 (60°C)	3.65 ± 0.151^{b}
k3 (70°C)	3.61 ± 0.142^{a}

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

Table 14. Maltodextrin concentration on vitamin C.

Maltodextrin concentration	Vitamin C (%)
t1 (10%)	0.008 ± 0.002^{a}
t2 (15%)	0.014 ± 0.002^{b}
t3 (20%)	0.021 ± 0.003^{c}

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

3.9 Scanning electron microscope

The examination of the size and morphology of nanoparticles of instant lemon powder drink at 70°C and 20% maltodextrin using SEM showed, in general, that the surface of this drink has an irregular and heterogeneous shape, visible in the pores after enlargement (Figure 1). The microcapsules produced by the vacuum drying co-crystallization method have smooth surfaces, no holes, and many small particles attached to the walls of large particles, so the particles become uneven in the treatment of instant lemon powder drink. The dressing material must have high solubility and emulsifiability and should be able to emulsify, form a film, and produce a high-concentration solution with low viscosity. The coatings that are often used in microencapsulation are maltodextrin (Reineccius, 1988).

3.10 Antioxidant activity

The antioxidant activity analysis on sample t3k3 showed a result of 2,570.6943 ppm (Table 16), which indicates that the antioxidant activity of the instant lemon powder drink was not active. According to Dewi et al. (2016), antioxidant activity decreases due to high drying temperatures. This is because the high heating temperature causes secondary metabolite compounds that can act as antioxidants (carotene) to be damaged. Based on the result, the antioxidants were found to be inactive, caused by the processing of the ingredients too long in contact with oxygen, heat, and light. Here's the resulting graph:

Table 15. Temperature process on vitamin C.

Temperature Process	Vitamin C (%)
k1 (50°C)	0.017 ± 0.007^{a}
k2 (60°C)	0.015 ± 0.006^{b}
k3 (70°C)	0.012 ± 0.006^{c}

Different letters indicate that there is a significantly different effect on each treatment ($p < 0.05$) according to Duncan's test.

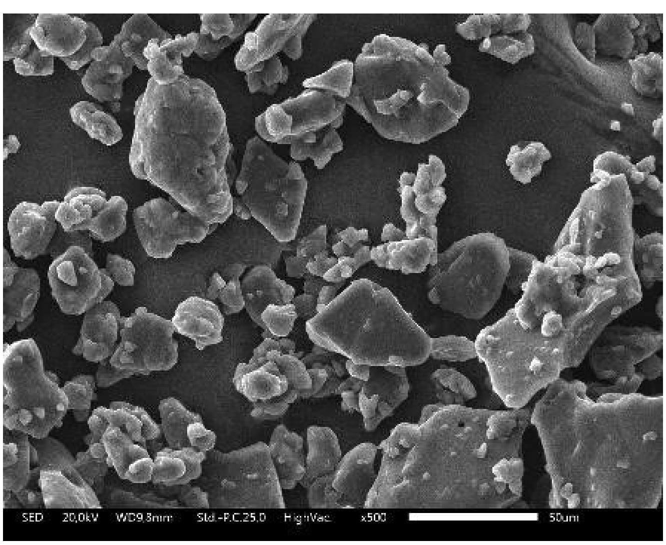

Figure 1. Scanning electron microscopy with 250x magnification.

Table 16. Antioxidant activity analysis results of selected samples.

Sample	Antioxidant Activity in IC50 Value (ppm)
T3K3	2,570.6943

ppm: parts per million; IC50: half maximal inhibitory concentration.

4 CONCLUSION

The concentration of maltodextrin on the physicochemical characteristics of instant lemon powder drink affects the response of water content, solubility, hygroscopicity, dissolution time, yield, pH, bulk density, vitamin C, and antioxidant activity. The drying temperature process on the physicochemical characteristics of instant lemon powder drink affects the response of hygroscopicity, vitamin C, antioxidant activity, dissolution time, pH, cage density, and yield. The interaction of both maltodextrin concentration and drying temperature on the physicochemical properties of instant lemon powder drink affects the hygroscopicity response, but does not influence the response of water content, solubility, dissolution time, yield, cube density, and acidity.

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