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Analysis of Nutritional Composition and Antioxidant Activity of Yogurt Enriched with Butterfly Pea (*Clitoria ternatea* L.) Extract

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Abstract

The growing demand for functional foods has encouraged the development of dairy products enriched with natural bioactive ingredients to improve nutritional value and health benefits. This study aimed to analyze the nutritional composition and antioxidant activity of yogurt enriched with butterfly pea (*Clitoria ternatea* L.) extract. Yogurt was prepared from fresh goat milk with varying concentrations of butterfly pea extract and evaluated for protein, fat, carbohydrate, moisture, ash, vitamin C contents, antioxidant activity, and sensory acceptance. Proximate analysis, UV–Vis spectrophotometry, and the DPPH method were used for chemical determinations, while a hedonic test assessed color, taste, aroma, and texture. Results showed that increasing butterfly pea extract significantly decreased protein and fat contents but increased vitamin C and antioxidant activity, with the highest values observed in yogurt containing 60% extract and 4% formulation (N60K2). Moisture and ash contents were not significantly affected. Sensory evaluation indicated that yogurt with 60% extract and 2% formulation (N60K1) was preferred regarding color, taste, aroma, and texture. Considering compliance with the Indonesian National Standard (SNI) and consumer acceptance, N60K1 was the optimal formulation. The findings suggest that butterfly pea extract can enhance the functional properties of yogurt, particularly its antioxidant potential, while maintaining acceptable sensory quality. This provides insights for developing functional dairy products with natural plant-based bioactives.

Keywords: Antioxidant Activity; Butterfly Pea; Clitoria ternatea; Nutritional Composition; Yogurt.

INTRODUCTION

Yogurt is one of the most widely consumed fermented dairy products in the world, valued for its distinctive flavor, creamy texture, and numerous health benefits (Farag et al., 2020). It is produced through the fermentation of milk by lactic acid bacteria, primarily *Lactobacillus bulgaricus* and *Streptococcus thermophilus*, which convert lactose into lactic acid. This process not only enhances the shelf life and digestibility of milk but also enriches its nutritional profile by increasing the bioavailability of certain nutrients (Kaur et al., 2017; Kok & Hutkins, 2018). In addition to being a source of high-quality proteins, essential fatty acids, vitamins, and minerals, yogurt contains probiotics that support gut health and contribute to overall well-being (Saritas et al., 2024). The growing demand for functional foods has further encouraged innovations in yogurt production, particularly through the incorporation of plant-based bioactive ingredients to improve both nutritional value and health-promoting properties (Bankole et al., 2023; Li et al., 2025).

One plant-based ingredient of increasing interest in food product development is butterfly pea (*Clitoria ternatea* L.) (Hasanah et al., 2023), a leguminous plant widely cultivated in tropical and subtropical regions (Marpaung et al., 2020; Handayani et al., 2024). Traditionally used in herbal medicine and as a natural food colorant, butterfly pea flowers are rich in anthocyanins particularly ternatins which are responsible for their vivid blue color and potent antioxidant activity (Lakshan et al., 2019). Beyond anthocyanins, the flowers contain flavonoids, phenolic compounds, and other phytochemicals that possess antioxidant, anti-inflammatory, and anti-glycation properties (Jeyaraj et al., 2021; Rawiningtyas et al., 2024). Recently, the food industry has shown growing interest in butterfly pea extract as a natural alternative to synthetic additives, both for its functional properties and visual appeal (Yudiono, 2024). Incorporating butterfly pea extract into food products not only enhances their sensory characteristics but also enriches their nutritional and functional profiles, making them more appealing to health-conscious consumers (Siregar et al., 2022).

Antioxidants play a critical role in neutralizing free radicals, thereby reducing oxidative stress, which is associated with the development of chronic diseases such as cardiovascular disorders, cancer, and neurodegenerative conditions (Sharma et al., 2023). The consumption of antioxidant-rich foods has been widely recommended as part of a balanced diet to promote health and prevent disease (Ali et al., 2022; Gyawali et al., 2022). Functional dairy products such as yogurt offer an ideal vehicle for delivering these bioactive compounds, given their widespread acceptability and compatibility with various fortifying agents (Li et al., 2022). Enriching yogurt with butterfly pea extract is expected to increase its antioxidant potential, while also providing additional nutrients that may synergistically contribute to health benefits (Jena & Choudhry, 2025).

In addition to bioactive compounds, the nutritional composition of yogurt is a key factor in determining its health value and marketability (Arab et al., 2023). The analysis of macronutrients such as protein, carbohydrates, and fats, along with micronutrients like vitamin C, offers important insights into the product's dietary contribution (Mefleh et al., 2022). Parameters such as moisture and ash content also provide valuable information regarding product stability, shelf life, and mineral content. Modifying yogurt through the addition of plant-based extracts can influence these nutritional attributes, either by enhancing certain components or altering the balance between them. Understanding these changes is essential for optimizing product formulation, ensuring compliance with nutritional standards, and meeting consumer expectations for quality and functionality (Islam et al., 2021; Al-Bedrani et al., 2023; Kumar et al., 2025).

Despite the increasing popularity of plant-enriched dairy products, scientific research examining the nutritional and functional characteristics of yogurt fortified with butterfly pea extract remains limited (Mehwish et al., 2023; Thillapudi et al., 2025). Most previous studies have focused on the phytochemical composition and biological activities of butterfly pea in isolation or in non-dairy matrices (Habiba et al., 2025). While a few studies have explored its use as a natural colorant in beverages or baked goods, its integration into yogurt and the effects on both nutritional composition and antioxidant activity have not been extensively documented (Arain et al., 2023; Zaini et al., 2023). This research gap highlights the need for systematic studies to evaluate the impact of butterfly pea extract on yogurt's proximate composition, vitamin content, and antioxidant capacity.

Therefore, the objective of this study is to analyze the nutritional composition and antioxidant activity of yogurt enriched with butterfly pea (*Clitoria ternatea* L.) extract. Specifically, the study aims to determine the levels of protein, carbohydrate, fat, vitamin C, moisture, and ash content, as well as to assess the antioxidant potential of the fortified yogurt. By providing empirical data on these parameters, the research seeks to contribute to the growing body of knowledge on functional dairy products and to inform future innovations in yogurt development. The findings are expected to offer valuable insights for food scientists, nutritionists, and the dairy industry in designing products that align with consumer preferences for natural, health-promoting, and visually appealing foods.

MATERIALS AND METHODS

Materials

This study was an experimental research conducted in Food Technology and Nutrition. The research samples comprised yogurt supplemented with butterfly pea flower extract (derived from a community service activity in Bakubakulu Village, Sigi Regency). The yogurt samples were prepared by the researchers using fresh goat milk, which was pasteurized at a temperature of 61°C to 63°C. After pasteurization, a starter culture was added at a ratio of 1:2 (starter culture to milk). Subsequently, butterfly pea flower extract was incorporated into the mixture, which was then thoroughly stirred and incubated for approximately 2 hours at 40°C (Yang et al., 2023). In this study, the yogurt samples consisted of eight different treatments with varying concentrations of butterfly pea extract, along with one control sample without the extract addition.

Protein Analysis

Protein content was analyzed using the Bradford method (Karimi et al., 2022). A 0.1 ml aliquot of the sample solution was taken and placed into a microtube. Then, 1000 µl of 10% acetone was added. The mixture was vortexed until thoroughly blended. The sample was centrifuged at 5000 rpm for 7 minutes. Subsequently, 20 µl of the supernatant was transferred to a new microtube, followed by the addition of 1000 µl of Bradford reagent. The solution was remixed using a vortex mixer and incubated for 10 to 60 minutes at room temperature. The absorbance was measured using a spectrophotometer at a wavelength of 595 nm.

Fat Analysis

Fat content was determined using the Soxhlet extraction method (Rezvankhah et al., 2019). The principle of this method involves extracting fat using diethyl ether as a solvent. After the solvent evaporates, the extracted fat is weighed and its percentage is calculated. Samples analyzed with this method must be in solid form. Five grams of the sample were weighed and placed into filter paper, which was then inserted into a Soxhlet extractor. The extractor was positioned above a fat collection flask. Diethyl ether solvent (500 ml) was poured into the fat collection flask. The system was refluxed for approximately 5 hours until the solvent in the fat flask became clear. After extraction, the fat collection flask was heated at 105 °C to evaporate the solvent, and then weighed after drying to determine the fat content.

Water Analysis
The water content was analyzed using the oven method (Li et al., 2022). The procedure for determining the water content involves weighing an empty crucible, then weighing approximately 5 grams of the sample and placing it into the empty crucible. Place the crucible and its contents into an oven at a temperature of 100ºC–102ºC for 6 hours. After 6 hours, remove the crucible and cool it in a desiccator for 5–10 minutes, then weigh the crucible again. Dry it again in the oven and weigh the sample until a constant weight is achieved.

Ash Analysis
The ash content was analyzed using the Drying Ash method (Pojić et al., 2015). The procedure began by weighing an empty crucible, then placing approximately 5 grams of the sample into it. The sample was heated on a hot plate until no smoke was observed. It was then placed in a muffle furnace and incinerated until gray ash with a constant weight was obtained. The ashing process was carried out in two stages, at temperatures of 400 °C and 550°C. Afterward, the crucible was cooled in a desiccator and weighed.

Carbohydrate Analysis
Carbohydrate content can be determined using the proximate analysis method, often referred to as *Carbohydrate by Difference* (Akalu & Geleta, 2019). This analysis estimates the carbohydrate content not through direct measurement, but by calculation. The percentage of carbohydrates in food is obtained by subtracting the total percentage of protein, fat, ash, and moisture content from 100%.

Vitamin C Analysis
Vitamin C was analyzed using the UV–Vis spectrophotometry method (Samide & Tutunaru, 2017). A total of 5 g of the sample was weighed and dissolved in 100 mL of CO_2-free distilled water. The filtrate was diluted by pipetting 10 mL, which was then diluted further with 100 mL of CO_2-free distilled water. The absorbance of the sample was measured using a UV–Vis spectrophotometer at a wavelength of 270 nm. Distilled water was used as the blank solution, and ascorbic acid was used as the standard solution.

Antioxidant Activity Analysis
Antioxidant activity was analyzed using the *2,2-Diphenyl-1-picrylhydrazyl* (DPPH) method (Xie & Schaich, 2014). The DPPH solution was prepared by dissolving 1 mg of DPPH in 1 mL (1000 μL) of methanol, then further diluting with 100 mL of methanol and homogenizing using a magnetic stirrer. The sample solution with a concentration of 100 ppm was prepared by taking 1 mL of sample and diluting it with methanol to a total volume of 1 mL. Absorbance measurements were carried out by adding 200 μL of sample solution to 1 mL of DPPH solution. The mixture was incubated for 30 minutes, followed by measurement of absorbance at a wavelength of 517 nm.

Organoleptic Test Analysis
The organoleptic test was conducted with a panel of 25 participants (Valente et al., 2021). Each panelist was provided with a sample and an evaluation sheet containing a hedonic scale, as well as space for comments and suggestions. Panelists were instructed to taste the product and provide assessments based on their individual perceptions. The evaluation included assessments of color, taste, aroma, and texture.

Statistical Analysis
Univariate Analysis
Univariate analysis was conducted to calculate the mean value and test the normality of the nutritional content, antioxidant activity, and organoleptic properties of yogurt with the addition of honey pineapple and cinnamon extract. The Shapiro–Wilk test was used to assess normality, as the sample size was fewer than 30.

Bivariate Analysis
Bivariate analysis was performed to determine the significant effect of variations in the addition of butterfly pea extract to yogurt on nutritional content, antioxidant activity, and organoleptic properties. If the data were normally distributed, the statistical test used was One-Way ANOVA (*Analysis of Variance*), while non-normally distributed data were analyzed using the Kruskal–Wallis test. Furthermore, a paired *t*-test was conducted to identify the effect of adding butterfly pea extract.

RESULTS AND DISCUSSION

Protein Content
The analysis of protein content in yogurt with adding butterfly pea extract (Table 1; Figure 1) showed significant differences between treatments (p = 0.00). All treatment groups exhibited differences in protein content, with a general decrease observed. In other words, the greater the addition of butterfly pea extract, the smaller the amount of milk incorporated into the formulation.

The control yogurt, without the addition of butterfly pea extract, had the highest protein content at 4.60 mg/100 mL, while the lowest value was 0.43 mg/100 mL. Previous research has shown that the protein content of yogurt is largely determined by the quality of its raw material, namely milk; the higher the milk protein content, the better the quality of the yogurt produced (Chalid et al., 2021; Habiba et al., 2025). The addition of butterfly pea extract had a significant impact on the protein content of the yogurt. According to the Indonesian National Standard (SNI) 01.2981-1992, the minimum protein content in yogurt should be 3.5%. Another study reported that protein content is influenced by the total number of lactic acid bacteria present; the greater the microbial population in yogurt, the higher the protein content, as most of the microbial components are composed of proteins (Brodziak et al., 2020; Li et al., 2022; Gan et al., 2023).

Table 1. Protein content in yogurt with the addition of butterfly pea extract.

Treatment	Protein Content		Difference (After − Before) mg/100 mL	*P*
	Before Mean ± SD (mg/100 mL)	After Mean ± SD (mg/100 mL)		
Control	4.60 ± 0.002	4.60 ± 0.002^{a}		
N0K1	4.60 ± 0.002	4.44 ± 0.008^{a}	-0.16 ± 0.011	0.02^{2}
N0K2	4.60 ± 0.002	4.40 ± 0.000^{a}	-0.20 ± 0.002	0.74^{2}
N20K1	4.60 ± 0.002	3.84 ± 0.020^{a}	-0.76 ± 0.019	0.54^{2}
N20K2	4.60 ± 0.002	2.71 ± 0.016$^{a;b}$	-1.89 ± 0.022	0.14^{2}
N40K1	4.60 ± 0.002	2.68 ± 0.002$^{a;b}$	-1.92 ± 0.005	0.00^{2}
N40K2	4.60 ± 0.002	1.77 ± 0.015^{b}	-2.83 ± 0.006	0.04^{2}
N60K1	4.60 ± 0.002	1.26 ± 0.004^{b}	-3.38 ± 0.017	0.00^{2}
N60K2	4.60 ± 0.002	0.43 ± 0.000^{b}	-4.17 ± 0.003	0.00^{2}
P		**0.00^{1}**		

Note: Values followed by different superscript letters (a, b) indicate significant differences; One-way ANOVA; Paired t-test.

Fat Content

The analysis of fat content in yogurt with the addition of butterfly pea extract (Table 2; Figure 1) showed significant differences among treatments (p = 0.00). All treatment groups exhibited decreased fat content, which was attributed to the reduced proportion of milk used in yogurt production. In other words, the greater the addition of butterfly pea extract, the smaller the amount of milk incorporated into the formulation.

The decrease in fat content was influenced by several factors, including the drying process performed prior to fat analysis (Oliveira et al., 2016). Oven-drying is known to reduce certain nutrients in the sample. In this study, drying was necessary to prepare the samples for fat analysis using the Soxhlet method, which requires dry samples (Zioud et al., 2023). The drying process was conducted at 40 °C for 48 hours. Previous studies have shown that temperature can significantly affect the fat content of cow's milk, with low storage temperatures recommended to inhibit the growth of harmful bacteria (Kaur et al., 2017; Kok & Hutkins, 2018; Jena & Choudhury, 2025).

In addition to temperature, storage duration also affects fat content, as prolonged exposure can lead to lipid degradation due to oxidation by free oxygen (Farag et al., 2020). Furthermore, fat in food materials can be reduced or damaged during cooking processes (Hasanah et al., 2023). According to the Indonesian National Standard (SNI), the minimum fat content in yogurt is 2.5% (Lakshan et al., 2019). In this study, yogurt with butterfly pea extract had fat contents ranging from 2.48% to 3.12%.

Table 2. Fat content in yogurt with the addition of butterfly pea extract.

Treatment	Fat Content		Difference (After − Before) mg/100 mL	*P*
	Before Mean ± SD (mg/100 mL)	After Mean ± SD (mg/100 mL)		
Control	3.12 ± 0.01	3.12 ± 0.01^{a}		
N0K1	3.12 ± 0.01	3.11 ± 0.03^{a}	-0.01 ± 0.04	0.90^{2}
N0K2	3.12 ± 0.01	2.73 ± 0.07$^{a;b}$	-0.39 ± 0.05	0.05^{2}
N20K1	3.12 ± 0.01	2.48 ± 0.51$^{a;b}$	-0.64 ± 0.50	0.31^{2}
N20K2	3.12 ± 0.01	2.92 ± 0.04$^{a;b}$	-0.20 ± 0.02	0.06^{2}
N40K1	3.12 ± 0.01	2.75 ± 0.03^{b}	-0.37 ± 0.02	0.02^{2}
N40K2	3.12 ± 0.01	2.58 ± 0.22$^{a;b}$	-0.54 ± 0.24	0.18^{2}
N60K1	3.12 ± 0.01	2.78 ± 0.02^{b}	-0.34 ± 0.00	0.01^{2}
N60K2	3.12 ± 0.01	2.50 ± 0.41$^{a;b}$	-0.62 ± 0.43	0.28^{2}
P		**0.00^{1}**		

Note: Values followed by different superscript letters (a, b) indicate significant differences; One-way ANOVA; Paired t-test.

Water Content

The analysis of water content in yogurt with the addition of butterfly pea flower extract (Table 3; Figure 1) showed no significant differences among treatments (p = 0.68). The average water content across all treatments was approximately 80%, which is slightly lower than the Indonesian National Standard (SNI) 2981:2009 requirement of 83–84% for yogurt (Maulid et al., 2025). This reduction in water content may be influenced by the variation in the amount of butterfly pea flower extract added, where a higher proportion of extract reduces the proportion of milk used (Ikrawan et al., 2023; Mehwish et al., 2023). In addition, the drying process also contributes to the decrease in water content, as longer drying times generally lead to lower water content in food products (Arain et al., 2023). Previous studies have reported that high water content in fermented products such as kefir can increase the population of lactic acid bacteria (LAB) and other microorganisms, as microbial growth is strongly dependent on water availability in food (Ali et al., 2022; Mefleh et al., 2022).

Table 3. Water content in yogurt with the addition of butterfly pea extract.

Treatment	Water Content		Difference (After − Before) mg/100 mL	*P*
	Before Mean ± SD (mg/100 mL)	After Mean ± SD (mg/100 mL)		
Control	82.00 ± 4.23	82.00 ± 4.22^{a}		
N0K1	82.00 ± 4.23	80.00 ± 0.68^{a}	-2.50 ± 3.51	0.49[2]
N0K2	82.00 ± 4.23	79.00 ± 1.39$^{a;b}$	-3.00 ± 2.80	0.36[2]
N20K1	82.00 ± 4.23	73.00± 9.87$^{a;b}$	-9.00 ± 5.64	0.25[2]
N20K2	82.00 ± 4.23	79.00 ± 2.80$^{a;b}$	-3.00 ± 7.06	0.64[2]
N40K1	82.00 ± 4.23	80.50 ± 0.69^{b}	-1.50 ± 3.51	0.64[2]
N40K2	82.00 ± 4.23	80.00 ± 0.00$^{a;b}$	-2.00 ± 4.22	0.61[2]
N60K1	82.00 ± 4.23	71.00 ± 15.54^{b}	-1.10 ± 11.30	0.39[2]
N60K2	82.00 ± 4.23	80.00 ± 2.81$^{a;b}$	-2.00 ± 1.40	0.28[2]
P		**0.68[1]**		

Note: Values followed by different superscript letters (a, b) indicate significant differences; One-way ANOVA; Paired t-test.

Ash Content

The analysis of ash content in yogurt with the addition of butterfly pea flower extract (Table 4; Figure 1) showed no significant differences among treatments (p = 0.38). Ash refers to the inorganic residue remaining after the combustion of organic material (Zhang & Wang, 2022). According to the Indonesian National Standard (SNI), the ash content of yogurt should not exceed 1.0%. Ash content is closely related to the mineral composition of the product, where higher ash levels indicate a greater mineral content (Oliveira et al., 2016). The levels of individual mineral components are influenced by factors such as species, physiological conditions, geographical location, frequency of waves, and the type of mineralization process used (Al-Bedrani et al., 2023). In this study, the ash content measurement was preceded by a drying process to remove moisture from the samples. This drying process may also affect the mineral content of the resulting yogurt (Islam et al., 2021; Kumar et al., 2025).

Table 4. Ash content in yogurt with the addition of butterfly pea extract.

Treatment	Ash Content		Difference (After − Before) mg/100 mL	*P*
	Before Mean ± SD (mg/100 mL)	After Mean ± SD (mg/100 mL)		
Control	4.07 ± 0.03	4.07 ± 0.03^{a}		
N0K1	4.07 ± 0.03	4.00 ± 0.04^{a}	-0.07 ± 0.02	0.12[2]
N0K2	4.07 ± 0.03	4.63 ± 0.17$^{a;b}$	-0.56 ± 0.22	0.18[2]
N20K1	4.07 ± 0.03	4.44 ± 0.25$^{a;b}$	-0.37 ± 0.29	0.33[2]
N20K2	4.07 ± 0.03	4.42 ± 0.08$^{a;b}$	-0.35 ± 0.11	0.16[2]
N40K1	4.07 ± 0.03	3.84 ± 0.16^{b}	-0.23 ± 0.20	0.36[2]
N40K2	4.07 ± 0.03	4.52 ± 0.13$^{a;b}$	-0.45 ± 0.16	0.17[2]
N60K1	4.07 ± 0.03	4.30 ± 0.59^{b}	-0.23 ± 0.62	0.69[2]
N60K2	4.07 ± 0.03	3.93 ± 0.82$^{a;b}$	-0.14 ± 0.84	0.85[2]
P		**0.38[1]**		

Note: Values followed by different superscript letters (a, b) indicate significant differences; One-way ANOVA; Paired t-test.

Carbohydrate Content

The analysis of carbohydrate content in yogurt with the addition of honey pineapple and cinnamon extract (Table 5; Figure 1) showed significant differences among treatments (p = 0.00). The carbohydrate analysis results indicated distinct values, with differences observed across all groups. The highest carbohydrate content recorded was 19.50%. Carbohydrates in milk are primarily in the form of lactose, which serves as the main carbon source for lactic acid bacteria in producing lactic acid (Taye et al., 2021; Arab et al., 2023). One of the carbohydrates present in butterfly pea flower extract in disaccharide form is fructose (Juturu & Wu, 2016). Fructose, commonly referred to as fruit sugar, is a type of sugar polymer (Sharma et al., 2023). It is a complex sugar that cannot be directly digested by the human digestive system and must first be converted into simple sugars (Li et al., 2025). The fermentation process aims to transform this form of carbohydrate into a form more readily absorbed by the human body (Kok & Hutkins, 2018).

Table 5. Carbohydrate content in yogurt with the addition of butterfly pea extract.

Treatment	Carbohydrate Content		Difference (After − Before) mg/100 mL	*P*
	Before Mean ± SD (mg/100 mL)	After Mean ± SD (mg/100 mL)		
Control	4.18 ± 4.53	4.18 ± 4.53[a]		
N0K1	4.18 ± 4.53	6.61 ± 0.83[a;b]	2.43 ± 3.67	0.55[2]
N0K2	4.18 ± 4.53	7.21 ± 0.07[a;b]	3.03 ± 4.45	0.50[2]
N20K1	4.18 ± 4.53	15.33 ± 7.02[a;b]	11.15 ± 2.49	0.10[2]
N20K2	4.18 ± 4.53	7.78 ± 5.43[a;b]	3.60 ± 9.98	0.70[2]
N40K1	4.18 ± 4.53	8.19 ± 0.13[a;b]	4.01 ± 4.38	0.40[2]
N40K2	4.18 ± 4.53	9.60 ± 0.42[a;b]	5.42 ± 4.95	0.35[2]
N60K1	4.18 ± 4.53	19.50 ± 15.03[b]	15.32 ± 10.49	0.27[2]
N60K2	4.18 ± 4.53	11.11 ± 2.34[a;b]	6.93 ± 2.17	0.13[2]
P		**0.00[1]**		

Note: Values followed by different superscript letters (a, b) indicate significant differences; One-way ANOVA; Paired t-test.

Vitamin C Content

The analysis of vitamin C content in yogurt with adding butterfly pea flower extract (Table 6; Figure 1) showed significant differences among treatments (p = 0.00). The vitamin C content varied across all treatment groups and demonstrated an increasing trend. The greater the addition of butterfly pea flower extract, the higher the vitamin C content.

Incorporating butterfly pea flower extract into yogurt significantly increased its vitamin C content. Each sample with the extract showed a significant difference compared to the control. The highest vitamin C content was observed in yogurt with the highest butterfly pea flower extract level, reaching 4.11 mg/100 mL. vitamin C content increased directly proportional to the amount of butterfly pea flower extract added. A decrease in vitamin C levels may occur due to its susceptibility to degradation from exposure to light, high temperatures, oxygen, and processing methods (Giannakourou & Taoukis, 2021). Vitamin C is highly water-soluble and readily oxidized when exposed to air (Bankole et al., 2023). Greater losses may result from heating at 90 °C for 3 minutes or from oxygen and light exposure (Li et al., 2022). The recommended daily intake of vitamin C for adults and the elderly is 90 mg/day for men and 75 mg/day for women (Giannakourou & Taoukis, 2021).

Table 6. Vitamin C content in yogurt with the addition of butterfly pea extract.

Treatment	Vitamin C Content		Difference (After − Before) mg/100 mL	*P*
	Before Mean ± SD (mg/100 mL)	After Mean ± SD (mg/100 mL)		
Control	0.16 ± 0.003	0.16 ± 4.53[a]		
N0K1	0.16 ± 0.003	0.19 ± 0.83[a]	0.03 ± 0.003	0.18[2]
N0K2	0.16 ± 0.003	0.38 ± 0.07[b]	0.22 ± 0.002	0.00[2]
N20K1	0.16 ± 0.003	0.60 ± 7.02[b]	0.44 ± 0.005	0.00[2]
N20K2	0.16 ± 0.003	1.51 ± 5.43[c]	1.35 ± 0.005	0.00[2]
N40K1	0.16 ± 0.003	3.17 ± 0.13[d]	3.01 ± 0.001	0.00[2]
N40K2	0.16 ± 0.003	3.87 ± 0.42[e]	3.71 ± 0.011	0.00[2]
N60K1	0.16 ± 0.003	4.21 ± 15.03[f]	4.05 ± 0.016	0.00[2]
N60K2	0.16 ± 0.003	4.27 ± 2.34[g]	4.11 ± 0.012	0.00[2]
P		**0.00[1]**		

Note: Values followed by different superscript letters (a, b, c, d, e, f, g) indicate significant differences; One-way ANOVA; Paired t-test.

Antioxidant Content

The antioxidant activity test results for yogurt with the addition of butterfly pea flower extract (Table 7; Figure 1) showed significant differences among groups (p = 0.00). Higher levels of butterfly pea flower extract resulted in increased antioxidant activity. Antioxidant activity refers to the ability of compounds in a food product to scavenge free radicals (Gulcin, 2020). The addition of butterfly pea flower extract to yogurt enhanced its antioxidant activity, with the highest activity observed in the 60% extract and 4% yogurt formulation (N60K2), reaching 47.8%. The antioxidant activity assay using the DPPH method indicated the ability of food components to scavenge 50% of free radicals (IC50). A higher antioxidant activity corresponds to a higher antioxidant concentration, thereby reducing the amount of food required to neutralize free radicals (Zhang & Wang, 2022).

Table 7. Antioxidant content in yogurt with the addition of butterfly pea extract.

Treatment	Antioxidant Content		Difference (After − Before) mg/100 mL	P
	Before Mean ± SD (mg/100 mL)	After Mean ± SD (mg/100 mL)		
Control	14.4 ± 0.11	14.4 ± 0.12[a]		
N0K1	14.4 ± 0.11	17.3 ± 0.02[a]	2.90 ± 0.10	0.00[2]
N0K2	14.4 ± 0.11	21.7 ± 0.03[a]	7.30 ± 0.16	0.00[2]
N20K1	14.4 ± 0.11	34.6 ± 0.11[a;b]	20.2 ± 0.24	0.00[2]
N20K2	14.4 ± 0.11	34.7 ± 0.25[a;b]	20.3 ± 0.39	0.00[2]
N40K1	14.4 ± 0.11	35.0 ± 0.20[a;b]	20.6 ± 0.26	0.00[2]
N40K2	14.4 ± 0.11	56.7 ± 0.20[b]	42.3 ± 0.34	0.00[2]
N60K1	14.4 ± 0.11	59.0 ± 0.03[b]	44.6 ± 0.17	0.00[2]
N60K2	14.4 ± 0.11	62.2 ± 0.00[b]	47.8 ± 0.22	0.00[2]
P		**0.00[1]**		

Note: Values followed by different superscript letters (a, b) indicate significant differences; One-way ANOVA; Paired t-test.

Organoleptic Test

Color

Based on statistical analysis, the addition of butterfly pea flower extract showed a significant difference among all samples (p = 0.00). Yogurt with 0% butterfly pea flower extract had the highest level of acceptance, whereas yogurt with 40% butterfly pea flower extract had the lowest.

As shown in Table 8 and Figure 1, the addition of butterfly pea flower extract had a significant effect on the color acceptance of the resulting yogurt. The control yogurt sample exhibited a milky white color, yogurt samples N0K1 and N0K2 had a light purple hue, while yogurt with higher concentrations of butterfly pea flower extract became progressively more purple in proportion to the amount of extract added. The milky white color in the control yogurt originates from beta-carotene in fat, which is encapsulated by protein (Molina et al., 2019). Milk casein has a translucent property, allowing all wavelengths to be reflected, thereby producing a white appearance (Milovanovic et al., 2020). The purple color in yogurt with butterfly pea flower extract is derived from beta-carotene, a natural compound belonging to the carotenoid group. The color of food products can influence their level of acceptance, with brightly colored foods generally being more readily accepted and preferred by consumers (Paakki et al., 2016; De Meija et al., 2020).

Table 8. Results of the analysis of color acceptance in yogurt with the addition of butterfly pea flower extract.

Treatment	Mean ± SD	Mean ± Rank
Control	5.46 ± 0.49	170.18[a]
N0K1	5.06 ± 0.77	141.44[b]
N0K2	5.06 ± 0.66	142.52[c]
N20K1	4.62 ± 0.69	108.50[d]
N20K2	4.54 ± 0.90	103.94[e]
N40K1	4.66 ± 0.69	111.74[f]
N40K2	3.86 ± 0.67	58.48[g]
N60K1	4.38 ± 0.85	97.64[h]
N60K2	4.02 ± 1.07	75.72[i]
P*		**0.00**

Note: Numbers followed by different superscript letters (a, b, c, d, e, f, g, h, i) indicate significant differences. *Kruskal–Wallis test; post-hoc Mann–Whitney test.*

Taste

As shown in Table 9 and Figure 1, the addition of butterfly pea flower extract had a significant effect on the taste of the resulting yogurt. Statistical analysis indicated that the yogurt most preferred by the panelists was sample N0K2, with a mean rank of 143.63. However, in some cases, the yogurt produced left a bitter aftertaste in the throat after consumption. This was attributed to the presence of bromelain enzymes, which react with milk (Kumar et al., 2025). Bromelain is a proteolytic enzyme, and excessive proteolytic activity can produce a bitter taste. Heating to a temperature of 100 °C inactivates bromelain enzymes; nevertheless, the bitter taste appeared only occasionally and did not affect the overall acceptance level of the yogurt (Juturu & Wu, 2016; Li et al., 2022).

Table 9. Results of the analysis of taste acceptance in yogurt enriched with butterfly pea flower extract.

Treatment	Mean ± SD	Mean ± Rank
Control	4.62 ± 0.92	110.12[a]
N0K1	4.06 ± 0.74	137.16[b]
N0K2	4.10 ± 0.9	143.63[c]
N20K1	4.62 ± 1.01	111.65[d]
N20K2	4.14 ± 0.98	82.19[e]
N40K1	4.18 ± 1.07	85.03[f]
N40K2	4.54 ± 0.88	104.01[g]
N60K1	5.10 ± 0.76	141.95[h]
N60K2	4.42 ± 1.01	101.37[i]
P*		**0.00**

Note: Numbers followed by different superscript letters (a, b, c, d, e, f, g, h, i) indicate significant differences. *Kruskal–Wallis test; post-hoc Mann–Whitney test.*

Aroma

As shown in Table 10 and Figure 1, the addition of butterfly pea flower extract to yogurt did not result in any significant increase or decrease in aroma ($p = 0.312$). There was no significant difference in the aroma of the resulting yogurt. The yogurt produced tended to have a sour aroma typical of conventional yogurt, so the characteristic aroma of butterfly pea flower was not strongly perceived (Saritas et al., 2024). According to previous research, the aroma components of butterfly pea flower are not lost during heating at the boiling temperature of milk (±100 °C). However, these aroma components begin to decline at 150 °C and decrease further as the temperature increases (Giannakourou & Taoukis, 2021).

Table 10. Results of the analysis of aroma acceptance in yogurt with the addition of butterfly pea flower extract.

Treatment	Mean ± SD	Mean ± Rank
Control	4.19 ± 0.56	131.75[a]
N0K1	4.03 ± 0.77	120.49[a]
N0K2	3.79 ± 1.03	107.35[a]
N20K1	3.79 ± 0.75	97.19[a]
N20K2	3.91 ± 0.56	107.35[a]
N40K1	3.79 ± 0.49	96.87[a]
N40K2	3.91 ± 0.39	107.35[a]
N60K1	4.15 ± 0.73	128.47[a]
N60K2	3.79 ± 1.07	111.25[a]
*P**		0.312

Note: Numbers followed by different superscript letters (a, b, c, d, e, f, g, h, i) indicate significant differences. *Kruskal–Wallis test; post-hoc Mann–Whitney test.*

Texture

As shown in Table 11 and Figure 1, the addition of butterfly pea flower extract had a significant effect on the texture acceptance of the resulting yogurt. Statistical analysis indicated that the most preferred texture was found in sample N0K2, with a mean rank of 161.61. The fiber in butterfly pea flower contributed to a slightly coarse texture in the yogurt. The butterfly pea flowers used in yogurt production had already undergone a grinding process, which should have reduced the fiber into smaller molecules (Farag et al., 2020). Smaller fiber size can enhance the absorption of beta-carotene in the body (Bankole et al., 2023). The texture of this yogurt was slightly coarse, differing from that of commercial yogurt drinks, in which the fruit texture is more fully integrated with the milk (Gulcin, 2020).

Table 11. Results of the analysis of texture acceptance in yogurt with the addition of butterfly pea flower extract.

Treatment	Mean ± SD	Mean ± Rank
Control	4.19 ± 0.56	157.93[a]
N0K1	4.03 ± 0.77	132.41[b]
N0K2	3.79 ± 1.03	161.61[c]
N20K1	3.79 ± 0.75	105.65[d]
N20K2	3.91 ± 0.56	93.45[e]
N40K1	3.79 ± 0.49	94.57[f]
N40K2	3.91 ± 0.39	89.69[g]
N60K1	4.15 ± 0.73	86.19[h]
N60K2	3.79 ± 1.07	86.59[i]
P*		**0.00**

Note: Numbers followed by different superscript letters (a, b, c, d, e, f, g, h, i) indicate significant differences. *Kruskal–Wallis test; post-hoc Mann–Whitney test.*

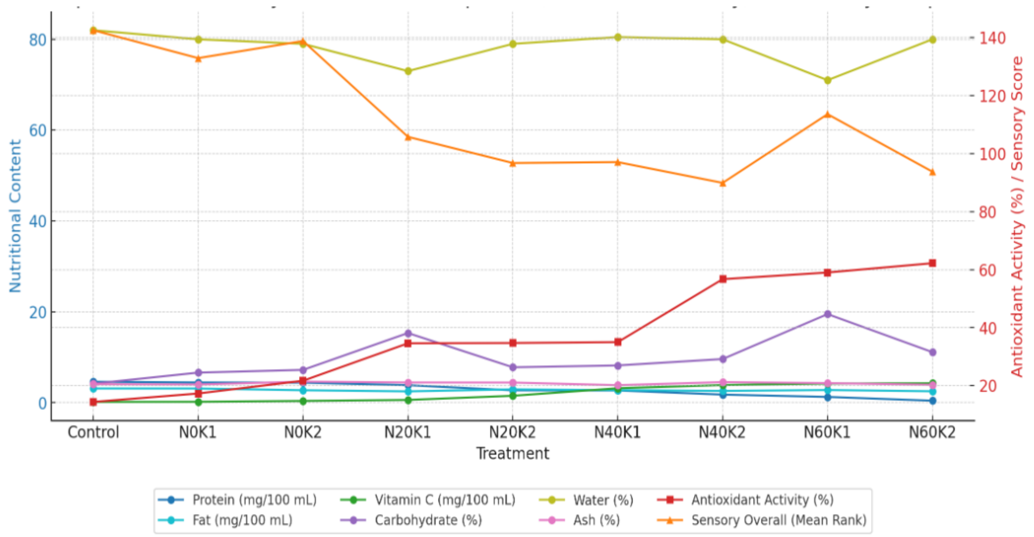

Figure 1. Comprehensive summary of nutritional composition, antioxidant activity, and sensory acceptance of yogurt enriched with butterfly pea (*Clitoria ternatea* L.) extract.

CONCLUSIONS

Yogurt with the addition of 60% butterfly pea flower extract and 4% (N60K2) had the highest vitamin C and antioxidant content but the lowest protein and fat content. The yogurt most preferred by panelists in terms of color, taste, aroma, and texture was the one with 60% butterfly pea flower extract and 2% addition. Based on the scoring conducted by the researchers, which considered compliance with the Indonesian National Standard (SNI) and consumer acceptance levels, yogurt with 60% butterfly pea flower extract and 2% (sample N60K1) was the most recommended formulation.

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