JOURNAL OF HALAL INDUSTRY & SERVICES
Journal Homepage: http://journals.hh-publisher.com/index.php/JHIS/index

HH PUBLISHER

Original Research Article

Effect of Different Gelling Agents on Sensory, Physicochemical, and Antioxidant Properties of Butterfly Pea (*Clitoria Ternatea*)-fortified Gummies

Nur Izzaty Izlan[1], Aida Safina Aridi[1*], Siti Aishah Baharuddin[2], Fara Jasseica Mohd Rashid[3], Faridatul Ain Mohd Rosdan[4]

[1]Department of Technology and Natural Resources, Faculty of Applied Sciences and Technology, Universiti Tun Hussein Onn Malaysia Pagoh Campus, Pagoh 84600, Johor, Malaysia

[2]Department of Engineering and Built Environment, Tunku Abdul Rahman University of Management and Technology, Penang Branch, 11200, Tanjung Bungah, Penang, Malaysia

[3]Miwa Manufacturing Sdn. Bhd., 39, Jalan Industri Bukit Badong 1, Taman Industri Bukit Badong, 45620, Ijok, Selangor, Malaysia.

[4]School of Chemical and Process Engineering, University of Leeds, LS2 9JT, Leeds, United Kingdom.

*Corresponding author: Aida Safina Aridi, Address; aidasafina@uthm.edu.my

Abstract: Limited information is available on the combined use of gelatine-pectin systems in butterfly pea (*Clitoria ternatea*)-fortified gummies and how these systems influence sensory and physicochemical properties. This study compared two formulations containing 10% gelatine and a gelatine-pectin combination (9% gelatine + 1% pectin) to evaluate their sensory, physicochemical, textural and antioxidant characteristics. Sensory evaluation (n = 50) was analysed using one-way ANOVA followed by Tukey's test ($p < 0.05$). The gelatine-only formulation showed significantly higher appearance scores, whereas the gelatine-pectin formulation achieved significantly higher sweetness and overall acceptance ($p < 0.05$). Texture Profile Analysis (TPA) indicated that the gelatine-only formulation exhibited higher firmness (610.30 ± 22.79 g) compared with the gelatine-pectin formulation (357.37 ± 19.01 g), whereas the gelatine-pectin formulation showed higher springiness (60.58 ± 3.09%). The selected gummy formulation showed a pH of 3.53 ± 0.01 and moisture content of 33.76 ± 0.06%. Total phenolic content was 33.95 ± 2.31 mg GAE/g dry weight with DPPH radical scavenging activity of 22.52 ± 0.80%, indicating retention of antioxidant activity after processing. These results demonstrate that modifying the gelling system influences both texture and consumer acceptance, supporting the

Article History:

Received: 10th November 2025
Accepted: 13th April 2026
Available Online: 20th June 2026
Published: 11th August 2026

Keywords:

Fortified gummies; Gummy candies; Gelling agents; Shelf life; Moisture content; Texture analysis

Citation:

Izlan, N. I., Aridi, A. S., Baharuddin, S. A., et al. (2026). Effect of different gelling agents on sensory, physicochemical, and antioxidant properties of butterfly pea (Clitoria ternatea)-fortified gummies. *Journal of Halal Industry & Services*, *9*(1), a0000680.

DOI: 10.36877/jhis.a0000680

potential of butterfly pea gummies as functional confectionery products.

1. Introduction

Gummy, a popular sugar confectionery, rely on hydrocolloids to form a gel network that traps sugar syrup with high moisture content, creating a chewable, flexible, and elastic matrix. This matrix is essential for delivering active ingredients, making gummy jellies not only a treat but also a functional food product (Matulyte *et al.*, 2021). They serve as an excellent method for delivering essential nutrients to children and have also gained widespread acceptance among adults. The primary components of gummy include hydrocolloids as gelling agents, sweeteners, acids, flavourings, and colouring agents. Gelatine is commonly sourced from animals such as bovine, is often used due to halal food. Alternatively, pectin, a plant-based option, is available as a vegetarian substitute. Hydrocolloids, such as gelatine and pectin, are large molecules that disperse in water to form a three-dimensional gel network, which is crucial for the texture and rheology of the gummies (Li *et al.*, 2022). However, the incorporation of other hydrocolloids like gelatine and pectin can modify the texture, making the gummy less chewy and more brittle (Renaldi *et al.*, 2022).

In recent times, nutritional gummies formulated for children with their specific doses of bioactive compounds and nutrients that contain vitamins, antioxidants, iron, calcium, and other essential supplements. One such functional ingredient is the butterfly pea flower (*Clitoria ternatea*), known for its vibrant colour and health benefits, particularly its antioxidant and anti-inflammatory properties (Grétarsdóttir, 2019). Native to Malaysia, the butterfly pea is a perennial vine species belonging to the plant family Fabaceae and growing well in neutral, moist soil (Jamil, 2018).

Rich in anthocyanins, the butterfly pea flower serves as a natural colorant and offers significant health benefits, including antioxidant protection, anti-aging effects, and support for eye health. Additionally, the flower is a good source of essential minerals like calcium, magnesium, and potassium, which are crucial for bone health and muscle function. Experimental findings suggest that butterfly pea is rich in antioxidant properties, compared with many other flowers and medicinal plants. In addition, butterfly pea has demonstrated promising antioxidant, antidiabetic, and hepatoprotective properties.

Despite increasing interest in functional confectionery products, limited studies have examined the combined effects of gelatine-pectin systems in anthocyanin-rich butterfly pea gummies. Furthermore, few reports have systematically linked instrumental texture measurements with sensory perception in such formulations. In addition, data on the retention of phenolic compounds and antioxidant activity after thermal gummy processing remain scarce. Therefore, this study investigates the influence of different gelling systems (10%

gelatine versus 9% gelatine + 1% pectin) on the physicochemical, sensory, and antioxidant properties of butterfly pea-fortified gummies.

2. Materials and Methods

Dried butterfly pea flowers, gelatine, pectin, citric acid, sodium benzoate, and castor sugar were obtained from Bake with Yen, a local Malaysian bakery market. Monin's agave syrup, primarily composed of fructose, was sourced from France, while dragon fruit extract powder was procured from Bionutricia Holding Sdn Bhd, a Specialty Food (Nutraceutical), Beverage, and Traditional Plant (Herbs) company in Malaysia.

2.1 Extraction of Butterfly Pea Flowers

Dried butterfly pea flowers were soaked in deionized water at a ratio of 1:40 (w/v) to minimize contamination from the chemical and harmful substances. These treatments were followed by 5 g of dried butterfly pea powder mixed with 200 mL of water (Figure 1). The process started with soaking the treatment in 200 mL of water for 20 minutes using the water bath at 90 °C (Karel, 2018).

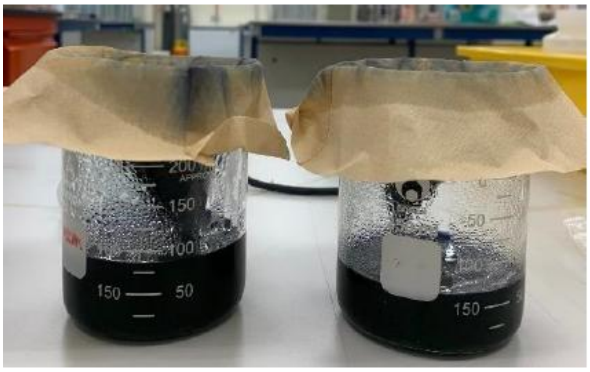

Figure 1. Butterfly pea extract

2.2 Preparation of Butterfly Pea Gummy

This formulation of producing butterfly pea-fortified gummies is shown in Table 1. It comprises the formulation in percentages, of butterfly pea extract, gelling agent, sweetener, citric acid, flavouring extract powder, sodium benzoate, and water.

Table 1. Formulation of butterfly pea-fortified gummies.

Ingredients	Formulations		
	Control	**1**	**2**
Butterfly pea extract	-	20	20
Agave syrup	25	25	25
Sucrose	15	15	15
Gelatine	10	10	9
Pectin	-	-	1
Citric acid	1	1	1
Extract powder	-	10	10
Sodium benzoate	0.15	0.15	0.15
Water	48.85	48.85	48.85

The main difference between the two formulations is the types of gelling used. The substitution of 1% pectin in place of gelatine was selected to evaluate the influence of partial hydrocolloid replacement on gel structure while maintaining comparable total gelling agent concentration (10%). Even minor modifications in hydrocolloid composition are known to significantly alter gel network formation, elasticity, and texture due to differences in molecular interactions and cross-linking mechanisms. This design allowed assessment of the synergistic interaction between gelatine and pectin without substantially changing the total solid content of the formulation. 10% of gelatine is used in formulation 1, which creates a chewy and elastic texture, while formulation 2 uses the combination of 9% gelatine with 1% pectin, whereas pectin is plant-based, that more suitable for vegans. Both formulations shared similar ingredients, but formulation 1 offers better stability and broader consumer appeal.

Gummy production involved a combination of sweeteners (fructose and sucrose) with water, dragon fruit extract powder, sodium benzoate, and citric acid. Separately, the gelling agent (gelatine or pectin) was mixed with butterfly pea extract, bloomed, melted, and combined with the sweetener mixture. Citric acid was added to both mixtures. The final product was poured into moulds, cooled, and refrigerated.

2.3 Sensory Evaluation

Sensory evaluation was conducted with 50 untrained panellists aged 18 to 26 years. Approximately 2 g (one piece) of each gummy sample was served at 24 ± 0.5 °C using randomized three-digit codes. Panellists evaluated colour, aroma, flavour, texture, and overall acceptability using a nine-point hedonic scale (1 = dislike extremely; 9 = like extremely). Participation was voluntary, and informed consent was obtained from all panellists prior to evaluation. Data were analysed using one-way ANOVA followed by Tukey's post hoc test at a significance level of $p < 0.05$.

2.4 Texture Profile Analysis (TPA)

Texture Profile Analysis (TPA) was performed using a TA-XT2i Texture Analyzer (Stable Micro Systems, Surrey, England) following standard double-compression methodology as described by Bourne (2002). Gummy samples (approximately 10 mm height × 15 mm diameter) were compressed to 50% of their original height using a TA3/1000 probe at a speed of 2 mm/s with a 10 g trigger force and a 5-second interval between compressions. Firmness (g) was defined as the maximum force required during the first compression cycle of the TPA test. Springiness was calculated as the ratio of the recovered height during the second compression to the original height and expressed as a percentage (%). Firmness (g) and springiness (%) were recorded. All measurements were performed in triplicate.

2.5 Colour Analysis

Colour measurements were performed using a calibrated colorimeter operating in the CIELAB colour space (L*, a*, b*). Measurements were conducted according to standard colour evaluation procedures described by Giusti *et al.* (2024). Each sample was measured in triplicate, and results were expressed as mean ± standard deviation.

2.6 pH value

pH was determined using a calibrated digital pH meter following AOAC Official Method 981.12. A 2.5 g sample was homogenized in 50 mL distilled water, filtered, and measured at ambient temperature. Analyses were conducted in triplicate.

2.7 Moisture analysis

Moisture content was determined using a moisture analyser (A&D MX-50) following AOAC Official Method 925.10 (loss-on-drying method). Approximately 1 g of crushed sample was heated at 140 °C until constant weight was achieved. Analyses were performed in triplicate.

2.8 Total phenolic content

The total phenolic content (TPC) of the butterfly pea-fortified gummies was determined using the Folin-Ciocalteu method (Vojvodić Cebin, 2024). A volume of 0.4 mL of the extract was mixed with 2 mL of Folin-Ciocalteu reagent and 1.6 mL of 7.5% (w/v) sodium carbonate. After allowing the mixture to rest for 45 minutes in the dark, the absorbance value was measured at 765 nm. The TPC was calculated from a calibration curve using gallic acid as the standard, and the results were expressed as mg gallic acid equivalents (GAE)/g dry weight (Singleton *et al.*, 1999).

2.9 Antioxidant activity (DPPH)

The antioxidant capacity of *Clitoria ternatea* (butterfly pea) extracts and the best gummy was measured using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay. The DPPH assay is a widely used method to evaluate the antioxidant capacity of various samples. The DPPH assay is a common method for measuring antioxidant capacity. A 0.01 mM DPPH solution in ethanol is mixed with the sample or extract in a 96-well plate and incubated in the dark for 30 minutes. The assay measures the reduction of the DPPH radical, indicated by a colour change from violet to yellow or colourless, using spectrophotometry at 515 nm using the VersaMax Elisa Microplate Ready (Molecular Devices, LLC). Antioxidant activity is expressed as a percent inhibition relative to a control, with ascorbic acid used as a standard for comparison. This process quantifies the sample's ability to neutralize free radicals, thus revealing its antioxidant potential (Renaldi, 2022).

2.10 Proximate analysis

The best formulation identified through sensory evaluation will subsequently be subjected to proximate analysis to determine the contents of fat, ash, carbohydrates, and energy. Fat content was measured using the Soxhlet extraction method, where a solvent, such as hexane, extracted the fat, which was then quantified after the solvent had evaporated. Ash content was determined by incinerating the sample in a muffle furnace at high temperatures until only inorganic residues remained. Carbohydrates were calculated by difference, subtracting the sum of moisture, protein, fat, and ash from the total weight. Energy content was estimated using the Atwater factors, which assign specific caloric values to protein, fat, and carbohydrates. The measurements were conducted in triplicate, and the results were presented as means with standard deviations.

3. Results

3.1. Hedonic Evaluation

The hedonic scores for the sensory attributes are presented in Table 2 and illustrated in Figure 2. Significant differences ($p < 0.05$) were observed for appearance, sweetness, and overall acceptance. Formulation 1 recorded a higher appearance score (8.35 ± 1.09) compared to Formulation 2 (8.15 ± 1.20). Formulation 2 showed a higher sweetness score (7.07 ± 1.80) than Formulation 1 (6.55 ± 1.76). The overall acceptance score was also higher for Formulation 2 (7.55 ± 2.06) compared to Formulation 1 (7.09 ± 1.47). No significant differences ($p > 0.05$) were observed for colour, odour, taste, hardness, chewiness, and aftertaste.

Table 1. Hedonic scores of butterfly pea-fortified gummies

Sensory attributes	Formulation 1	Formulation 2	P-value
Appearance	8.35 ± 1.09^{a}	8.15 ± 1.20^{b}	0.026
Colour	7.78 ± 1.47^{a}	7.98 ± 1.41^{a}	0.231
Odour	6.31 ± 1.90^{a}	6.55 ± 1.97^{a}	0.189
Taste	7.00 ± 1.43^{a}	7.36 ± 2.16^{a}	0.063
Sweetness	6.55 ± 1.76^{b}	7.07 ± 1.80^{a}	0.008
Hardness	6.40 ± 2.25^{a}	6.55 ± 2.19^{a}	0.498
Chewiness	6.51 ± 2.06^{a}	6.85 ± 2.11^{a}	0.138
Aftertaste	7.09 ± 1.59^{a}	7.25 ± 1.57^{a}	0.339
Overall acceptance	7.09 ± 1.47^{b}	7.55 ± 2.06^{a}	0.007

*Different superscript letters within the same row indicate significant differences based on paired t-test ($p < 0.05$).

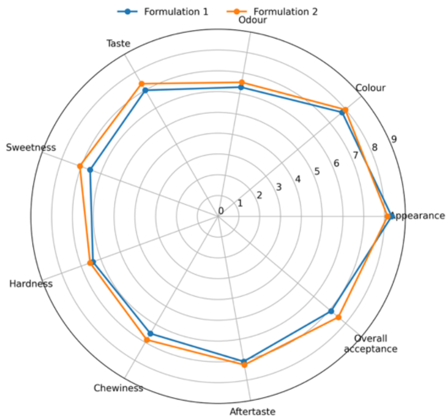

Figure 1. Radar plot of mean hedonic scores for butterfly pea-fortified gummies prepared with different gelling formulation: Formulation 1 (10% gelatine) and Formulation 1 (9% gelatine + 1% pectin).

3.2. Texture Profile Analysis (TPA)

The texture profile analysis results are presented in Table 3, while the experimental setup and gummy samples are shown in Figure 3. Formulation 1 exhibited higher firmness (610.30 ± 22.79 g) compared to Formulation 2 (357.37 ± 19.01 g). Conversely, Formulation 2 showed higher springiness (60.58 ± 3.09%) than Formulation 1 (55.14 ± 0.40%).

Table 2. Texture profile analysis (TPA) results showing firmness (g) and springiness (%) of butterfly pea-fortified gummies.

Samples	Firmness (g)	Springiness (%)
Formulation 1	610.30 ± 22.79	55.14 ± 0.40
Formulation 2	357.37 ± 19.01	60.58 ± 3.09

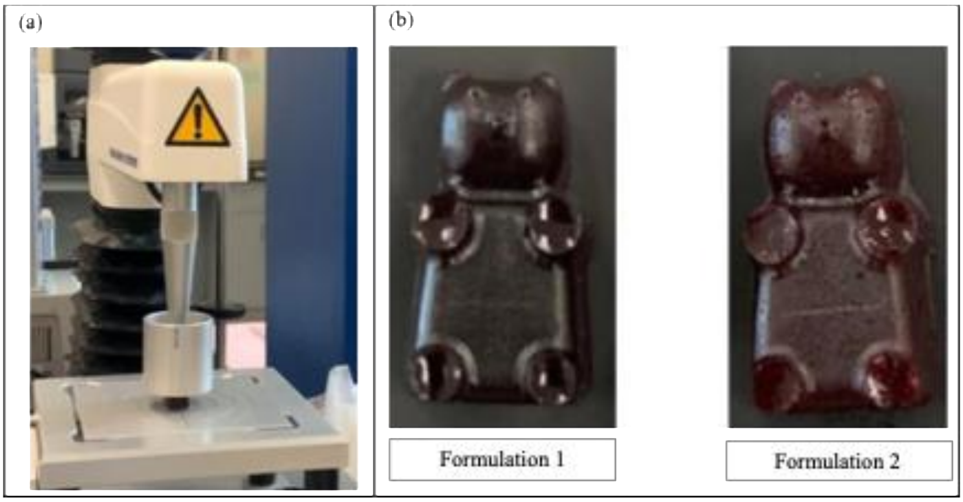

Figure 2. (a) Texture analyser (b) Image of butterfly pea-fortified gummies

3.3. Colour Analysis

The colour parameters of butterfly pea extract and gummy samples are shown in Table 4. The gummy exhibited higher L* values (9.60 ± 0.80) compared to the extract (0.18 ± 0.01). Similarly, higher a* (27.23 ± 3.03 vs 19.58 ± 3.27) and b* values (37.50 ± 3.54 vs 7.47 ± 1.83) were observed in the gummy compared to the extract.

Table 3. The colour parameters (L*, a*, b*) of extraction and gummies

Samples	Colour parameters		
	L*	***a****	***b****
Butterfly pea extraction	0.18 ± 0.01	19.58 ± 3.27	7.47 ± 1.83
Butterfly pea-fortified gummies	9.60 ± 0.80	27.23 ± 3.03	37.50 ± 3.54

3.4. pH and Moisture Content

The pH and moisture content are presented in Table 5. The moisture content of the gummy was 33.76 ± 0.06%, while the pH was 3.53 ± 0.01.

Table 4. pH and the moisture content of butterfly pea-fortified gummies.

Sample	pH value	Moisture content (%)
Butterfly pea-fortified gummies	3.53 ± 0.01	33.76 ± 0.06

3.5. Total Phenolic Content (TPC) and Antioxidant Activity (DPPH)

The TPC and DPPH radical scavenging activity are presented in Table 6. The gummy showed a TPC value of 33.95 mg GAE/g dry weight and antioxidant activity of 22.52 ± 0.80%.

Table 5. The total phenolic content and antioxidant capacity of butterfly pea-fortified gummies

Sample	Total phenolic content (mg GAE/ g dry weight)	Antioxidant activity (%)
Butterfly pea-fortified gummies	33.95 ± 2.31	22.52 ± 0.80

3.6. Proximate Analysis

The proximate composition is presented in Table 7. The butterfly pea gummy contained 59.64 g/100 g carbohydrates and provided 261.29 kcal/100 g. Protein content was 5.68 g/100 g, while ash content was 0.91 g/100 g. No fat was detected.

Table 6. Proximate analysis of butterfly pea-fortified gummies.

Sample	Ash (g/100 g)	Fat (g/100 g)	Protein (g/100 g)	Carbohydrate (g/100 g)	Energy (Kcal/100 g)
Butterfly pea-fortified gummies	0.91 ± 0.02	0.00 ± 0.00	5.68 ± 0.02	59.64 ± 0.05	261.29 ± 0.13

4. Discussion

4.1. Hedonic Evaluation

Formulation 1 received a significantly higher score for appearance (8.35 ± 1.09) compared to Formulation 2 (8.15 ± 1.20), indicating that the gelatin-only formulation provided a slightly more visually appealing product. In contrast, Formulation 2 obtained a significantly higher sweetness score (7.07 ± 1.80) than Formulation 1 (6.55 ± 1.76), suggesting that the inclusion of pectin may have enhanced perceived sweetness.

Most notably, overall acceptance was significantly higher for Formulation 2 (7.55 ± 2.06) compared to Formulation 1 (7.09 ± 1.47), indicating greater consumer preference for the gelatine-pectin formulation. No significant differences were observed between formulations for colour, odour, taste, hardness, chewiness, or aftertaste ($p > 0.05$). Although numerical variations were present, these differences were not statistically significant at the 95% confidence level. Overall, the results suggest that while both formulations exhibited comparable sensory characteristics across most attributes, the incorporation of pectin in Formulation 2 positively influenced sweetness perception and overall consumer acceptance.

4.2 Texture Profile Analysis (TPA)

The higher firmness of Formulation 1 is consistent with the slightly higher sensory hardness scores observed for Formulation 1 in Section 4.1, although the difference was not statistically significant. This agrees with the established role of gelatine in forming a strong, elastic gel matrix because of its ability to form a triple-helix structure upon gelation. This gives rigidity to the gummies, making them thicker and firmer. Hence, these properties are suitable for a chewy gummy texture. The addition of pectin probably caused the lower firmness observed in Formulation 2. Under acidic conditions, pectin forms a more brittle, softer gel matrix through hydrogen bonding and ionic cross-linking. Such a combination with gelatine may weaken the gel structure, leading to reduced firmness and increased flexibility. This finding agrees with previous observations showing that pectin addition reduced hardness and chewiness in gelatine-based gummies (Angriani, 2019). Similarly, Renaldi (2022) reported that the incorporation of pectin significantly reduced firmness and gumminess in gelatine-based gummy formulations.

The higher springiness observed in Formulation 2 suggests is consistent with the slightly higher sensory chewiness scores reported for Formulation 2 in Section 4.1, although no significant difference was observed in the sensory evaluation. Springiness was calculated as the ratio of recovered height during the second compression cycle to the original height and is expressed as a percentage (%). This may be attributed to the interaction between gelatine and pectin, which can create a more elastic gel matrix that allows the gummy to recover its original shape after deformation (Hani, 2014). Such flexibility and resilience are desirable characteristics that contribute to consumer perception of gummy texture. Overall, these results highlight the complementary roles of gelatine and pectin in gummy formulations, where gelatine contributes to structural strength while pectin enhances elasticity and softness.

4.3 Colour Analysis

The increase in L*, a*, and b* values in the gummy compared to the extract indicates that processing and formulation influenced colour characteristics. This colour difference is related to several factors occurring during the gummy production process. The addition of citric acid in both the sweetener mixture and gelling system likely influenced the structural stability of anthocyanins, which are responsible for the blue-purple colour of butterfly pea extract. Under acidic conditions, anthocyanins shift toward flavylium cation forms, resulting in increased redness at lower pH values. This pH-induced transformation may explain the increase in the a* value and the decrease in the b* value observed in the gummy compared to the extract (Sutharut and Sudarat, 2012).

Anthocyanins are natural pigments commonly found in plants, responsible for colours like pink, red, purple, blue, and yellow (Khoo et al., 2017). They have an aromatic ring structure with a polar component and a glycosyl residue, making them soluble in water (Adam, 2015). The anthocyanins from the extract can further interact in the gummy mix itself, for example, with other formulation components such as the dragon fruit extract, agave syrup, sucrose, and even the gelling agents themselves. These could be a set of complex reactions, which might affect structural and colour modifications in anthocyanin pigments.

Colour analysis, therefore, shows that upon incorporation into the gummy matrix, there is a great change in the colour characteristics of the butterfly pea extract. Most probably, this is due to the combined pH effects and interactions with other ingredients during the gummy production process; the gummy was darker and redder compared to the extract.

4.4 pH and Moisture Analysis

The moisture content was measured in the butterfly pea-fortified gummies to understand how processing and formulation could affect such content. The moisture content is directly related to the shelf life of food products. A high moisture content encourages microbial growth, such as bacteria and molds, which may cause spoilage. Besides, moisture can accelerate chemical reactions like oxidation and enzymatic processes, leading to changes in flavour, colour, and nutritional quality.

Based on Table 5, the result of moisture content in gummy was determined to be 33.76 ± 0.06% in triplicate, indicating low deviation and high consistency of the measurement. This observed moisture content was also remarkably higher than the typical moisture range reported for commercial gummy confections (approximately 15 to 25%) (Gunes *et al.*, 2022; Grétarsdóttir, 2019). Higher moisture content provides a softer texture, while lower moisture content results in a harder jelly that has a greater shelf life. Drying plays a crucial role in moisture reduction and increasing the solids content, which may lead to increased hardness and modifications in other textural properties (Gunes *et al.*, 2022). The relatively high moisture content observed in this study suggests that the gummy is likely soft and chewable, which may be desirable for certain consumer preferences. Further optimization may, however, be necessary in terms of moisture content to ensure product stability and microbial safety for a longer period.

The butterfly pea gummy recorded a pH value of 3.53 ± 0.01, which falls within the acidic range. This value is comparable to previously reported pH values for gelatine- and pectin-based gummy products, which typically range between 3.0 and 4.0 depending on acid concentration and formulation (Renaldi *et al.*, 2022; Vojvodić Cebin *et al.*, 2024). Similar pH values have been associated with improved anthocyanin stability and enhanced microbial safety in gel-based confectionery systems. Such acidity is desirable in gummy products as it enhances the sensory profile by providing a mild tartness that balances the sweetness, contributing to a more refreshing taste. In addition, maintaining a pH around 3.5 plays an important role in stabilizing anthocyanin pigments from butterfly pea, which are highly sensitive to pH changes and may shift in hue depending on the environment. A pH below 4.0 is generally associated with reduced microbial growth in confectionery systems. However, microbiological and water activity analyses were not conducted in this study; therefore, conclusions regarding microbial stability or shelf-life extension cannot be confirmed.

4.5 Total Phenolic Content and Antioxidant Activity (DPPH)

Based on Table 6, the butterfly pea-fortified gummies demonstrated a total phenolic content (TPC) of 33.95 mg GAE/ g dry weight and an antioxidant activity of 22.52 ± 0.80 %. The presence of phenolic compounds is particularly significant, as they are well known for their health-promoting properties, including free radical scavenging, anti-inflammatory, and anti-aging effects (Prior *et al.*, 2005). Phenolic compounds from butterfly pea (*Clitoria ternatea*) are largely attributed to anthocyanins, specifically ternatins, which contribute not only to the vivid blue-purple coloration but also to the antioxidant capacity of the product (Sutharut and Sudarat, 2012).

The antioxidant activity observed in the gummy suggests that the bioactive compounds were retained even after processing into a gel matrix, making it an appealing choice for consumers seeking health-oriented confectionery. Similar findings have been reported in studies where anthocyanin-rich extracts incorporated into gummy formulations preserved considerable antioxidant potential (Panche *et al.*, 2016). Therefore, the combination of appreciable TPC and antioxidant activity indicates that butterfly pea gummy has both nutritional and functional benefits, supporting its potential as a novel functional food product.

4.6 Proximate Analysis

The proximate composition results in Table 7 revealed that the butterfly pea-fortified gummies contained 59.64 g/100 g carbohydrates and provided 261.29 kcal/100 g, which was significantly lower than the energy values of Commercial A (338 kcal/100 g) and Commercial C (375 kcal/100 g), though slightly higher than Commercial B (209 kcal/100 g). This reduction in caloric contribution can be attributed to the balanced use of sucrose and light corn syrup in the formulation, as well as the absence of additional glucose syrup or fruit juice concentrates commonly found in commercial product. The absence of fat across all samples, including the butterfly pea gummy, is consistent with the water-based nature of gummy formulations, where hydrocolloids such as gelatine or pectin provide texture rather than lipid-based ingredients. Interestingly, the butterfly pea gummy exhibited a measurable protein content (5.68 g/100 g), which was absent in commercial counterparts; this is likely derived from gelatine, a protein-rich gelling agent, highlighting the contribution of formulation components to nutritional value. The ash content (0.91 g/100 g) also indicates the presence of minerals from both chamomile infusion and butterfly pea flower extract, which may enhance the functional appeal of the product. Meanwhile, the carbohydrate level of commercial gummies, particularly Brands A and B (84 g/100 g), was substantially higher, reflecting their reliance on sugar and glucose syrup as primary bulking agents, which contributes to higher caloric density but minimal additional nutrients.

The incorporation of butterfly pea extract is of particular importance, as it not only imparts natural colour through anthocyanins but also provides antioxidant activity that could add functional benefits beyond basic nutrition. Taken together, the results suggest that butterfly pea gummies can serve as a healthier and functional alternative to conventional gummies, addressing consumer demand for reduced-sugar, plant-based, and nutritionally enhanced confectionery products. The proximate composition values obtained in this study are comparable to those reported for gelatine- and pectin-based gummy products in previous literature. Renaldi *et al.* (2022) reported carbohydrate contents ranging between 60 to 85 g/100 g in commercial gummy formulations, depending on the proportion of sugar and glucose syrup used. Similarly, Vojvodić Cebin *et al.* (2024) observed energy values between 250–380 kcal/100 g in fortified gummy candies. The carbohydrate and energy values of the butterfly pea gummy in the present study fall within the lower range of these reported values, likely due to controlled sweetener composition and absence of additional glucose syrup.

5. Conclusions

The findings of this study highlight the potential of butterfly pea extract as a functional ingredient in gummy formulations. The choice of gelling agents influenced the textural and sensory characteristics of the gummies. The gelatine-only formulation produced a firmer structure, while the gelatine-pectin combination resulted in a softer and more elastic texture. The butterfly pea gummies exhibited favourable physicochemical properties, including an acidic pH that may contribute to pigment stability and microbial safety, although the relatively high moisture content suggests that further optimisation may be required to improve shelf life. In addition to acceptable sensory characteristics, the gummies retained measurable levels of phenolic compounds and antioxidant activity after processing, indicating the potential functional benefits of incorporating butterfly pea extract. The proximate composition also suggests that the product provides a moderate energy value relative to typical confectionery products. Overall, these results demonstrate that butterfly pea gummies have potential for development as a novel functional confectionery product combining desirable sensory properties with nutritional and antioxidant attributes.

Author Contributions: Conceptualization, Nur Izzaty Izlan and Aida Safina Aridi; methodology, validation, formal analysis, investigation, data curation, writing—original draft preparation, Nur Izzaty Izlan; writing—review and editing, Aida Safina Aridi and Faridatul Ain Mohd Rosdan; supervision, Aida Safina Aridi; co-supervision, Siti Aishah Baharuddin; project administration, Aida Safina Aridi; conceptual input and idea contribution, Aida Safina Aridi and Fara Jasseica Mohd Rashid.

Funding: This work was funded by the Multi-Disciplinary Research Grant (MDR) with grant vote number Q768.

Acknowledgments: The authors would like to express their sincere gratitude to Universiti Tun Hussein Onn Malaysia for providing the facilities and support, and to Miwa Manufacturing Sdn. Bhd. for their valuable contribution.

Conflicts of Interest: The authors declare no conflict of interest.

References

Adam, P. (2015). Anthocyanins: Pigments responsible for the vibrant colors in plants. *Journal of Plant Sciences, 12*(3), 45–52.

Angriani, L. (2019). Potensi ekstrak bunga telang (*Clitoria ternatea*) sebagai pewarna alami lokal pada berbagai industri pangan. *Canrea Journal: Food Technology, Nutritions, and Culinary Journal, 2*(1), 32–37.

Bourne, M. C. (2002). Food texture and viscosity: Concept and measurement (2nd ed.). Academic Press.

Giusti, M. M., Gordillo, B., & González-Miret, M. L. (2024). Color analysis. In B. P. Ismail & S. S. Nielsen (Eds.), *Nielsen's food analysis* (6th ed., pp. 509–522). Springer. https://doi.org/10.1007/978-3-031-50643-7_31

Grétarsdóttir, S. (2019). Nutritional gummies for children: Formulation and benefits. *Journal of Nutritional Science, 8*(2), 123–130.

Gunes, R., Palabiyik, I., Konar, N., *et al.* (2022). Soft confectionery products: Quality parameters, interactions with processing and ingredients. *Food Chemistry, 385*, 132735.

Hani, U., Shivakumar, H. G., & Osmani, R. A. M. (2014). Solubility enhancement and delivery systems of curcumin, an herbal medicine: A review. *Current Drug Delivery, 11*(6), 792–804.

Jamil, N., Mohd Zairi, M. N., Mohd Nasim, N. A., *et al.* (2018). Influences of Environmental Conditions to Phytoconstituents in *Clitoria ternatea* (Butterfly Pea Flower) – A Review. *Journal of Science and Technology, 10*(2), 208–228. https://doi.org/10.30880/jst.2018.10.02.029

Karel, A., Kumar, H., & Chowdhary, B. (2018). *Clitoria ternatea* L. A Miraculous Plant. *International Journal of Current Microbiology and Applied Sciences, 7*(9), 672–674. https://doi.org/10.20546/ijcmas.2018.709.079

Khoo, H. E., Azlan, A., Tang, S. T., & Lim, S. M. (2017). Anthocyanidins and anthocyanins: Colored pigments as food, pharmaceutical ingredients, and the potential health benefits. Food & Nutrition Research, 61(1),

Li, Y., Zou, Y., Que, F., *et al.* (2022). Recent advances in fabrication of edible polymer oleogels for food applications. *Current Opinion in Food Science, 43*, 114–119. https://doi.org/10.1016/j.cofs.2021.11.007

Matulyte, I., Marksa, M., & Bernatoniene, J. (2021). Development of innovative chewable gel tablets containing nutmeg essential oil microcapsules and their physical properties evaluation. *Pharmaceutics, 13*(6), 873. https://doi.org/10.3390/pharmaceutics13060873

Meilgaard, M. C., Civille, G. V., & Carr, B. T. (2007). *Sensory evaluation techniques* (4th ed.). CRC Press. https://doi.org/10.1201/b16452

Nurhayati, R., Shoviantari, F., Munandar, T. E., *et al.* (2024). Butterfly Pea (*Clitoria ternatea* L.) Flower Water and Ethanol Extract: Phytochemical Screening, FTIR Analysis, and Antioxidant Activity Estimation using comparison of ABTS, DPPH, and FRAP Assays. *Research Journal of Pharmacy and Technology, 17*(5), 1973–1982. https://doi.org/10.52711/0974-360X.2024.00313

Panche, A. N., Diwan, A. D., & Chandra, S. R. (2016). Flavonoids: An overview. *Journal of Nutritional Science, 5*, e47. https://doi.org/10.1017/jns.2016.41

Prior, R. L., Wu, X., & Schaich, K. (2005). Standardized methods for the determination of antioxidant capacity and phenolics in foods and dietary supplements. *Journal of Agricultural and Food Chemistry, 53*(10), 4290–4302.

Renaldi, G., Junsara, K., Jannu, T., *et al.* (2022). Physicochemical, textural, and sensory qualities of pectin/gelatin gummy jelly incorporated with *Garcinia atroviridis* and its consumer acceptability. *International Journal of Gastronomy and Food Science, 28*, 100505. https://doi.org/10.1016/j.ijgfs.2022.100505

Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. *Methods in Enzymology, 299*, 152–178. https://doi.org/10.1016/S0076-6879(99)99017-1

Sutharut, J., & Sudarat, J. (2012). Total anthocyanin content and antioxidant activity of germinated colored rice. *International Food Research Journal, 19*(1), 215–221.

Vojvodić Cebin, A., Bunić, M., Mandura Jarić, A., *et al.* (2024). Physicochemical and sensory stability evaluation of gummy candies fortified with mountain germander extract and prebiotics. *Polymers, 16*(2), 259. https://doi.org/10.3390/polym16020259