International Journal of Chemical and Biochemical Sciences
(ISSN 2226-9614)

Journal Home page: www.iscientific.org/Journal.html

© International Scientific Organization

Development and characterization of butterfly pea (*Clitoria ternatea* L.) flower juice from spray dried powder

Rejean Marie F. Darroca[1,2], Marilou J. Ang Lopez[1], Nguyen Minh Thuy[2,*], Tran Ngoc Giau[2], Hong Van Hao[2], Ngo Van Tai[3]

[1]*School of Technology, University of the Philippines Visayas, Miagao, Iloilo 5083, Philippines*

[2]*Department of Food Technology, Institute of Food and Biotechnology, Can Tho University, Can Tho, Vietnam*

[3]*School of Food Industry, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand*

Abstract

This study intended to use Butterfly pea (*Clitoria ternatea* L.) double petaloid in producing a powder used in formulating a stable, nutritious and antioxidant rich juice. The butterfly pea powder (BPP) was produced through spray drying and it had a recovery of 87.8%. The antioxidant activity of BPP ranged from 52.1 to 61.9% and its anthocyanin content was 24.0 mg/L. The physico-chemical analysis of the BPP obtained a mean pH of 4.86, %TSS value of 29.2% and mean %TA of 0.023%. The proximate composition of BPP was 0.08% moisture content, 0.004% crude fat, 0.003% crude protein, 0.83% crude fiber, 0.58% crude ash and a total of 98.5% carbohydrates. Three formulations were used in the production of Butterfly pea juice (BPJ) with varying BPP content as follows: 0.01 g BPP/ml (BPJT1), 0.02 g BPP/ml (BPJT2) and 0.03 g/ml of water (BPJT3). The constant amounts of calamansi (*Citrofortunella microcarpa*) and sugar were used for all three formulations. It was observed that BPJT3 is the most preferred formulation. Kramer's test performed at the 5% level of significance showed a significant difference between the BPJ treatments. As for the overall acceptability of the three formulations, BPJT1 and BPJT2 were "liked moderately" while BPJT3 was "liked much". The Kruskal-Wallis test at α=0.05 showed no significant difference between the general acceptability of the formulas with a P-value of 0.099. The antioxidant activity of BPJ ranged from 46.4% to 50.1% and its anthocyanin content was 18.6 mg/L. The physicochemical analysis of butterfly pea juice (BPJ) obtained an average pH of 2.95, a %TSS value of 10.4% and a mean %TA of 0.029%.

Keywords: foam-mat drying, foaming agents, drying temperatures, chemico-physical properties, optimization

Full length article **Corresponding Author*, e-mail: nmthuy@ctu.edu.vn Doi # https://doi.org/10.62877/41-IJCBS-24-25-19-41

1. Introduction

Butterfly pea (*Clitoria ternatea* L.) double petaloid blue is a vine with bright blue flowers that is quite abundant in the rural mountainous areas of the Philippines. It has not widely utilized in the country, but it is currently gaining popularity in the food industry. Products appearing in the market utilizing the petals include freshly made juice, ice cream, and salads. It is also being fried and consumed in some households. In other Asian countries, butterfly pea flower (BPF) has long been used in the food industry. A sticky rice dessert in Malaysia known as *Pulut Tai Tai* uses the dried butterfly pea as a blue colorant [1]. A drink commonly sold as street food in Thailand named *namdokanchan* also uses BPF. The BPF has a cooling taste [2]. The petals alone are dipped in batter and fried in Thailand and Burma [3]. BPF is considered as a medicinal plant that boosts or enhances neurological health [4]. The bright blue color of BPF is due to its anthocyanin pigment. The plural aromatic acyl residues (p-coumaroyl, caffeoyl, feruoloyl) in anthocyanins, polyacylated anthocyanin, exhibits a blue color as a result of intramolecular stacking [5]. The petals of blue flowers contain aromatically acylated delphinidin derivatives. In BPF, the color is due to the accumulation of polyacylated anthocyanins, ternatin A1, and it is the loss of acyl groups that directs change from blue to mauve color, lacking substitutions at both 3′- and 5′-positions in the ternatins. In the mauve petal line, the flavonoid component is delphinidin 3-*O*-(2″-*O*-α-rhamnosyl-6″-*O*-malonyl)-β-glucoside while there are ternatins (3′,5′-disubstituted polyacylanthocyanins) in the blue petal lines. In producing the blue color in the

butterfly pea petals, the critical step is the glucosylation at the 3′- and 5′-positions of anthocyanin [6]. Thuy *et al.* [7] reported that five anthocyanins to be identified in BPF extract, including delphinidin-3-(6”-p-coumaroyl)-rutinoside, cyanidin 3-(6”-p-coumaroyl)-rutinoside, delphinidin-3-(p-coumaroyl) glucose in both *cis* and *trans* isomers, cyanidin-3-(p-coumaroyl-glucoside) and delphinidin-3-pyranoside. The utilization of BPF as food is only limited to its availability upon harvest and there is no sufficient supply for production year-round. One way of preserving the shelf life of the petals, to make it readily available for consumption, is to prolong its quality through drying and powderization. The most common method to produce powders in the food and pharmaceutical industries is spray drying [8]. It is a process that includes converting a liquid or slurry feed into a dry powder by atomization in a drying chamber where hot air is mixed into the resulting spray and the liquid is evaporated while the dried particles remain [9]. Identification of the anthocyanin content of butterfly pea and how blanching and drying pretreatments could affect its stability is important to food production that utilizes BPF. Spray drying offers a very flexible control over powder particle properties such as density, size, flow characteristics and moisture content while other drying methods using ovens, freeze dryers and rotary evaporators produce materials that require further processing such as grinding and filtering which may lead to production of particles with irregular size and shape [10]. The main objective of this study was to process BPF through spray drying and utilize the butterfly pea powder (BPP) for juice production. The study focused on determining the antioxidant activity, anthocyanin content, physico-chemical characteristics, and proximate composition of the produced butterfly pea powder.

2. Materials and methods

2.1 Samples collection

Samples were collected around Iloilo, Philippines-Oton, Lapaz, City Proper, and Pavia. The study was conducted at the University of the Philippines Visayas, Miagao Campus– School of Technology (SOTECH) Analytical Laboratory (AL) and Food Preparation Laboratory (FPL), College of Arts and Sciences (CAS) Chemistry Laboratory,- and the Department of Science and Technology Food Innovation Center Guimaras State College (GSC), Mosqueda Campus, Guimaras, Iloilo and Can Tho University.

2.2 Design of the study

Since spray drying was applied into the butterfly pea petals, the study was divided into two phases. Phase I had a descriptive design, which included the production and characterization of powder obtained from spray drying (Figure 1). Phase II had an experimental design of Randomized Complete Block Design (RCBD) consisted of the formulation and analysis of butterfly pea juice (BPJ) (Figure 2).

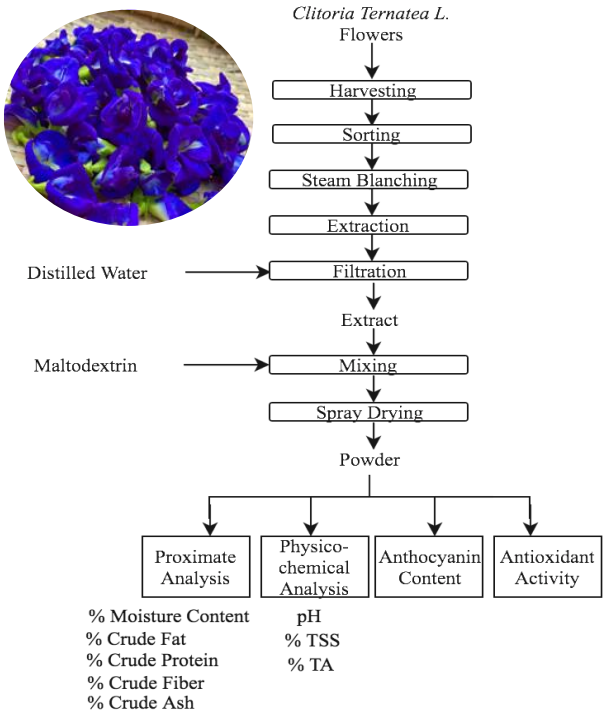

Figure 1. Schematic Diagram of Phase I: Production and characterization of spray dried BPP

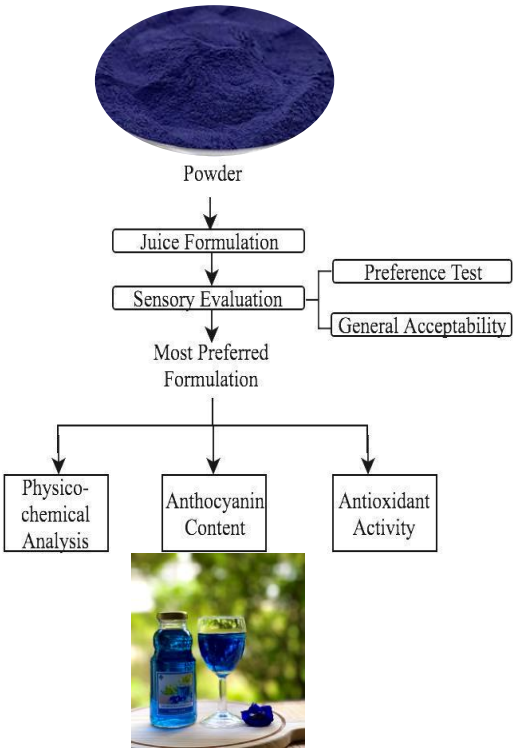

Figure 2. Schematic Diagram for Phase II: Formulation and analysis of BPJ from spray dried powder

2.2.1 Phase I: Butterfly pea powder production

Harvesting of BPF: the BPF were randomly collected in terms of date, time, and harvesting method in the four areas within Iloilo-Oton, Lapaz, Pavia and City Proper. Only blue double petaloid variety was collected. It was picked during the morning in full-bloom and immediately stored in a thermochest to retain moisture and maintain low temperature conditions. It is also done to prevent wilting, avoid light exposure and maintain the freshness of the plant.

Sorting of BPF: the individual flowers were selected and de-stemmed so that the petals alone were obtained. The qualities of the petals were checked, and only good quality petals were subjected to drying, which means that there was absence of cuts, bruises, and discoloration. Butterfly pea petals were assessed to meet quality parameters such as double petaloid blue, uniform size and color, in full bloom, and no signs of physical damage. After sorting, the petals were isolated from its sepals, stamen, and ovule (Figure 3). The petals alone were the main source of the anthocyanin extracted for powder production.

Steam blanching: steam blanching method was applied to retain the color of the petals and inactivate enzymes. First, water was boiled in a pot then the butterfly pea petals were placed in a steamer basket and the basket was positioned 2-3 inches above the boiling water in a pot. Steam blanching was carried out for 4-6 minutes.

Extraction: the blanched petals were homogenized using a Westinghouse Food Processor to increase the surface area and maximize the extraction and distilled water was added in a 1:4 w/v ratio. The extract was obtained after homogenizing and filtering the butterfly pea petals. The extraction process was very crucial since full utilization of the anthocyanin content in the flower petals must be done to produce powder with optimum quality.

Filtration: cheesecloth was used to strain the liquid. To ensure that there are no particles included in the mixture that would damage the spray drier, the filtrate was passed into a 60-mesh sieve.

Microencapsulation: Maltodextrin (Dongxiao Biotechnology Co. Ltd.) was the carrier added to the extract with 30% concentration and it was agitated to ensure homogeneity. After extraction, the Pearson square method was used to determine the amount of maltodextrin to be added in the extract to achieve the desired concentration. A total of 2257.21 grams was mixed with the extract. The mixture was then passed through the 60-mesh sieve again to avoid particles that were not dissolved to interfere with the spray drying process.

Spray Drying: A spray dryer fabricated by Roll Master Machinery and Industrial Services Corporation was used (Figure 4). The extract was poured in the feed stream of the spray dryer and the powder was obtained in the outlet stream of the equipment.

Figure 3. Butterfly pea flowers

Figure 4. Spray Drier

Packaging and storage: the powder was collected in an 8x13 inches plastic vacuum bag. It was then sealed using a mechanical sealer. The packed powder in the sealed vacuum bag was wrapped in a foil and stored in a dark area with ambient temperature.

Analysis of powder quality:

Moisture content was determined following the method of AOAC [11]. The Soxhlet method of AOAC [11] was used in determining fat content of the BPP. Crude protein was analyzed according to the Kjeldahl method [11]. For the digestion process, a digestion unit, Foss Digestor 2006, was used while for fast distillation, a distilling unit, Kjeltec 2100 was used. Crude fiber of the powder was determined using the gravimetric method [11]. Crude ash was determined according to the procedure of AOAC [11]. Incineration was done prior to ashing and it was placed in a Kenton SX-8-12 muffle furnace at 550°C. Carbohydrate was determined using the values obtained in the proximate analysis. The pH of the dissolved BPP (10 grams in 50 ml distilled water) was determined using an EutechCyberscan pH meter with RS232.Total soluble solids (%TSS) was determined using an Atago Hand Refractometer N-1E 0-32% Brix. Titratable acidity (%TA) was determined using the potentiometric method since the sample contains the anthocyanin pigment. Titration was used and the endpoint of pH 8.1 was determined using an EutechCyberscan pH meter with RS232. Anthocyanin content determination by the pH differential method. The extracting solution used in the BPP was ethanol and water at an 80:20 ratio based on the study of Thao *et al.* [12]. The solutions were analyzed using a Shimadzu UVmini-1240 UV-Vis Spectrophotometer with an absorbance value of 520 nm and 700 nm. Determination of antioxidant activity: 2-2-Diphenyl-1-picrylhydrezyl (DPPH) assay was used in determining the radical scavenging activity (RSA) of the BPP. The extracting solution used in the BPP was ethanol and water at an 80:20 ratio based on the study of Thao *et al.* [12].

2.2.2 Phase II: Utilization of Butterfly Pea Powder for Juice Preparation (BPJ)

The second phase followed an experimental design, particularly the RCBD, with the runs as blocks and treatments

as formulations. The powder was utilized in different concentrations in making the juice.The treatments contained butterfly pea powder in distilled water (g/ml), with Treatment 1 having 0.01 g/ml, Treatment 2 having 0.02 g/ml, and Treatment 3 having 0.03 g/ml. The amounts of sugar (115 g), fresh calamansi juice (60 mL) and distilled water (1000 mL) remained the same. The ingredients added are common ingredients used in making juice in the Philippines. The amount of ingredients in the formulations was based on an informal sensory evaluation in a preliminary run conducted with 15 panelists. The preference and acceptability of the BPJ was determined through sensory evaluation for 3 runs with 20 panelists per run. For sensory evaluation, the prepared BPJ were placed in coded cups and 20 trained panelists, who were able to take a sensory evaluation course, were invited to evaluate the samples. The preference rank and general acceptability of the juice were determined. Physico-chemical analysis, anthocyanin content and antioxidant activity of most preferred BPJ were determined (as described above).

2.3. Statistical Analysis

Color: the descriptive test for color was evaluated using a color scale and sensory evaluation with 20 panelists was conducted to determine the color of the BPP. *Kramer's Rank Sum Test*: Kramer's rank sum test was used to analyze the data for the rank sum for preference. A total of 3 runs were made with 20 panelists each. The critical value for rank totals table at the 5% level of significance was used to see if there is a significant difference among the treatments. Each cell in the tables had two pairs of values, the upper and lower pairs. According to Joanes [13] the upper pair of critical values gave the smallest and largest rank-sums such that the probability of any of the observed rank-sums being exceeded by the smaller value and exceeding the largest value is less than or equal to the specified level of significance. If any of the observed rank-sums is outside the range of upper pair of values, the samples may be significantly different. Meanwhile, the comparison with lower pair of values will reveal as to which of the samples is significantly superior or inferior to others in preference ranking [13].

***Kruskal-Wallis Test*:** the panelists were asked to determine the acceptability of the product through a nine-point hedonic scale. The Kruskal-Wallis test was applied to the general acceptability scores gathered from the evaluation. It was accomplished in three runs with 20 panelists per run. Kruskal-Wallis test at 0.05 significance level was applied.

3. Results and Discussions

3.1 Phase I Butterfly Pea Powder (BPP)

3.1.1. Blanching and Spray drying conditions

Butterfly pea extract was subjected to specified drying conditions with inlet and outlet temperatures of 200^{o}C and 85^{o}C, respectively. Prior to drying, butterfly pea petals were harvested, sorted, blanched, homogenized and extracted. The extract was mixed with a carrier, maltodextrin, and it was diluted in water to meet the minimum feed volume of the spray drier. The total weight of the petals used was 602 grams and the powder yield was 795 grams. The percent recovery after spray drying was 87.8% as shown in Table 1. The value was obtained by dividing the final weight with the initial weight of the feed multiplied to the total soluble solids value of the extract with added maltodextrin. In this study, steam blanching was applied for 4 minutes.

Table 1. Butterfly pea powder (BPP) production

Parameter	Value
Initial wt. of petals	602 g
Blanching time	4 minutes
Blanching temperature (Steam)	85°C
Initial volume of extract	342 ml
Volume wateradded	1905 ml
Volume of diluted extract	2240 ml
Volume of sieved diluted extract	2227 ml
Amount of maltodextrin added	894g
Volume of sieved diluted extract with maltodextrin	3101 ml
Volume after secondsieving	3079 ml
Yield	795g
Percent recovery	87.8%
Drying time	37 minutes

Blanching alters the color, taste, aroma, texture and nutritional value of a product and these alterations may be desirable or undesirable [14]. Enzyme activity leads to undesirable changes in the flower that may include deterioration, wilting, volume reduction and gas expulsion. Steam blanching was more effective since it was found to have greater nutrient retention than water blanching because water leaching out vitamins and minerals usually caused degradation of nutritional value, as heat would degrade the nutrients. By applying steam blanching, natural sugars were retained in the petals, its color was improved, and flavor was conserved. Thus, superior quality petals were produced.

Extraction was carried out after blanching and homogenizing the blanched petals. The yield of the extract

from the petals was 43.19%. In order to meet the minimum weight capacity of the spray dryer, distilled water was added to the extract with a ratio of 1:6 in order to obtain a feed volume of at least two liters. The extract maintained the distinct color of blanched petals. With the aid of steam blanching, it is assumed that maximum amount of the petal components was extracted especially its nutrients, natural sugars and flavor. During the process of spray drying, powder particles may stick to one another and to the drier walls, which may cause problems in the operation and probable reduction of product yield. In order to avoid this, a carrier or encapsulator, maltodextrin, was added to the extract. The carrier added had high molecular weight since its purpose was to increase the glass transition temperature of the feed mixture to combat stickiness. Stickiness is associated with high sugar and acid content of food since low molecular weight sugars (glucose and fructose) and organic acids (citric, malic and tartaric acid) have low glass transition temperature [9]. Addition of maltodextrin prevents the powder from sticking into the spray drier walls. A total of 30% was added to the extract based on the previous studies [15], which obtained optimum anthocyanin content, and antioxidant activity of powder containing that amount of maltodextrin. Also, the 30% maltodextrin contributed to the high percent recovery of the powder, so it was found to increase the overall yield [16]. The percentage of carrier agents incorporated ranges from 3% for watermelon juice powder to 40–64% for pomegranate juice powder [17, 18]. Maltodextrin content also affected the color of the powder.The color of BPP was evaluated based on the color scale in Figure 5, which fell within the range of 4 (dark bluish purple) to 6 (light bluish purple).

Maltodextrin was a white powder while the extract was a dark blue liquid. Upon drying, the color of the powder resulted to pale bluish purple. The maltodextrin concentration was found to affect the intensity of the color of BPP (**Figure 6**). Pranatri *et al.* [16] reported that the intensity of the color of BPP declined along with the increase of maltodextrin concentration from 15% to 30%.

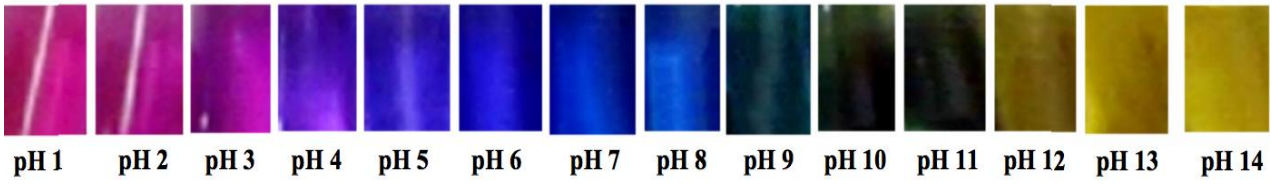

Figure 5. Color change of Butterfly pea extract at different pH levels [3]

Figure 6. Produced BPP with 30% maltodextrin

Table 2. Proximate composition of BPP

Moisture Content (%)	Crude Fat (%)	Protein (%)	Crude fiber (%)	Crude ash (%)	Carbohydrates (%)
0.08	0.004	0.027	0.83	0.58	98.5

Table 3. Physico-chemical characteristics of BPP and BPJ

Physico-chemical characteristics	BPP	BPJ
pH	4.86	2.95
Total soluble solids content	29.2%	10.4%
Titratable acidity	0.023%	0.029%

3.1.2 Proximate analysis

Table 2 shows the proximate composition of the spray dried BPP. The moisture content of BPP is 0.08%, it decreased significantly from the petals to the powder. The powder production involved extraction and addition of water to the pure extract at a 1:6 ratio however, the added water still evaporates throughout the drying process. The significant decrease in moisture content could be because of inlet temperature which was 200°C as moisture content is decreased with the increase in drying temperature. When the inlet air temperature is high, there is a faster heat transfer between the product and the drying air as there is a high temperature gradient between the feed and drying air [19], this could have caused the significant decrease in moisture content of the powder. The crude fat content of BPP is 0.004%. The value for crude fat decreased from the petals to the powder based on the results of Handoyo [20] and Deka *et al.* [21]. The petals alone already had a very little amount of fat and as it went through different operations before being produced into a powder, loss in the fat content was inevitable.

The crude protein content of BPP is 0.027%. A big decrease occurred from the value of protein in the petals and the powder. In the study of Deka *et al.* [21] butterfly pea flowers had 41.3% crude protein while in the study of Handoyo [20], the crude protein of the flowers was only 1.41%. In this study, a very small value for crude protein was obtained indicating a huge amount of loss throughout the process. The drying procedure affected the protein content of butterfly pea especially the high temperature leading to rampant protein denaturation and significant losses. External stresses triggered by thermal conditions, interfacial contacts and dehydration process lead to protein denaturation signified by losses of tertiary and secondary protein structures. When a protein is unfolded, the hydrophobically buried sites are exposed to the solvent and subsequently interact with interfaces and other unfolded polypeptides wherein the unfolded protein allows subsequent cross-linking interactions such as protein–protein hydrophobic, electrostatic, and disulfide–sulfhydryl interactions. The very little amount of protein in the powder proved that the spray drying conditions applied triggered the denaturation. The crude fiber content of BPP is 0.83. The value of the crude fiber decreased from the petals to the powder. In the study of Deka *et al.* [21], the petals had a crude fiber content of 17.9%. However, in this study, only the extract from the petals was used in powder production and the process involved a series of filtration and sieving therefore removing fibrous particles in the extract prior to drying. Hence, the decrease in crude fiber content is reasonable.

The crude ash content of BPP is 0.58%. The value of the crude ash content of the petals in the study of Handoyo [20] showed a similar amount. Since the ash content represented the inorganic residue of buterfly pea which can withstand combustion, no significant change in the ash content of the petals and the BPP was observed.

The carbohydrate content of butterfly pea powder was 98.5%. The total amount of carbohydrates in the powder was higher than in the petals. It was due to the extraction process and influenced by the addition of maltodextrin. The values for carbohydrate content in the flowers were varying based on the studies of Handoyo [20] and Deka *et al.* [21] where the former obtained 6.55% while the latter got 29.2%. Meanwhile, the value obtained in the analysis of the powder was 98.5%. If compared with the first study, the value increased slightly unlike the second study where the value decreased much.

3.1.3 Physico-chemical characteristics of BPP

Some physico-chemical characteristics of BPP and PPJ is shown in Table 3. The mean pH for the powder was 4.86. According to Kungsuwan *et al.* [22], the color of anthocyanin was affected by pH. The color of the powder was light bluish purple while the dissolved powder in liquid was dark blue, similar to that of pH 5 (Figure 5). The mean value obtained in the dissolved powder was slightly acidic. This pH value also indicated that the antioxidant activity of the powder was quite high since at pH 3, the butterfly pea reached the optimum point yielding the highest antioxidant activity [22]. This is because anthocyanin is more stable in an acidic medium. It was found that pH affected the degree of extraction because increase in extraction was observed when the pH of the solvent increased and it was related with anthocyanin content [23]. When the pH was low, the red color was evident and it signified presence of anthocyanin while the greenish-blue color was expected if the pH was high since it signified the presence of a quinoidal base [23]. The prevailing pH in the butterfly pea petals was affected by the four anthocyanin species present which affect the change in equilibrium [23, 24]. The % TSS value for the dissolved BPP was 29.2%. The %TSS value of the powder was adjusted to have 30% maltodextrin which was in accordance with the experimental value. The soluble solids that may be contained in the dissolved powder may be sucrose, fructose and glucose [25]. The %TA of the dissolved BPP was 0.0235%. The TA measures the strength of acid present in the dissolved powder. The calculation done was for the citric acid component alone so the presence of citric acid in the BPP was very low.

Anthocyanin

Anthocyanin in BPP was extracted using ethanol and water at an 80:20 ratio and concentrated through rotary evaporation. The solvent ratio was based on the study of Thao *et al.* [12] which yielded the most anthocyanin and high antioxidant activity from purple rice. The anthocyanin content of BPP was 23.96 mg/L. The anthocyanin value of butterfly pea extract in the study of Siti Azima *et al.* [26] was 16070 μg/g, which was very high. The anthocyanins in BPF were highly acylated and present as stable stacked intramolecular co-pigments or condensed with other phenolics. The stability of anthocyanin depended on a combination of environmental and chemical factors such as pH, structure, concentration of pigments, light, temperature, oxygen and enzymes [27]. The pigments of butterfly pea petals were water-soluble anthocyanin stable in mild acid solutions [22, 28]. Since anthocyanin in the BPP was stable, it did not significantly affect the color and antioxidant activity.

Antioxidant activities

The radical scavenging activity of the powder analyzed in concentrations from 25 ppm, 50 ppm, 100 ppm, 125 ppm, to 150 ppm ranged from 52.1% to 61.89% IA (Inhibition Activity). The concentrations used was based on the study of Rabeta and An Nabil [29] which resulted to a range of 32.67% IA- 401.33% IA when methanol was used as solvent while 390.67% IA-506.67% IA when water was

used as solvent and readings were conducted from 25, 50, 100, 125 to 150 ppm. Meanwhile, the solvent used in this study was ethanol and water at an 80:20 ratio. Polyphenols and anthocyanins donate hydrogen in DPPH which results to its reduction. The main factor that affected antioxidant activity in butterfly pea was pH. The structure of anthocyanins in acidic pH yielded a more stable form of reduced anthocyanins by free radicals [22]. The antioxidant activity of BPP was high, the high antioxidant activity in higher pH was due to the hydroxyl groups on the molecules of anthocyanins in acidic pH which may attach to more stabilizing locations than in a medium with basic pH.

3.2 Phase II: Butterfly Pea Juice (BPJ)

Usage of BPP in making BPJ was favorable since it was soluble in water. The particles remained in suspension without any visible settling in all treatments applied.

3.2.1 Sensory Evaluation

Color

The color of BPJ intensified as the concentration of the powder increased in the treatments. The color of Treatment 1 with 0.01g BPP/ml distilled water was less intense than that of Treatment 3 with 0.03 g BPP/ml distilled water. The addition of *calamansi* triggered a change in color from dark bluish purple to lighter purple. The intensity of colors of BPJ were still increasing and only the shade of the colors changed since the volume of *calamansi* remained the same in all three treatments. The colors of BPJ in the three treatments were stable. Color stability was dependent on pH as it was more stable in acidic environment while least stable in alkaline environment [24].

Preference Ranking Test

Total and mean ranks of (BPJ) are shown in Table 4. Results show that Treatment 3 was the most preferred formulation in the three runs since it consistently had the lowest rank. Kramer's test was applied to the data gathered. The critical value for 3 samples and 20 panelists at 5 percent level of significance is 32-48 or 34-36 Narain, 1984). The rank sums were within the range of the upper critical values except for Treatment 1 in the first run which was significantly inferior among others.

Table 4. Mean ranks of Preference ranking test for different formulations of BPJ

Butterfly Pea Juice	**Run 1**			**Run 2**			**Run 3**		
BPJ	T1	T2	T3	T1	T2	T3	T1	T2	T3
Total Rank Sum	49	36	35	43	44	33	41	40	39
Mean	2.45	1.8	1.75	2.15	2.2	1.65	2.05	2	1.95

Table 5. General acceptability of BPJ formulations

Formulation	**General Acceptability**	**N**	**Median**	**Mean Rank**	**Z-Value**	**Method**	**DF**	**H-Value**	**P-Value**
F1	Like moderately	60	3.00	99.2	1.59	Not adjusted for ties	2	4.62	0.099
F2	Like moderately	60	3.00	93.0	0.46				
F3	Like much	60	2.00	79.3	-2.05				
		180		90.5					

a. **b.**

Figure 7. Butterfly pea flowers Juice (a. without calamansi and b. with calamansi)

General acceptability test.

The 9-point Hedonic scale was used to determine the general acceptability of the three treatments. Table 5 showed that T1 and T2 had a median of 3, which was equivalent to *like moderately* while T3 had the median of 2, which was equivalent to *like much*. Kruskal Wallis Test at 0.05 significance level was used to analyze the data gathered. The P value obtained was 0.099. It was found that there was no significant difference between the three samples since the P value is greater that the value of the level of significance.

3.2.2. Physico-chemical characteristics of most preferred BPJ

The mean pH of the most preferred formulation was 2.95. BPJ T3 with 0.03g BPP/ml distilled water was blue (Figure 7a). However, it turned purple (Figure 7b) upon the addition of 60 ml *calamansi* similar to the color of pH 3 (as shown in Figure 5). The mean value obtained in BPJ T3 indicated that it was acidic. Kungsuwan *et al.* [22] showed that at pH 3, the butterfly pea reached the optimum point which yielded the highest antioxidant activity. Anthocyanin was more stable in BPJ since it was more acidic. The %TSS value of BPJ T3 was 10.4%. Citric acid and mineral components contribute to the soluble solids of a juice [25]. In the study, the %TSS value from BPP to BPJ decreased. This was due to the concentration of the powder in distilled water where there was 30g of BPP in 1000 ml of distilled water. The addition of citric acid was supposed to lead an increase in the %TSS of the juice however, the solution was too diluted, so the %TSS value decreased. BPJ T3 had a titratable acidity of 0.0291%. The calculation done was for the citric acid component in BPJ and the formulation contained 60 ml calamansi. The value of titratable acidity of the BPJ increased slightly from that of BPP. Calamansi was added in the diluted powder however, there was only 0.03 grams of powder per ml distilled water in the formulation. Calamansi is a citrus fruit known to have high pH. The dilution of the calamansi and powder to 1000ml of distilled water and the addition of sugar affected the amount of titratable acidity which did not cause any significant increase in the %TA value of BPJ despite the addition of a high acid ingredient. The anthocyanin content of the BPJ T3 was 18.6 mg/L. The concentration of the powder in the juice was very small so it affected the amount of anthocyanin present in the juice. Also, the drying temperature, 200°C, was too high and it led to the significant loss in anthocyanin content in the juice. Anthocyanin was degraded during high temperatures [30, 31]. The radical scavenging activity of BPJ T3 was analyzed in concentrations from 25ppm, 50ppm, 100ppm, 125ppm to 150 ppm and the values obtained ranged from 46.5% IA to 50.1%IA. The %IA in the juice are lower compared with the powder. The juice had a higher pH than the powder, so it was expected to have higher antioxidant activity. However, BPJ T3 was too diluted and so despite the addition of calamansi and the increase in pH, the %IA of BPJ lowered. The addition of sugar might have a potential effect to the decrease in %IA.

4. Conclusions

BPP was produced through spray drying at 200°C for 37 minutes with 87.8% recovery with sufficient quality information recorded. Butterfly pea juice formulated using BPP was stable, nutritious, high in antioxidants and generally acceptable. The result of the study can prove the efficacy of the spray drying method in preserving flower extracts. The results of the study can yield valuable information on food application of butterfly pea powder for nutrition, health benefits, juice pigmentation, and shelf life. It could be a basis for utilization of butterfly pea flowers as juice, an easily grown herb and highly adaptable to local conditions, which would be readily accessible and nutritious

References

[1] D. Goldstein, S. Mintz. The Oxford companion to sugar and sweets: Oxford University Press; 2015.

[2] N. Jacobsen, C. P. Salguero. Thai herbal medicine: Traditional recipes for health and harmony: Simon and Schuster; 2014.

[3] N. M. Saptarini, D. Suryasaputra, H. Nurmalia. (2015). Application of Butterfly Pea (Clitoria ternatea Linn) extract as an indicator of acid-base titration. Journal of Chemical and Pharmaceutical Research, 7(2): 275-80.

[4] P. Kosai, K. Sirisidthi, K. Jiraungkoorskul, W. Jiraungkoorskul. (2015). Review on ethnomedicinal uses of memory boosting herb, butterfly pea, Clitoria ternatea. Journal of Natural Remedies, 15(2): 71-6.

[5] J. J. Rybczyński, M. R. Davey, A. Mikuła. The gentianaceae-volume 1: characterization and ecology: Springer; 2014.

[6] K. Kazuma, N. Noda, M. Suzuki. (2003). Flavonoid composition related to petal color in different lines of Clitoria ternatea. Phytochemistry, 64(6): 1133-9.

[7] N. M. Thuy, V. Q. Minh, T. C. Ben, M. T. Thi Nguyen, H. T. N. Ha, N. V. Tai. (2021). Identification of anthocyanin compounds in butterfly pea flowers (Clitoria ternatea L.) by ultra performance liquid chromatography/ultraviolet coupled to mass spectrometry. Molecules, 26(15): 4539.

[8] A. Marulanda, M. Ruiz-Ruiz, M. Cortes-Rodríguez. (2018). Influence of spray drying process on the quality of avocado powder: a functional food with great industrial potential. Vitae, 25(1): 37-48.

[9] K. Muzaffar, G. A. Nayik, P. Kumar. (2015). Stickiness problem associated with spray drying of sugar and acid rich foods: a mini review. Journal of Nutrition & Food Sciences, 5(12): 1-13.

[10] V. Venkatachalapathy, N. K. Katiyar, A. Matthews, J. L. Endrino, S. Goel. (2023). A guiding framework for process parameter optimisation of thermal spraying. Coatings, 13(4): 713.

[11] AOAC. Official methods of analysis of the Association of Official Analytical Chemists: Association of Official Analytical Chemists.; 2005.

[12] L. Thao, D. K. Thoa, L. P. Thang, T. U. Xi, D. Mai, N. N. Tram. (2015). Effect of ethanol on the anthocyanin extraction from the purple rice of Vietnam. Journal of Food and Nutrition Sciences, 3(1-2): 45-8.

[13] D. Joanes. (1985). On a rank sum test due to Kramer. Journal of food science, 50(5): 1442-4.

[14] H.-W. Xiao, Z. Pan, L.-Z. Deng, H. M. El-Mashad, X.-H. Yang, A. S. Mujumdar, et al. (2017). Recent developments and trends in thermal blanching–A comprehensive review. Information processing in agriculture, 4(2): 101-27.

[15] S. Sapiee. The Extraction of Anthocyanin from Clitoria Ternatea (Blue Pea Flower) by Using Spray Dryer: UMP; 2013.

[16] F. Pranatri, A. M. Marpaung, I. S. Kartawiria. The study of formulation of effervescence on butterfly pea petals extract: Swiss German University; 2012.

[17] E. Horuz, A. Altan, M. Maskan. (2012). Spray drying and process optimization of unclarified pomegranate (Punica granatum) juice. Drying Technology, 30(7): 787-98.

[18] S. Y. Quek, N. K. Chok, P. Swedlund. (2007). The physicochemical properties of spray-dried watermelon powders. Chemical Engineering and Processing: Process Intensification, 46(5): 386-92.

[19] N. Phisut. (2012). Spray drying technique of fruit juice powder: some factors influencing the properties of product. International Food Research Journal 19(4): 1297-306.

[20] M. Handoyo. Spray Drying of Butterfly Pea Petals Extract (ClitoriaternateaL.)and Study of Its Stability. Tangerang:: Swiss German University.; 2011.

[21] M. Deka, A. Medhi, J. Kalita, K. Sarma, L. Deka. (2013). Proximate Analysis of Primary Metabolites in Different Parts of Clitoria ternatea L. A Comparative Study. International Archive of Applied Sciences and Technology, 4(3): 62-7.

[22] K. Kungsuwan, K. Singh, S. Phetkao, N. Utama-ang. (2014). Effects of pH and anthocyanin concentration on color and antioxidant activity of Clitoria ternatea extract. Food and Applied Bioscience Journal, 2(1): 31-46.

[23] K. S. Keka Sinha, P. D. Saha, V. Ramya, S. D. Siddhartha Datta. (2012). Improved extraction of natural blue dye from butterfly pea using microwave assisted methodology to reduce the effect of synthetic blue dye. International Journal of Chemical Technology, 4: 57-65.

[24] A. Tantituvanont, P. Werawatganone, P. Jiamchaisri, K. Manopakdee. (2008). Preparation and stability of butterfly pea color extract loaded in microparticles prepared by spray drying. The Thai Journal of Pharmaceutical Sciences, 32(3): 59-69.

[25] M. W. Siddiqui. Postharvest biology and technology of horticultural crops: principles and practices for quality maintenance: CRC Press; 2015.

[26] A. Siti Azima, A. Noriham, N. Manshoor. (2014). Anthocyanin content in relation to the antioxidant activity and colour properties of Garcinia mangostana peel, Syzigium cumini and Clitoria ternatea extracts. International food research journal, 21(6): 2369-75.

[27] Z. Idham, I. I. Muhamad, S. H. MOHD SETAPAR, M. R. Sarmidi. (2012). Effect of thermal processes on roselle anthocyanins encapsulated in different polymer matrices. Journal of food processing and preservation, 36(2): 176-84.

[28] J. Li, X.-d. Li, Y. Zhang, Z.-d. Zheng, Z.-y. Qu, M. Liu, et al. (2013). Identification and thermal stability of purple-fleshed sweet potato anthocyanins in aqueous solutions with various pH values and fruit juices. Food chemistry, 136(3-4): 1429-34.

[29] M. Rabeta, Z. An Nabil. (2013). Total phenolic compounds and scavenging activity in Clitoria ternatea and Vitex negundo linn. International Food Research Journal, 20(1): 493-500.

[30] Y. Hamzah, N. A. Jumat, W. W. Sembok, editors. Effect of drying on the storage stability of encapsulated anthocyanins powder extract from Butterfly pea flower (Clitoria ternatea). 13th ASEAN Food Conference; 2013.

[31] N. M. Thuy, L. N. Han, N. Van Tai. (2022). Thermal stability of anthocyanin in mixed raspberry-pomegranate-banana nectar in the presence of ascorbic acid and citric acid. Journal of Applied Biology and Biotechnology, 10(1): 189-95.