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Optimization of maltodextrin concentration in improving the stability and quality of instant butterfly pea flower powder beverage

[Optimalisasi konsentrasi maltodekstrin dalam peningkatan stabilitas dan kualitas minuman serbuk instan bunga telang]

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ABSTRACT

As consumer awareness of health issues increases, demand for products that are not only tasty but also nutritious is on the rise. Instant powdered butterfly pea flower drinks have attracted attention due to their appealing color and potential health benefits, as they contain bioactive compounds such as anthocyanins, which have antioxidant, anti-inflammatory, and neuroprotective properties. However, in the production process of instant powdered drinks, product stability and quality often pose challenges, particularly in maintaining the integrity of bioactive compounds and their attractive color. Therefore, research is needed to determine the optimal concentration of fillers to ensure the stability and quality of instant powdered butterfly pea flower beverages. This study was designed using a completely randomised design (CRD) with five levels of maltodextrin concentration treatment, namely 5%, 7%, 9%, 11%, and 13%. Each treatment was replicated four times, resulting in 20 experimental samples, which were tested for physicochemical properties (yield, solubility, moisture content, anthocyanin content, antioxidant activity) and hedonic properties (taste, color, aroma). The test results were analysed using Analysis of Variance (ANOVA) for physicochemical parameters and the Friedman test for hedonic parameters. The results of the study demonstrated that the addition of 11 g of maltodextrin (11% concentration) produced the best instant butterfly pea flower powder drink with very strong antioxidant activity (IC50 value = 2.62 ppm); anthocyanin content of 1.75 mg/l; moisture content of 0.28%; solubility of 39.28%; highly preferred sensory taste (4.55 ≈ 5); preferred sensory aroma (3.60 ≈ 4); preferred sensory color (4.00); and a yield of 12.90%.

Keywords: anthocyanin, butterfly pea flower, maltodextrin, powdered beverage

ABSTRAK

Seiring dengan meningkatnya kesadaran konsumen akan kesehatan, permintaan akan produk yang tidak hanya enak tetapi juga bergizi semakin meningkat. Minuman serbuk instan bunga telang telah menarik perhatian karena warna yang menarik dan potensi kesehatannya, yang mengandung senyawa bioaktif seperti antosianin yang bersifat antioksidan, anti-inflamasi, dan neuroprotektif. Namun, dalam proses produksi minuman serbuk instan, stabilitas dan kualitas produk akhir sering kali menjadi tantangan, terutama dalam menjaga keutuhan senyawa bioaktif dan warna yang menarik. Untuk itu, perlu dilakukan penelitian untuk menentukan konsentrasi bahan pengisi (filler) yang optimal agar stabilitas dan kualitas produk minuman serbuk instan bunga telang tetap terjaga. Penelitian ini didesain menggunakan Rancangan Acak Lengkap (RAL) dengan 5 taraf perlakuan konsentrasi maltodekstrin, yaitu 5%, 7%, 9%, 11%, dan 13%. Perlakuan mengalami pengulangan sebanyak 4 kali sehingga terbentuk 20 sampel percobaan, yang diuji secara fisikokimia (rendemen, daya larut, kadar air, antosianin, aktivitas antioksidan) dan hedonik (rasa, warna, aroma). Data hasil uji dianalisis menggunakan uji *Analysis Of Variance* (ANOVA) untuk parameter fisikokimia dan uji Friedman untuk parameter hedonik. Hasil penelitian membuktikan bahwa penambahan maltodekstrin sebanyak 11 g (konsentrasi 11%) mampu menghasilkan produk minuman serbuk instan bunga telang terbaik dengan aktivitas antioksidan sangat kuat (nilai IC_{50} = 2.62 ppm); kadar antosianin sebesar 1.75 mg/l; kadar air sebesar 0.28%; daya larut sebesar 39.28%; sensori rasa yang sangat disukai (4.55 ≈ 5); sensori aroma yang disukai (3.60 ≈ 4); sensori warna yang disukai (4.00); dan memiliki rendemen sebesar 12.90%.

Kata kunci: antosianin, bunga telang, maltodekstrin, minuman serbuk

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Introduction

Instant powdered butterfly pea flower beverages have gained attention because of its health potential, besides their strong blue color. Inline with the increase of consumer awareness towards health, the demand for such tasty and nutritional products has also increased. According to the Mordor Intelligence Research & Advisory (2025), the global health beverage market is predicted to reach 1.3 trillion USD in 2025. This indicates a high potential for healthy beverages, including the pea flower-based functional beverage with various health benefits, especially antioxidants. Butterfly pea flower (*Clitoria ternatea*) contains antioxidant, anti-inflammatory, and neuroprotective bioactives (Nabavi et al., 2020). Various research has been conducted to produce pea flower-based functional beverages, such as butterfly pea flower tea (Widjajanti et al., 2023); isotonics (Utami et al., 2023); and herbals (Indriasari et al., 2023). Nonetheless, there are issues regarding its convenience for consumption at any time when wanted. Production of herbal drinks in powdered form can be a solution to increase the convenience for consumers of all ages. Nonetheless, in the manufacturing of instant powdered drinks, issues with product stability and quality become a hurdle, mainly in maintaining the integrity of bioactive compounds and the strong color of the flower.

Butterfly pea flower (*Clitoria ternatea*) is known for its rich for ternatin type anthocyanins (delphinidin-derived acylated anthocyanins) which gives its strong blue unique color and antioxidant activity. The acylated structure strengthens its color to last longer in acidic conditions which is normal in beverages, making it suitable as a natural colorant while also as an antioxidant source for flower extract based functional beverages. Color and anthocyanin content of butterfly pea flower has been reported stable at pH ±3–5 and also under light pasteurization processes. However, they prone to photodegradation, therefore, protection strategies are needed during processing and storage (Vidana Gamage et al., 2021). Generally, instant powdered beverages are produced through crystallization, spray drying, freeze drying, and foam-mat drying. The most practical and cost efficiency method for small to medium scaled industries is foam-mat drying (Purbasari, 2019). Foam-mate drying stands out because of its simplicity, energy efficiency, and prodcues powders that are easily dispersed if foam formula and drying are optimized (foam thickness, mixing time, temperature). Recent studies on food matrixes has shown that optimization of foam-mat parameters, including choice of foaming/ stabilizing agent can increase the solubility and shorten pwoder rehidration time, as welll as maintain heat sensitive compounds. This method involves drying processes at 70-75°C with a liquid foaming technique added with a foam stabilizer. The processing of Instant powdered butterfly pea flower functional beverage needs fillers such as maltodextrin, a foaming agent and a foam stabilizer

Recent reviews on anthocyanin instant beverages also show that increasing maltodextrin concentration generally increase yield and powder solubility, decrease moisture content, and extend storage stability. On the other hand, there is an optimal point as excess addition of a carrier can reduce the total measured antocyanine, and weaked color intensity. A similar fenomena has been reported in strawberry based instant beverages and in other antocyanine systems. Based on a previous study by (Paramita et al., 2015), a maltodextrin percentage of 20% produced the best quality instant powdered sinom beverage. According to (Ramadhia et al., 2012), a 15% maltodextrin succeeded to produce a better powdered aloe vera beverage compared to concentrations of 5% and 10%. This finding is supported by (Komang et al., 2021), where the best treatment for instant powdered marigold is a concentration of marigold at 10% and Tween 80 of 0.7%. Previous research has shown that addition of maltodextrin at various concentrations and Tween 80 gives different results on powdered beverages. Therefore, determination of the optimum maltodextrin concentration is curcial to balance the process performance (yield, solubility, moisture content), and functional quality (antocyanine concentration, antioxidant acitivity, and sensoric acceptance.

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Material and method

Materials and instruments

This study utilized fresh butterfly pea flower obtained from areas surrounding Palu city, Central Sulawesi Regency. Additives used were maltodekstrin DE 12 (*Maltrin*), Tween 80 (*Matpers*), CMC (*Arbecel*), DPPH (*Himedia*), indicator fenolftalein, reagen arsenomolibdat, Na-Thiosulfat 0,1 N, buffer pH 1, buffer pH 4, Nelson reagent, and ethanol p.a. Instruments used were spektrofotometer UV-Vis (Shimadzu ASUV-3100PC), centrifuge (Damon/IEC Division), and vortex (Gemmy VM-300).

Research methodology

This study used a non-factorial experiment, arranged in a Completely Randomized Design (CRD), with treatment of 5 levels of maltodextrin concentration (BT1 = 5%; BT2 = 7%; BT3 = 9%; BT4 = 11%; BT5 = 13%). The percentage of maltodextrin was based on the weight of the total Butterfly pea extract. Replicates were done four times to form 20 units of experiments (samples). The formulation of the powdered beverage is shown in Table 1.

Table 1. Formulation of butterfly pea *(Clitoria ternatea L.)* powdered beverage

Composition	Formula				
	BT1	BT2	BT3	BT4	BT5
Butterfly pea extract (ml)	100.0	100.0	100.0	100.0	100.0
Maltodekstrin (%)or (g)	5.0	7.0	9.0	11.0	13.0
Tween 80 (g)	0.7	0.7	0.7	0.7	0.7
CMC (g)	0.3	0.3	0.3	0.3	0.3

Data processing was done using an Analysis of Variance (ANOVA) to evaluate the effect of the treatments, then further tested using the Honestly Significant Difference (HSD) test with a significance level of 0.05 and 0.01. Analysis of hedonic tests was done using the Friedman (Chi square) test, while the best treatment was determined by the *Effectiveness Index* De Garmo (Zahrah et al., 2023).

Preparation of butterfly pea extract

Preparation of butterfly pea extract began with flower sortation by removing unnecessary parts including the dirt, until only flower petals were ready to use. An amount of 500 g of petals was washed with running tap water. Water was then added, with a ratio of petal to water of 1:1, and blended for ±3 minutes. The flower extract was then separated using food-grade cheesecloth (Tama et al., 2014).

Preparation of instant powdered butterfly pea powdered beverage

Preparation of instant powdered butterfly pea beverage refers to Mahendra et al. (2023). A volume of 100 ml of flower extract was mixed with the filler and foaming agent. The fillers used were maltodextrin of 5 g, 7 g, 9 g, 11 g, and 13 g. Tween 80 of 0.7 g was used as the foaming agent, while CMC at 0.3 g was used as the foam stabilizing agent. The mixture was homogenized at the maximum speed of the blender (level 5) for ±7 minutes, until foam was formed and stable. Drying was done by pouring the mixture over a tray until the hieght of the mixture was 5 mm, then drying process was performed in the oven at 65 °C for 5 hours until a dry layer of foam was formed. After drying, the foam was powdered using a mortar then passed through a 60 mesh seiver.

Research parameter

Parameters tested included (a) moisture content using gravimetri (AOAC, 2005); (b) Solubility was determined based on the principle of dissolving the sample water solvent and filtered. Solubility value is the difference of initial and final mass, times by 100% (AOAC, 2005); (c) yield was calculated by comparing the initial and the final weight (Afdhaliah et al., 2024); (d) anthocyanin was determined using the pH

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differential method (Herlina et al., 2023); (e) antioxidant acitivty by the DPPH method (Putri et al., 2025), and (f) hedonik test was performed by 20 trained panalists with a scale of, 1 = dislike extremely, 2 = dislike, 3 = neither like nor dislike, 4 = like, and 5 = like extremely (Riandani, 2024).

Results and discussion

Yield

Yield is usually used in agriculture and industriy to describe the efficiency of a process in converting raw materials into final products. A high yield indicates the process is efficient and economically advantageous, whereas a low yield mas suggest problems with the production process or raw material quality (Zhang et al., 2022). In this study, analysis of variance (ANOVA) revealed that the use of maltodextrin in instant butterfly pea powder had a significant effect on the yield (Fcalculated = 542.67 > F table = 4.89), indicating that maltodextrin addition significantly influenced the yield of instant butterfly pea powder.

The data showed that the mean yield increased along with higher maltodextrin concentration (Table 2). The average yield ranged from 6±0.28% to 13.7±0.19%, with the highest yield obtained at 13% maltodextrin (BT%) and the lowest yield at 5% maltodextrin (BT1). Maltodextrin is a complex carbohydrate widely used in the food industry as a filler, binder, and stabilizer. Its application in the production of instant butterfly pea beverage powder enhances product solubility and stability (Yudiono, 2024). Hence, increasing maltodextrin concentration is directly proportional to yield improvement.

Consistent with the findings of Pui & Saleena (2022), higher maltodextrin levels contributed to an increase in yield, reduced hygroscopicity, and improvement of reconstution properties of powdered beverages. The Increase in maltodextrin levels resulted in an increase in the yield of the instant powdered butterfly pea beverage, which indicated improved drying process efficiency. However, the higher the yield, does not necessarily correspond to the higher the antocyanine concentration and antioxidant activity, inline with previous results reported by Maneeratanachot et al. (2024).

Table 2. Yield, solubility, and moisture content of the butterfly pea instant powdered beverage

Maltodextrin concentration (%)	Yield (%)	Solubility (%)	Moisture content (%)
5	6.6 ± 0.28^{a}	29.41 ± 0.02^{a}	0.54 ± 0.03^{e}
7	9.7 ± 0.22^{b}	30.75 ± 0.22^{b}	0.45 ± 0.02^{d}
9	11.5 ± 0.35^{c}	38.60 ± 0.14^{c}	0.35 ± 0.03^{c}
11	12.9 ± 0.11^{d}	39.28 ± 0.01^{d}	0.28 ± 0.02^{b}
13	13.7 ± 0.19^{e}	42.04 ± 0.02^{e}	0.16 ± 0.02^{a}
	HSD 1% = 0.68	HSD 1% = 0.32	HSD 1% = 0.06

Note : Mean values followed by the same lowercase letters in the same column are not significantly different ($P \geq 0.05$).

Solubility and moisture content

Statistical analysis (ANOVA) indicated that maltodextrin addition had a significant effect (Fcalculated > Ftable) on the solubility and moisture content of instant butterfly pea beverage powder, as confirmed by the 1% Honestly Significant Difference test presented in Table 2. The data showed that the highest solubility value was obtained in treatment BT5 with 13% maltodextrin, reaching 42.04±0.02%, while the lowest solubility was observed in BT1 with 5% maltodextrin, at 29.41±0.02%. The results demonstrated that the solubility of instant butterfly pea powder increased proportionally with increasing maltodextrin concentration. This finding is consistent with Komang et al. (2021), who reported that higher maltodextrin levels enhance product solubility due to increased viscosity and water-binding capacity. Similarly, Amelia et al. (2023) stated that materials containing a greater number of free hydroxyl groups exhibit higher

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solubility. Therefore, a higher solubility value indicates better product quality, as it facilitates ease and more practical reconstitution.

Solubility is also influenced by moisture content. A higher moisture content in powdered beverages generally results in lower solubility. According to Ueda et al. (2023), changes in moisture content affect particle density and internal porosity, thereby directly influencing the solubility of the final product. Higher moisture content tends to promote the formation of larger, non-porous particles, leading to reduced solubility. As shown in Table 2, solubility exhibited an inverse relationship with moisture content. Treatments with higher solubility values showed lower moisture content. For instance, BT5 (13% maltodextrin) exhibited the highest solubility (42.04 ± 0.02%) and the lowest moisture content (0.16 ± 0.02%). The moisture content of instant butterfly pea beverage powder was also significantly affected by maltodextrin addition. Increasing maltodextrin concentration resulted in lower moisture content. Saavedra-Leos et al. (2024) reported that maltodextrin has a relatively low molecular weight (less than 4,000) with a simple molecular structure, allowing both free and bound water to evaporate more readily during the heating process

Anthocyanin content and antioxidant activity

Anthocyanins are natural pigments widely found in plants, particularly in fruits and vegetables, and are well known for their strong antioxidant activity (Sadowska-Bartosz & Bartosz, 2024). Based on the analysis of variance (ANOVA), the addition of maltodextrin to instant butterfly pea beverage powder had a highly significant effect (Fcalculated > Ftable) on both anthocyanin content and antioxidant activity, as indicated by the IC_{50} values.

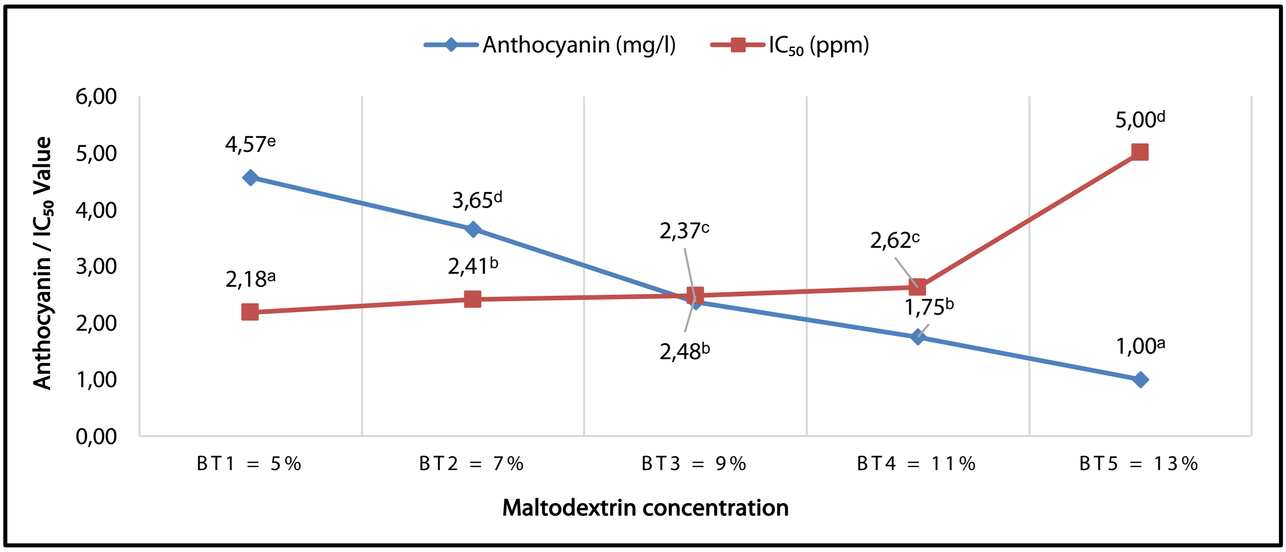

Figure 1. Anthocyanin content and antioxidant activity of instant butterfly pea beverage powder
Note: Mean values followed by the same lowercase letters in the same line are not significantly different ($P \geq 0.05$).

Figure 1. illustrates that the highest anthocyanin content was observed in instant butterfly pea beverage powder with 5% maltodextrin addition (BT1), reaching 4.570 mg/L, whereas the lowest anthocyanin content was found in BT5 with 13% maltodextrin, at 0.997 mg/L (≈ 1 mg/L). The results indicate that increasing maltodextrin concentration led to a decrease in anthocyanin content. This reduction is likely attributed to the dilution of anthocyanins within a larger carrier matrix, resulting in a lower relative concentration of the pigment. Therefore, achieving an optimal balance between maltodextrin concentration and desired anthocyanin content is crucial to maintain product quality.

These findings are consistent with the study by Santana et al. (2023), which reported that higher maltodextrin concentrations during anthocyanin powder production from Java plum resulted in powder with a more pale color and reduced total anthocyanin content and antioxidant activity. Indrawan (2022)

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reported that beverages with higher anthocyanin content tend to exhibit stronger antioxidant activity, which is important as antioxidants help protect body cells from damage caused by free radicals. In this context, measuring anthocyanin content is essential for assessing both the quality and potential health benefits of the resulting powdered beverage.

The antioxidant activity of instant butterfly pea beverage powder in this study was evaluated using the DPPH method by determining the IC_{50} value. A lower IC_{50} value indicates higher antioxidant activity. The data (Figure1) showed that increasing maltodextrin concentration resulted in reduced antioxidant activity, as evidenced by increasing IC_{50} values. The IC_{50} values of instant butterfly pea beverage powder ranged from 2.18 to 5 ppm, indicating very strong antioxidant activity. This classification is consistent with Widyantari et al. (2024), who stated that IC_{50} values below 50 ppm correspond to very strong antioxidant activity.

Sensory characteristics

The results of the sensory evaluation are presented in Table 3. For the taste attribute, the analysis showed a p-value = 0.00 < α = 0.01, indicating that the treatments had a significant effect on taste preference. The highest hedonic score (4.85) was obtained with 13% maltodextrin addition (BT5). These results indicate that increasing maltodextrin concentration enhanced taste acceptability, as the higher perceived sweetness made the product more favorable to panelists.

This finding is consistent with Erfianti et al. (2022), who reported that increasing maltodextrin concentration led to a proportional increase in sweetness (°Brix) in vinca flower crown coloring powder. This effect is attributed to maltodextrin being derived from monosaccharides and their derivatives, which exhibit high solubility in cold water.

Table 3. Hedonic test results of instant butterfly pea beverage powder

Maltodextrin concentration (%)	Taste	Color	Aroma
5	2.20 ± 0.41^{a}	2.95 ± 0.69^{a}	2.60 ± 0.60^{a}
7	2.60 ± 0.50^{a}	3.20 ± 0.52^{a}	3.00 ± 0.65^{a}
9	3.55 ± 0.51^{b}	3.50 ± 0.51^{a}	3.35 ± 0.67^{b}
11	4.55 ± 0.51^{c}	4.00 ± 0.56^{b}	3.60 ± 0.60^{b}
13	4.85 ± 0.37^{c}	4.50 ± 0.61^{b}	4.00 ± 0.73^{c}
α = 0.01	p-value = 0.00	p-value = 0.0000019	p-value = 0.0000005

Note : Mean values followed by the same lowercase letters in the same column are not significantly different (P ≥ 0.05).

Hedonic test data for taste, color, and aroma of instant butterfly pea beverage powder were analyzed using the Friedman test. A p-value lower than the significance level (α) indicates that differences in maltodextrin concentration had a significant effect on panelists' preference. For the color sensory attribute, the analysis yielded a p forlayout -value = 0.0000019 < α = 0.01, indicating that the treatments significantly influenced color acceptability. The addition of 13% maltodextrin (BT5) resulted in the most preferred color, with a hedonic score of 4.50, whereas the addition of 5% maltodextrin (BT1) produced the least preferred color, with a score of 2.20. According to Ernawati et al. (2014), maltodextrin is capable of forming complex molecules with the flavylium cation of anthocyanins, thereby protecting and stabilizing these pigments. This interaction helps preserve the color quality of instant butterfly pea beverage powder, particularly at higher maltodextrin concentrations. Similarly, Wiriani et al. (2020) reported that increasing maltodextrin concentration led to higher b* and hue angle (°hue) values in anthocyanin microencapsules. These findings are consistent with Sari et al. (2024), who demonstrated that coating butterfly pea extract with

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maltodextrin successfully preserved anthocyanin content during 15 days of storage, resulting in stable color retention.

For the aroma sensory attribute, the Friedman test showed a p-value = 0.0000005 < α = 0.01, indicating a significant effect of treatment on aroma preference. The highest aroma acceptability score (4.00, corresponding to like very much) was obtained with 13% maltodextrin addition (BT5). The results indicate that increasing maltodextrin concentration was directly proportional to increased panelist preference for aroma. This finding is in agreement with Gabriela et al. (2020), who reported that higher maltodextrin levels led to greater aroma acceptability in instant powdered beverages made from papaya and nutmeg. This effect is attributed to the role of maltodextrin as a carrier material that accelerates the drying process, protects volatile compounds from thermal degradation, and enhances flavor stability.

Effectiveness index

The determination of the optimal maltodextrin was conducted using the De Garmo effectiveness index method (Zahrah et al., 2023). This method is based on assigning weighted scores to each evaluated parameter according to its relative importance as a quality indicator of instant butterfly pea beverage powder. The optimal maltodextrin concentration to be used as a filler in the production of instant butterfly pea beverage powder is presented in Table 4.

Tabel 4. Effectiveness index

Parameter	Weight	Treatment									
		5%		7%		9%		11%		13%	
		NE	NP	NE	NP	NE	NP	NE	NP	NE	NP
Yield	0.028	0.000	0.000	0.437	0.012	0.690	0.019	0.887	0.025	1.000	0.028
Solubility	0.139	0.000	0.000	0.106	0.015	0.728	0.101	0.781	0.109	1.000	0.139
Moisture content	0.167	0.000	0.000	0.237	0.039	0.500	0.083	0.684	0.114	1.000	0.167
Anthocyanin	0.194	1.000	0.194	0.742	0.144	0.384	0.075	0.210	0.041	0.000	0.000
Antioxidant	0.222	1.000	0.222	0.918	0.204	0.894	0.199	0.844	0.188	0.000	0.000
Taste	0.111	0.000	0.000	0.151	0.017	0.509	0.057	0.887	0.099	1.000	0.111
Color	0.056	0.000	0.000	0.161	0.009	0.355	0.020	0.677	0.038	1.000	0.056
Aroma	0.083	0.000	0.000	0.286	0.024	0.536	0.045	0.714	0.060	1.000	0.083
Total	1.000		0.417		0.464		0.598		0.671		0.583

Based on the De Garmo effectiveness index analysis, the optimal maltodextrin concentration was determined to be 11% (BT4). This treatment produced instant butterfly pea beverage powder with very strong antioxidant activity (IC_{50} = 2.62 ppm), an anthocyanin content of 1.75 mg/L, moisture content of 0.28%, solubility of 39.28%, highly preferred taste (hedonic score 4.55 ≈ 5), preferred aroma (3.60 ≈ 4), preferred color (4.00), and a yield of 12.90%.

Conclusion

The addition of maltodextrin at various concentrations as a filler during the production of instant butterfly pea beverage powder significantly affected product stability and quality. The addition of 11 g maltodextrin (11% concentration) was identified as the optimal level, producing instant butterfly pea beverage powder with very strong antioxidant activity (IC_{50} = 2.62 ppm), anthocyanin content of 1.75 mg/L, moisture content of 0.28%, solubility of 39.28%, highly preferred taste (4.55 ≈ 5), preferred aroma (3.60 ≈ 4), preferred color (4.00), and a yield of 12.90%. These results indicate that an appropriate balance of maltodextrin concentration is essential to achieve optimal physicochemical, sensory, and bioactive properties in instant butterfly pea beverage powder.

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