Effect of trehalose and butterfly pea (Clitoris ternatea L.) on physicochemical characteristics of drum dried milk powder

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Effect of trehalose and butterfly pea (*Clitoris ternatea* L.) on physicochemical characteristics of drum dried milk powder

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Abstract

The purpose of this study was to determine the effect of Trehalose and Telang-Pea (*Clitoris ternatea* L.) which are used as fillers for Telang-Yellow milk powder. This study used a randomized block design, 3x3 factorial, and 2 replications. Trehalose concentrations (10%, 15% and 20%) and t butterfly pea flower concentrations (0.5%, 1% and 1.5%) were research factors. The results of this study included water content, antioxidant activity, viscosity, yield, solubility, dissolution time, hygroscopicity, color intensity, and preference for taste, color, aroma and after taste. The results showed that water content, hygroscopicity, dissolution time, solubility, yield, pH value, color, and hedonic assessment of taste, color, aroma, and aftertaste were affected by trehalose and eggplant concentrations. The best organoleptic results were obtained with t1b2 samples (0.5% trehalose and 15% Butterfly Pea). The best treatment was the t3b3 treatment with the results of the analysis of water content 2.86%, hygroscopicity 7.15%, amendment 20.00%, soluble time 29.13%, solubility 83.98%, pH 6.72, antioxidant activity 557.77 ppm, color intensity *L 48.01, *a 4.73 and *b 6.10.

Keywords: butterfly pea; drum drying; milk powder; trehalose.

Practical Application: Concentration of natural dyes and trhalose used in the manufacture of butterfly pea milk powder.

1 Introduction

The wild plant known as Butterfly Pea (*Clitoria Ternatea L.*) has a great deal of potential, but its applications are currently somewhat limited. Butterfly Pea exhibit blue, purple, and red hues because anthocyanin pigments are present in them. Anthocyanins are flavonoid molecules that act as natural antioxidants and free radical scavengers, as well as protecting liver cells and other human tissues (Devina, 2018). The naturally occurring delphinidin glycoside pigment anthocyanin is what gives the Butterfly Pea its blue color (Tantituvanont et al., 2008). Anthocyanins are a source of antioxidants as well as a healthy substitute for colours that are also edible (Hartono et al., 2013).

One of the animal products that is frequently discovered and consumed is dairy. Wanniatie & Hanum (2015) assert that milk is a food element with a high nutritional value and a nearly ideal nutritional composition. Milk can be processed into beverages that can be consumed instantly as powdered beverages, packaged beverages that can be consumed immediately, or beverages that require brewing before consumption. In order to lower the water content of powdered milk products, a drying process is applied to them, and as a result, milk products are created in powder form.

Milk powder quality is complex because it is dependent on a complex combination of physical and functional properties of milk powder (Sharma et al. 2012). For example, the dissolution behaviour of the milk powder is driven by its physical properties, such as particle size distribution and bulk density, and functional properties such as dispersibility (Oldfield & Singh, 2005).

The drying of the milk prolongs its shelf life, allows its use in times outside the production season and permits its international commercialization (Paez et al., 2006; Davis et al., 2017). In the drying process, fillers are needed; fillers are very important to convert fresh milk into milk powder through a drying process. The function of the filling material is to cover the flavoring material, increase the number of solids, speed up drying, and protect against damage from high temperatures (Oktaviana, 2012). Trehalose is a filler with high potency but its user base is small.

Trehalose, a disaccharide sugar, is both a filler and a sweetener. Winata (2018) claims that trehalose is an irreducible disaccharide made up of two glucose units joined together by α-1,1-glycosidic link. Compared to sucrose, trehalose is 45–50% sweeter. Trehalose has an essential application in food since, in addition to being employed in low-calorie foods, it can also play a function in safeguarding and maintaining cell structure in food, and it is also heat stable.

For instant powder drink products, there are numerous drying techniques available, including *spray drying, freeze drying, drum drying, tray drying* dan *foam mat drying.* Drum drying is ideal for most heat-sensitive materials since it exposes them to high temperatures in a matter of seconds. This is in line with research (Rif'an & Aminah, 2017) which states that drum drying is the best drying method because it does not change physicochemical properties.

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Based on the above description, it is important to perform a study to assess the influence of the concentration of trehalose and Butterfly Pea fillers on the properties of Butterfly Pea milk powder by drying technique using a *Drum Dryer* machine. Materials and Methods

2 Materials and methods

2.1 Creating Butterfly Pea milk powder

Butterfly Pea are sorted and cleansed before being dried in a *Cabinet Dryer* machine at 60 °C for 12 hours, The Butterfly Pea powder was then processed using a *Chopper* for 1-2 minutes at 1200 RPM and sifted using a *Vibratory Screen Mesh* 80 to create a consistent powder.

Fresh milk was weighed according to the recipe and then pasteurized at 70 degrees Celsius for 15 minutes. It was then combined with CMC, Butterfly Pea powder, and trehalose. The drying process was then completed using a DRUM DRYER machine at 133-140 °C for 27-33 minutes. The milk powder is next milled for 1-2 minutes with a *Chopper* and sifted with a *Vibratory Screen Mesh* 80 machine to create a consistent powdered milk powder.

2.2 Selected sampling

The chosen sample was determined by the highest score from the hedonic organoleptic test with 30 panelists, as well as the scoring test for all chemical and physical responses.

2.3 Experimental statistical design and analysis

The experimental design was a 3x3 factorial block design with two replications. Trehalose concentrations (0.5%, 1%, and 1.5%) and Butterfly Pea concentrations (10%, 15%, and 20%) were the experimental variables. Analysis of variance (ANOVA) was used to examine the data, and Duncan's test was used to pinpoint statistically significant changes (P 0.05). P value of 0.05 or less was regarded as significant.

3 Results and discussion

3.1 Water content

The moisture level of dry items is critical. SNI 01-2970-2015 specifies a maximum water content of 5% for fat milk powder quality criteria (Table 1). Because the water content does not exceed 5% for all procedures, this Butterfly Pea milk powder meets the SNI quality requirements.

Table 1. Findings from an Analysis of Butterfly Pea Milk Powder's Moisture Content.

Treatment	Water content (%)
t_1b_1	3.59 ± 0.34^{b}
t_1b_2	3.34 ± 0.66^{a}
t_1b_3	3.59 ± 0.34^{b}
t_2b_1	3.62 ± 0.29^{b}
t_2b_2	3.58 ± 0.33^{b}
t_2b_3	3.10 ± 0.34^{a}
t_3b_1	2.91 ± 0.03^{a}
t_3b_2	2.66 ± 0.38^{a}
t_3b_3	2.86 ± 0.01^{a}

Different letters in the same column indicate that the data is statistically significant ($p < 0.05$) from the smallest difference.

The water content decreases as the concentration of trehalose increases. This is due to the nature of trehalose, which binds water and hence reduces the material's water content. According to Li et al. (2022) research, the higher the trehalose concentration, the lower the water content of the product because trehalose has the ability to enhance hydrogen bonds.

3.2 Hygroscopicity

The amount of moisture in a material or product affects its level of hygroscopicity (Table 2). The greater the hygroscopicity of a material, the lower its water content must be. This is in line with Purnomo et al. (2014) research, which found that a powder with a low water content becomes more hygroscopic and readily absorbs water, increasing its solubility in water. The hygroscopicity value increases as trehalose content increases. According to studies by Samantha et al. (2015), the low water content is what causes the high amount of hygroscopicity. This investigation supports that finding.

Table 2. Results of Hygroscopicity Analysis of Butterfly Pea Milk Powder.

Treatment	Hygroscopicity (%)
t_1b_1	3.55 ± 0.64^{a}
t_1b_2	4.85 ± 0.07^{b}
t_1b_3	4.60 ± 0.28^{bc}
t_2b_2	5.45 ± 0.07^{cd}
t_2b_3	6.05 ± 0.07^{de}
t_2b_3	6.35 ± 0.35^{ef}
t_3b_1	6.80 ± 0.42^{efg}
t_3b_2	7.25 ± 0.49^{g}
t_3b_3	7.15 ± 0.07^{fg}

Data that differs from the smallest difference statistically ($p < 0.05$) is indicated by different letters in the same column.

3.3 Yield

The trehalose filler concentration can influence the yield of Butterfly Pea milk powder (Table 3). This is due to the filler's ability to increase the volume and mass of the dry product. This assertion is backed by Richards et al. (2002) research, which shows that the addition of trehalose can enhance the volume of the material and the overall amount of solids.

3.4 Solubility time

The concentration of trehalose might impact the time it takes to dissolve in water. According to Haryanto (2017), the higher the concentration of trehalose, the faster the substance dissolves (Table 4). According to Permata & Sayuti (2016), one of the elements influencing dissolving time is the water content of the material; the higher the water content, the longer it takes to dissolve.

The water content of a material or product can affect its dissolution time, and one of the factors that affects the water content is the drying temperature; the higher the drying temperature, the lower the water content of the material. The higher the water content of the powdered milk, the lesser the product's solubility. According to Adhayanti and Ahmad (2020), an increase in the water content of foodstuffs results in the creation of clumps and a longer time to dissolve the bindings between particles.

3.5 Solubility

The higher the solubility number, the higher the quality of the final product (Table 5). The more a product's solubility, the faster it will dissolve in water since it may be supplied more readily (Alfonsius & Purwijantiningsih, 2015). According to Yuliawaty & Susanto (2015), the higher the solubility value obtained, the higher the product quality. The higher the trehalose concentration, the higher the solubility of Butterfly Pea milk powder. This is apparently owing to sugar's great solubility in water; raising the concentration of trehalose used causes an increase in solubility (Haryanto, 2017). According to Li's et al. (2022) research, raising the concentration of trehalose will increase the solubility of royal jelly powder. Water content is one of the factors that influence solubility. A product's solubility decreases as its water content increases.

3.6 Color intensity

Colorimetric analysis of the color intensity of Butterfly Pea milk powder (L*, lightness; a*, redness; and b*, yellowness) (Table 6). The L* and a* values increase as the trehalose concentration increases, but the b* values drop. This is due to the fact that trehalose is a white powder that produces a bright hue when added; the more trehalose added, the brighter the powdered Butterfly Pea milk, thereby raising the lightness value.

All Butterfly Pea milk powder samples have a negative *b value, indicating that all Butterfly Pea milk powder samples are blue in color. This assertion is consistent with Sinaga (2019)

Table 3. Results of the Yield of Butterfly Pea Milk Powder Analysis.

Treatment	Yield (%)
t_1b_1	13.72 ± 0.51^{a}
t_1b_2	13.26 ± 0.20^{a}
t_1b_3	13.50 ± 0.20^{a}
t_2b_1	16.38 ± 0.14^{b}
t_2b_2	16.76 ± 0.17^{b}
t_2b_3	16.52 ± 0.23^{b}
t_3b_1	18.48 ± 0.17^{c}
t_3b_2	19.50 ± 0.25^{d}
t_3b_3	20.00 ± 0.23^{d}

Data that differs from the smallest difference statistically ($p < 0.05$) is indicated by different letters in the same column.

Table 4. The results of the analysis of the Solubility time of the Egg Flower Milk Powder.

Treatment	Solubility Time (second)
t_1b_1	34.82 ± 1.10^{d}
t_1b_2	34.04 ± 0.86^{cd}
t_1b_3	34.02 ± 1.05^{cd}
t_2b_1	32.20 ± 0.20^{bc}
t_2b_2	32.15 ± 0.98^{bc}
t_2b_3	32.51 ± 0.47^{bc}
t_3b_1	31.87 ± 0.46^{b}
t_3b_2	32.23 ± 0.78^{bc}
t_3b_3	29.13 ± 0.17^{a}

Data that differs from the smallest difference statistically ($p < 0.05$) is indicated by different letters in the same column.

Table 5. Result of Solubility Analysis of Butterfly Pea Milk Powder.

Treatment	Solubility (%)
t_1b_1	81.68 ± 0.12^{ab}
t_1b_2	81.16 ± 1.39^{a}
t_1b_3	81.02 ± 0.39^{a}
t_2b_2	81.96 ± 0.20^{ab}
t_2b_3	81.87 ± 0.80^{ab}
t_2b_3	82.13 ± 0.24^{ab}
t_3b_1	83.09 ± 0.05^{bc}
t_3b_2	84.07 ± 0.81^{c}
t_3b_3	83.98 ± 0.65^{c}

Data that differs from the smallest difference statistically ($p < 0.05$) is indicated by different letters in the same column.

Table 6. Color Intensity Analysis of Lab Milk Powder Butterfly Pea.

Treatment	L*	a*	b*
t_1b_1	38.56 ± 0.26^{a}	4.7 ± 0.03^{bc}	-4.70 ± 0.18^{d}
t_1b_2	42.18 ± 0.36^{d}	3.27 ± 0.23^{bc}	-3.41 ± 0.28^{cd}
t_1b_3	40.43 ± 0.43^{bc}	4.39 ± 0.18^{a}	-5.38 ± 0.07^{e}
t_2b_1	39.21 ± 1.09^{ab}	4.34 ± 0.17^{bc}	-5.41 ± 0.15^{a}
t_2b_2	41.59 ± 0.57^{cd}	4.66 ± 0.40^{bc}	-6.11 ± 0.16^{bcd}
t_2b_3	43.84 ± 0.25^{e}	4.33 ± 0.10^{b}	-6.75 ± 0.20^{bcd}
t_3b_1	44.69 ± 0.83^{e}	4.66 ± 0.16^{c}	-5.87 ± 0.27^{ab}
t_3b_2	45.35 ± 0.57^{e}	4.41 ± 0.13^{bc}	-5.52 ± 0.52^{bc}
t_3b_3	48.01 ± 0.52^{f}	4.73 ± 0.05^{bc}	-6.10 ± 0.06^{bcd}

Data that differs from the smallest difference statistically ($p < 0.05$) is indicated by different letters in the same column.

research, which claims that the notation *b is a mixed chromatic color of blue-yellow with a value of *b (positive) ranging from 0 to +70 for yellow and a value of *b (negative) ranging from 0 to -70 for blue. Angriani (2019) claims that the Butterfly Pea (*Clitoria Ternatea L.*) exhibits purple, blue, and red colors because it contains anthocyanins.

3.7 pH

The Butterfly Pea powdered milk is affected by the addition of Butterfly Pea concentration. The pH will rise in areas where Butterfly Pea concentration is growing (Table 7). This research contradicts Sumiati's (2022) research, which found that adding Butterfly Pea extract to the meatball dough had no impact on the meatballs' pH level. This is possible because the pea flower can mimic the acidity or pH of the extraction solvent or the item being combined. According to Astuti (2018) research, the Butterfly Pea extract can also be used as an acid-base indicator because of the anthocyanin compounds that the Butterfly Pea contains. Anthocyanins are chemicals that are amphoteric, meaning they may react with both acids and bases (red and purple colors) (Sumartini & Muntaha, 2020).

3.8 Antioxidant activity

The antioxidant activity increases in direct proportion to the amount of pecan blossom powder used (Table 8). Gracelia & Dewi (2022) research, there is an increase in antioxidant activity or the ability to fend off free radicals when Butterfly Pea is added in increasing concentrations because the IC50 value decreases as Butterfly Pea concentration rises. High temperatures can affect a low IC_{50} value and a reduction in antioxidant activity. This claim can be supported by study done in 2019 by Kusuma, who found that high drying temperatures cause antioxidant activity to decline. Sidoretno's research from 2018, drying temperature can have an impact on antioxidant activity since high temperatures can readily damage antioxidant qualities. As a result, if the drying temperature is particularly high, the antioxidant content in the product will be harmed.

Drying the sample using the *Drum Drying* technique at a sufficiently high temperature can diminish the temperature-sensitive active component, namely the antioxidants. As a result, excessively high temperatures during the drying process likely to diminish antioxidant activity. Syafarina et al. (2017), antioxidants are active compounds of the polyphenol group with the basic structure of phenol whose compounds have qualities that are easily oxidized and damaged due to high temperature drying, which will impair the antioxidant activity included in the sample.

3.9 Organoleptic response

Aroma of this butterfly pea milk powder is distinctively milky (Tble 9). This is consistent with the findings of Fizriani et al. (2020), which argues that because the Butterfly Pea has no perfume, it will follow the aroma of the blended substances (Table 9). As a result, the perfume of Butterfly Pea milk powder has a hedonic value of Butterfly Pea milk powder, which the panelists prefer to appreciate.

Table 7. Results of Butterfly Pea Milk Powder pH Analysis.

Treatment	pH
t_1b_1	6.64 ± 0.01^{a}
t_1b_2	6.64 ± 0.01^{ab}
t_1b_3	6.64 ± 0.01^{ab}
t_2b_1	6.63 ± 0.00^{a}
t_2b_2	6.65 ± 0.01^{ab}
t_2b_3	6.67 ± 0.02^{ab}
t_3b_1	6.68 ± 0.01^{bc}
t_3b_2	6.71 ± 0.01c
t_3b_3	6.72 ± 0.01^{c}

Data that differs from the smallest difference statistically ($p < 0.05$) is indicated by different letters in the same column.

Table 8. Findings from an Analysis of Butterfly Pea Milk Powder's Antioxidant Activity.

Treatment	Antioxidant activity value IC_{50} (ppm)
t_1b_1	694.80 ± 0.41
t_1b_2	613.23 ± 0.26
t_1b_3	610.53 ± 1.07
t_2b_2	597.44 ± 0.00
t_2b_3	582.97 ± 0.26
t_2b_3	569.45 ± 0.27
t_3b_1	578.28 ± 0.24
t_3b_2	563.32 ± 0.25
t_3b_3	558.77 ± 0.60

Data that differs from the smallest difference statistically ($p < 0.05$) is indicated by different letters in the same column.

The amount of Butterfly Pea powder used impacts the color of the Butterfly Pea powder milk generated; the more Butterfly Pea powder added, the bluer the color of the Butterfly Pea powder milk produced. This statement is consistent with the findings of Pratimasari & Lindawati (2018), who discovered that the color of paracetamol syrup dyed with Butterfly Pea varies from light purple to dark purple, and that the higher the concentration of Butterfly Pea added to the syrup, the more intense the color intensity produced.

The sweet flavor of the trehalose filler has an impact on the flavor of Butterfly Pea milk powder. Trehalose has a sweetness level of 45% of sucrose, according to research by Walmagh et al. (2015). Accordingly, the panelists prefer to like the taste of Butterfly Pea milk powder, which gives the flavor a high hedonic value.

After Taste Milk powder has a hedonic value that panelists frequently appreciate. The aftertaste of Butterfly Pea milk powder is supposed to be affected by the sweetness of the trehalose filler, which has been added and has a sweetness level of 45% from sucrose. The concentration of Butterfly Pea added does not alter the taste of butterfly pea powdered milk. According

Table 9. Butterfly Pea Milk Powder Hedonic Analysis Results.

Treatmeant	Aroma	Colour	Flavor	*after taste*
t_1b_1	6.33 ± 0.14^{abc}	6.37 ± 0.05^{bc}	7.10 ± 0.10^{cd}	6.33 ± 0.14^{d}
t_1b_2	6.54 ± 0.05^{c}	6.40 ± 0.10^{bcd}	7.15 ± 0.03^{d}	6.47 ± 0.05^{d}
t_1b_3	6.28 ± 0.07^{abc}	6.08 ± 0.07^{a}	6.47 ± 0.05^{a}	6.28 ± 0.07^{ab}
t_2b_1	6.22 ± 0.02^{ab}	6.52 ± 0.07^{cd}	7.07 ± 0.14^{cd}	6.19 ± 0.02^{ab}
t_2b_2	6.24 ± 0.19^{abc}	6.39 ± 0.02^{bcd}	7.05 ± 0.03^{cd}	6.30 ± 0.10^{ab}
t_2b_3	6.20 ± 0.00^{ab}	6.28 ± 0.07^{b}	6.78 ± 0.07^{b}	6.15 ± 0.07^{a}
t_3b_1	6.34 ± 0.33^{bc}	6.54 ± 0.05^{d}	6.92 ± 0.07^{bc}	6.39 ± 0.26^{cd}
t_3b_2	6.15 ± 0.03^{a}	6.52 ± 0.07^{cd}	6.37 ± 0.05^{a}	6.12 ± 0.02^{ab}
t_3b_3	6.27 ± 0.05^{ab}	6.45 ± 0.05^{cd}	6.54 ± 0.05^{a}	6.20 ± 0.04^{bc}

Data that differs from the smallest difference statistically ($p < 0.05$) is indicated by different letters in the same column.

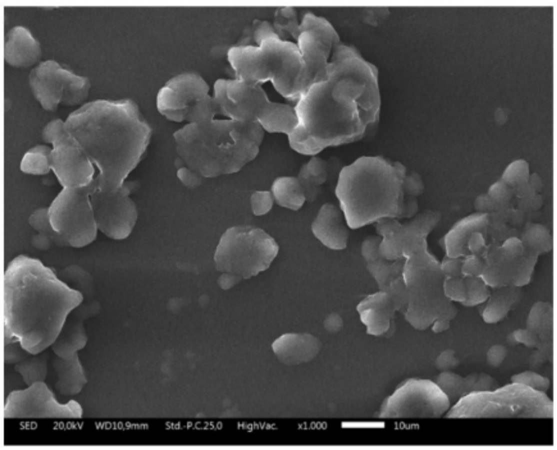

Figure 1. 1000x Magnification SEM Test Results.

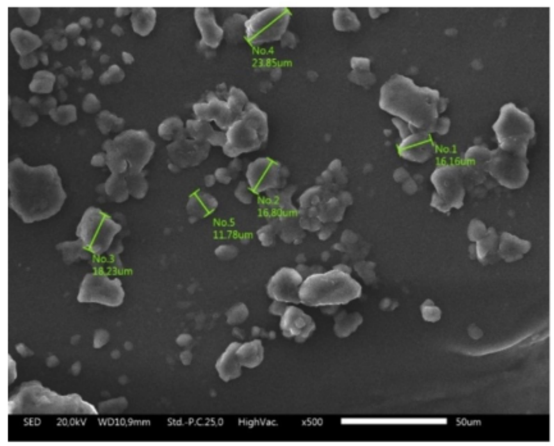

Figure 2. 500x Magnification SEM Test Results.

to Andarwulan (2013), the use of Butterfly Pea won't have an impact on the flavor and scent of food because the Butterfly Pea extract solely includes anthocyanin dyes.

3.10 SEM (Scanning Electron Microscope)

The goal of *Scanning Electron Microscope* (SEM) analysis is to determine the sample's surface morphology, shape, and size as shown in an image. The sample that had the best average value or the panelists' favored hedonic test of all qualities was sample t1b2 (10% trehalose and 1% Butterfly Pea), on which SEM analysis was performed. The aggregate shape of the Butterfly Pea milk powder was found to be uneven with a smooth surface according to the findings of the SEM examination, and the shape was not uniform to the sample of butterfly pea milk powder (Figure 1).

How hot the drying process is heated can have an impact on the morphology of the particles made utilizing SEM equipment. The rate at which water in the product evaporates increases with increasing drying temperature. This is in line with studies by Septevani et al. (2013), who found that applying high temperatures during the drying process can hasten uneven water evaporation, causing the surface of the particles to wrinkle (Figure 2).

Analysis of particle size was also done on the SEM analysis data. Hariadi et al. (2020) claims that the method of drying, the process of decomposition, and the dissolution of the sample can all have an impact on the size of the particle diameter of a powder. The faster the dissolution time and the better the powder's solubility, the smaller the resulting particle size. The degree of agglomeration (clumping) of a material will be impacted by the rapid and uneven evaporation of water caused by the *Drum Drying* method of drying. This is because a material's solubility decreases with decreasing water content.

4 Conclusion

The concentration of trehalose had an impact on the moisture content, hygroscopicity, soluble time, solubility, yield, pH value, color, and all other aspects of the reaction to the organoleptic test of Butterfly Pea milk powder. The concentration of Butterfly Pea affects the hygroscopicity, solubility time, yield, pH value, color, organoleptic reaction to color characteristics, taste attributes, and after taste attributes of Butterfly Pea milk powder. Color and yield are influenced by the relationship between trehalose concentration and Butterfly Pea, although water content, hygroscopicity, solubility, soluble time, pH value, and organoleptic response to the taste characteristics of milk powder Butterfly Pea are unaffected.

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