Effect of vacuum freeze-drying condition and maltodextrin on the physical and sensory characteristics of passion fruit (*Passiflora edulis sims*) extract

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Abstract. Passion fruit including the Passifloraceae family. It has more than 500 species. Currently, the most popular species is *Passiflora edulis Sims*. To study the influence of vacuum freeze drying air pressure and maltodextrin concentration on physical and sensory characteristics of passion fruit extract. This study used a vacuum drying system to produce passion fruit extract. This research was carried out by varying drying air pressures such as 0.59, 0.69, and 0.79 bars and maltodextrin concentration such as 10, 20, 30, 40, and 50%. The physical characteristics of passion fruit extract observed were particle size, flow ability, and moisture content, while sensory tests included color intensity. The results showed that drying 1 liter of passion fruit juice takes 48 hours. The mechanism of the freezing process of the sample begins with a decrease in the temperature of the material to be frozen, and then the change in the water becomes frozen. This process occurred continuously until most of the sample moisture content had been turned into ice crystals and stopped when the solids of the material became supersaturated. The variation of vacuum freeze drying air pressure does not significantly influence physical and sensory characteristics of passion fruit extract. The variation of maltodextrin concentration does significantly influence particle size, moisture content, and color intensity, but it does not significantly influence the flow ability of the passion fruit extract.

1. Introduction
Passion fruit is a plant group of the Passifloraceae family, which consists of more than 500 species [1]. The most popular species is *Passiflora edulis Sims*. This species was discovered by Spanish missionaries in the seventeenth century in South America as a medicinal plant [2]. The majority of *Passiflora edulis Sims* species are able to grow in subtropical regions such as in India, China, Australia, and Pacific Islands [3, 4]. It is fruit has a distinctive aroma and taste, so Christian missionaries in South America considered it as a symbol of the Passion of Christ [5].
Currently, the species of *Passiflora edulis* Sims have been cultivated in tropical countries for their use as feedstock, pharmacology, and cosmetics. It was often used as an ornamental plant since it has unique and beautiful flower [5, 6].

In Indonesia, the most popular species of passion fruit are the purple passion fruit (*Passiflora edulis* Sims). This kind can be directly eaten or used as raw material for instant drinks [7, 8]. The fruit is round with a diameter between 8 and 10 cm. It has purple skin when ripe. It contains seeds which are surrounded by gelatin yellow pulp with a strong taste and aroma [9] as shown in figure 1.

![Figure 1. Passiflora edulis Sims.](image)

Firstly, purple passion fruit (MA-02 and MA-01) are seasonal plants which only grow in highlands (1,200 meters above sea level) [10, 11]. Currently there are superior varieties easy to grow and resistant to various types of plant pests. These fruits can be available throughout the year with productivity between 20 and 30 tons/ha/year [12, 13, 14].

Passion fruit are a climacteric fruit and are easily damaged when ripe [15, 16]. They can be consumed either as fresh or in processed forms as syrup, juice, and jelly [13, 17]. Passion fruits were favored by consumers because they contain multiple nutrients such as beta carotene, potassium, dietary fiber, and vitamin C. They are also very beneficial for human health and can lower high blood pressure [18].

All this time, the process of drying the passion fruit juice has been done by using a spray dryer, but the rendement obtained was very low since some of the powder stuck to the dryer cyclone. The product color, aroma, and taste also changed because the drying temperature used was high at around 80°C [19, 20]. One method of drying that was considered appropriate for drying passion fruit juice was vacuum freeze drying. The advantage of using this method was to keep the vacuum cleaner chamber and control the pressure and temperature below freezing, so that the product color, aroma, and taste can be maintained as the characteristics of material [21]. Therefore, the temperature used in this study was freezing temperature (-52°C), so it did not influence the chemical content of the material changes.

There are many researchers who have revealed that the quality vacuum freeze drying products are strongly influenced by the type of filler, the ratio between the raw material and the filler, the duration and the drying temperature [21, 22, 23]. The addition of maltodextrin to the thickened extract of passion fruit before it was dried was expected to produce a dry extract which meets the standards of dry food products. Based on this fact, the purpose of this research is to study the influence of vacuum freeze drying air pressure and maltodextrin concentration on physical and sensory characteristics of passion fruit extract.
2. Materials and methods

2.1. Passion fruit preparation
The raw materials are used passion fruit and were obtained from farmers in the Malino, South Sulawesi, Indonesia. The passion fruit was washed by water and cut into 1/4 parts then the pulp was taken out using a spoon. The separation of seeds and pulp was done using a pulpier sieve machine (Model IK-401 from brand IKON). The pulp was stored in the freezer at temperature of -5°C to wait for the next process.

2.2. Passion fruit extract preparation
The pulp passion fruit was combined with maltodextrin with concentration variations such as 10, 20, 30, 40, and 50%. They were mixed and stirred for 15 minutes using a rotary evaporator to produce passion fruit extracts.

2.3. Vacuum freeze drying
Drying of passion fruit extracts was done using Christ Series vacuum freeze drying. The vacuum temperature was set at -52°C and the drying air pressure was regulated varying such as 0.59, 0.69, and 0.79 bar. Drying was carried out for 48 hours to get the extract water content of 14%.

2.4. Particle size measurement
The particle size of passion fruit extract was measured using a Laser Particle Analyzer (Fritsch Analysette22, Germany). This device calculated $D_{32}$ from 32 Lorenz-Mie model and Fraunhofer theory by connecting laser scattering and breaking with droplet diameters [24]:

$$D_{32} = \sum n_1 d_1^3 / n_1 d_1^2$$

Where $n_1$ were the number of droplets of diameter $d_1$. Theoretical specific surface area, span and droplet volume fraction distribution were also calculated with a particle analyzer.

2.5. Flow ability testing
Flow ability of the passion fruit extract was measured using the tapping method [25]. Approximately 25 g of the sample was weighed and put into the bottom closed funnel. The bottom of the funnel was opened, so that samples could be flowing on the graph paper. The flow ability time was measured from when the sample flow time started until it stopped by using a stopwatch.

2.6. Moisture content determination
The moisture content of passion fruit extract was determined based on the standard analysis method [26]. Approximately 5 g of the sample was weighed into a can (should be petri dish). The sample was heated to 100+5°C until constant weight was reached, transferred to a desiccator, and was weighed soon after it had reached room temperature.

2.7. Color determination
The color change of samples was analyzed by using Hunter Lab (Color Quest, USA). The result was expressed as $L^*$ $a^*$ $b^*$, where $L^*$ mean lightness, $a^*$ mean redness, and $b^*$ mean yellowness [27].

2.8. Sensorial analysis
Sensorial analysis was used to determine the level of consumer acceptance of the passion fruit extract produced from vacuum freeze drying. The panelists were 25 trained panelists, who consisted of 10 men and 15 women between 18 and 40 years old. All samples were presented to each panelist in an environmental temperature with randomly generated sample code. Each panelist was required to score between 1 and 5. Sensory analysis includes color intensity, aroma intensity, and taste.
2.9. Statistical analysis
The data verification of research used analysis of variance (ANOVA) to know the influence of variation of drying air pressure and maltodextrin concentration on physical and sensory characteristics of the passion fruit extract. If the value of F-count was greater than F-table, it shows that there was a significant effect difference at the significance level of 95%. In order to find out the most influential variables we used DMRT (Duncan’s Multiple Ranges Test) [28].

3. Results and discussions

3.1. Particle size
Drying air pressure does not significantly influence the particle size of passion fruit extract, but the concentration of maltodextrin has a significant influence (fig. 2). Particle size increases with increasing concentration of maltodextrin. This happens because maltodextrin has a strong particle binding strength and forms a high bonding structure among particles. This phenomenon has been reported by Moghadan and Sani [24] that the use of a higher ratio of maltodextrin causes the particle size of the powder to be greater. Meanwhile, the dryer air pressure does not significantly influence the particle size because the dryer air pressure velocity used was very small. A similar case was expressed by Hariadi [21] that air pressure during the vacuum drying process does not significantly influence the particle size.

![Figure 2](image.png)

**Figure 2.** Effect of different maltodextrin concentrations (%) on average diameter size of the passion fruit extract.

3.2. Flow ability
The effect of maltodextrin concentration on the flow ability of the passion fruit extract was presented in figure 3.
The result of observation shows that the average flow ability of the passion fruit extract at each different treatment of maltodextrin concentration such as 12.34, 11.93, 12.16, 12.34, and 12.22 gram/sec. This data indicates that the variation of maltodextrin concentration does not significantly influence (p > 0.05) on the flow ability of the passion fruit extract. This was shown by the small value of the coefficient of determination ($R^2$) which was only 0.0253. This occurred because the particle diameter size and shape of the passion fruit extract at five treatments was not much different. The same case has been revealed by Mirhosseini and Amid [24] that the main factors affecting the particle flow ability are the particle size and granule form. It was further mentioned that the softer and smaller the particle size, the faster the flow ability.

The flow ability of dry powder of food were often analogous to non-Newtonian fluids because it exhibits plastic flow. Some researchers have explained that the ability of dry powder to flow freely or compressed depends on size, shape, porosity, density, and particle surface area. The same case has been revealed by A-sun [29] who stated that dry powder particles are affected by cohesive forces among the surfaces of particles.

### 3.3. Moisture content

The moisture content of the passion fruit extract as a result of vacuum freeze drying was approximately between 14.5 and 22.3% (wet basis). The analysis result of the effect of the maltodextrin concentration on the moisture content of the passion fruit extract was shown in figure 4. Based on the picture it was seen that the higher a concentration of maltodextrin, the lower the moisture content of the passion fruit extract produced. The use of high maltodextrin concentrations may increase viscosity of the passion fruit extract, so that the moisture content of the material evaporates faster. This was in accordance with the results of research conducted by Moghadan and Sani [24] that the addition of a high concentration of maltodextrin can increase the viscosity of the material, so that the moisture content was more volatile.

The addition of maltodextrin to the thick extract before being dried can increase the viscosity, so evaporation of the moisture content was also easier. This was in accordance with Jittanit et al. [30] statement that the addition of maltodextrin can bind the water content of the material, resulting in faster water vaporization. Thus, the drying time becomes shorter and the quality of the dried extract still meets SNI standards (14.5%). Drying using a vacuum freeze dryer was safer than other types of dryers against
the risk of compound degradation in materials because the temperatures used were freezing temperatures [31].

![Figure 4](image.png)

**Figure 4.** The correlation between variation of the maltodextrin concentration (%) and moisture content (%) of the passion fruit extract.

The use of maltodextrin at concentration of 10% has very high water binding strength, so the evaporation process of moisture content was also slower. As a result, the process of drying the material took longer. This also affects the quality of the product due to the longer drying time, causing a decrease in quality. Conversely, the higher the concentration of maltodextrin, the shorter the drying time, so product quality can be maintained. This was in accordance with the results of Sopian's *et al.* [32] who reported that the addition of maltodextrin can shorten the drying process and prevent material damage due to short drying times.

The use of maltodextrin at a concentration of 20% results moisture content of the passion extract of 21.65%, consequently the product was easy to clot because due to hygroscopic. When reacting with steam air, the product immediately binds the water back.

Based on evaporation of water content and drying speed, the most optimal use of maltodextrin was at a concentration of 30%. This was in accordance with the benefits of encapsulation to maintain material stability and speed up the drying process [22].

The result of analysis of variance shows F-count (3.885) is bigger than F-table (0.003) at 95% significance level. This shows that the use of maltodextrin significantly influences the moisture content of passion fruit extract. To know the most influential treatment on the water content of passion fruit extract, further testing of DMRT (table 1) was performed.

| Maltodextrin Concentration (%) | Frequency | Average* |   |
|-------------------------------|-----------|----------|---|
|                               | I         | II       | III |   |
| 10                            | 22.32     | 21.38    | 22.15 | 21.95 ab |
| 20                            | 21.75     | 21.67    | 21.53 | 21.65 ab |
| 30                            | 19.14     | 19.66    | 19.34 | 19.38 cd |
| 40                            | 16.23     | 16.45    | 16.92 | 16.53 cd |
| 50                            | 14.52     | 14.73    | 13.26 | 14.17 e  |

* The same notation shows no significant difference.
The moisture content of the material has an important role in maintaining the shelf life of the product. The moisture content of foodstuffs greatly determines the acceptability, freshness, and resistance to microbial attack. Foods with high water content are more susceptible to bacteria than dry foodstuffs [33].

3.4. Color

3.4.1. Lightness parameter (L*)

The results of the measurement of lightness parameters from passion fruit extract were presented in Figure 5. The figure shows that variations in the concentration of maltodextrin significantly influence the lightness parameter of passion fruit extract. The highest lightness parameter value (L*) occurs at maltodextrin concentration of 10%. This was due to the concentration of the passion fruit extract still being higher than maltodextrin concentration, so the color of the passion fruit extract was still yellow.

![Figure 5](image_url)

**Figure 5.** Graph of lightness parameter (L*) of the passion fruit extract resulting from vacuum freeze drying.

The data in figure 5 also shows that the L* value of the passion fruit extract decreases with the high number of maltodextrin concentration. The higher the maltodextrin concentration, the lower the color L* value from passion fruit extract. This can happen due to high evaporation of water content of high filler concentrations, so that the base color of passion fruit extract was also degraded. The same was expressed by Choong et al. [34] that discoloration of a product depends heavily on raw materials, processing, and chemical processes.

3.4.2. Redness chromaticity parameter (a*)

The result data of redness chromaticity parameter (a*) shows that all treatment of maltodextrin concentration variations were positive, although it has relatively small difference (fig. 6). This indicates that the passion fruit extract has redness chromaticity.
Based on the data shown in figure 6, it can be explained that the highest redness chromaticity values \((a^*)\) were obtained at the treatment of 10% maltodextrin concentration. This happened because the red pigment of passion fruit extract was higher than the green one. In accordance with this, Choong et al. [34] stated that the passion fruit extract in general tends to have higher redness chromaticity than green chromaticity.

### 3.4.3. Yellowness chromaticity paramater \((b^*)\)

The measurement of yellowness chromaticity parameters showed that passion fruit extract has a positive value (fig. 7). This data shows that the color of passion fruit extract was dominated by yellow. The image also shows that the decrease in yellowness chromaticity \((b^*)\) has a linear pattern in line with the high use of the concentration of maltodextrin. The highest yellowness chromaticity occurs at 10\% of maltodextrin concentration, then 20, 30, 40, and 50\%, respectively. The results of this study are in accordance with the research reported by Naknean and Meenune [27] that excessive use of filler can affect the pigment of the product, so in certain materials a suitable and appropriate filler concentration was required.
4. Conclusion
The variation of drying air pressure does not significantly influence physical and sensory characteristics of passion fruit extract. The maltodextrin concentration variations significantly influenced to particle size, water content, and color of passion fruit extract, but did not significantly influence flow ability, aroma, and taste of passion fruit extract. The color of passion fruit extract was strongly influenced by the use of maltodextrin concentrations. The higher the maltodextrin concentration used in the vacuum freeze drying process, the lower of lightness, redness, and yellowness parameters. Addition of 30% maltodextrin concentration can produce better quality passion fruit extract than other concentrations.

5. References
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