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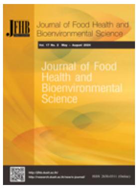

Utilization of Banana Blossom Sheaths with Different Skin Colors as Raw Materials for Healthy Pasteurized Banana Blossom Juice Production

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Abstract

This research aimed to investigate the physical properties and chemical compositions of banana blossom sheaths, as well as the physicochemical and microbial properties of their juices. Banana blossom sheaths come in two varieties: the light-yellow inner (inner) and the pink-red outer (outer). Chemical analyses of both inner and outer sheaths, including moisture, protein, lipid, ash, total carbohydrate and crude fiber, revealed ranges of 90.83–93.41%, 1.22–1.71%, 0.29–0.34%, 0.97–1.01%, 3.62–6.60% and 0.96–2.14%, respectively. The healthy pasteurized banana blossom juices (HPBJ) derived from both sources were rich in phenolic compounds (254±0.12 and 124±0.38 mg GAE/100 mL), total anthocyanin contents (0.19±0.23 and 15.0 ±0.35 mg cyanidin-3-glucoside equivalent (CGE)/100 mL) and exhibited antioxidant properties using the DPPH method (2,280.49±0.45 and 2,156.53±0.78 µmol of Trolox equivalents/100 mL), respectively. Microbial analysis of HPBJ, including total plate counts (TPC), yeast and mold, *Escherichia coli,* Coliform, *Salmonella* spp., *Staphylococcus aureus, Bacillus cereus,* and *Clostridium perfringens,* indicated levels within acceptable limits, confirming their safety for consumption.

Abbreviations: Inner, the inner of the banana blossom sheath (light-yellow); Outer, the outer of the banana blossom sheath (pink-red); HPBJ, the healthy pasteurized banana blossom juices; HPBJI, the healthy pasteurized banana blossom juices produced from inner sheath; HPBJO, the healthy pasteurized banana blossom juices produce from outer sheath

Introduction

The banana flower, or banana blossom, is typically considered a waste material after harvesting and processing. However, it is an edible agricultural byproduct with high nutritional value. The banana blossom is the part of the inflorescence that does not develop into fruit. It consists of real flowers that are wrapped in large bracts. The inner bracts are light-yellow (inner) and the outer bracts are pink-red (outer), arranged tightly overlapping each other. Tall lotus bud shape

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banana blossoms are classified as herbal vegetables, which are eaten only in the inner sheaths that are light-yellow and has a soft texture. Raw banana blossoms have an astringent taste, but if cooked they have a sweet and creamy taste (Lau et al., 2020). Banana blossoms have been used as a raw material for cooking for a long time. It can be used to produce a variety of beverage products, especially those that contain milk, due to its properties that enhance milk flow. Examples include banana blossom curry, banana blossom salad, pasteurized banana blossom juice mixed with herbs, banana blossom tea and powdered banana blossom drinks. Banana blossoms are mostly consumed in Asian countries such as Thailand, Sri Lanka, Malaysia, Indonesia, the Philippines, Burma and India (Mathew & Negi, 2017; Ramírez-Bolaños et al., 2021; Soni & Saxena, 2021). In terms of nutritional value, banana blossoms are rich in 70% dietary fiber, 53.78% carbohydrates and 19.60% protein (Ramu et al., 2017). They are a source of important primary and secondary minerals, including potassium, sodium, phosphorus, calcium, magnesium, zinc and iron (Sheng et al., 2010; Elaveniya & Jayamuthunagai, 2014), with the highest amount of potassium, followed by calcium, magnesium, phosphorus and sodium, respectively (Ramu et al., 2017). Banana blossoms have 4 times more calcium than ripe bananas and 4-5 times less energy than bananas due to low carbohydrates. Banana blossoms are also rich in vitamin A, vitamin C, vitamin E, quality protein and unsaturated fatty acids (Sheng et al., 2010; Sharma et al., 2019). In addition, banana blossoms are a source of various bioactive phytochemical substances such as beta-carotene, tannins, phenolic acids (caffeic acid, ferulic acid, synaptic acid, paracoumaric acid and gallic acid) and water-soluble flavonoid compounds (quercetin and anthocyanins) (Sumathy et al., 2011; Zehla et al., 2018; Sharma et al., 2019; Ramírez-Bolaños et al., 2021). These compounds have antiviral, antimicrobial, anti-inflammatory and antioxidant properties. Therefore, it is involved in the prevention of various chronic diseases such as heart disease, stroke, neurological diseases, diabetes and cancer (Lau et al., 2020). In addition, tannins in banana blossoms extracted with water also influences increasing the level of prolactin in the blood, resulting in increased breast milk production (Yimyam, 2018). Importantly, banana blossom is a source of lactagogum that has the property of stimulating the production of oxytocin and prolactin, which are important hormones in the production of breast milk (Aisya et al., 2020). The trend of ready-to-drink banana blossom juice is popular with breastfeeding mothers because of the properties of helping to expel breast milk. The banana blossom juice is usually sold in glass bottles, or plastic bottles, or cans with various flavors such as banana blossom alone or mixed with other herbs including galangal, honey, ginger and mulberry leaves. It is an option to help mothers to be healthy and able to produce milk as needed.

However, there has been no study and research on the differences in nutritional values of the inner and the outer sheathes of banana blossom with different skin colors. Therefore, this research is interested in studying the physical properties and chemical compositions of banana blossom sheaths which are considered waste materials after harvesting in Suphanburi Province. To maximize benefits and minimize food waste, parts of banana blossom sheaths can be selected for use in the food industry, such as raw materials for meat substitutes in vegan food products. Moreover, due to their high production yield, easy availability, low cost and health benefits, they may be used as ingredients in a variety of functional food products in the future.

The objectives were to study physical properties and chemical compositions of inner and outer sheaths of banana blossoms. The physico-chemical properties and microbial quality of the healthy pasteurized banana blossom juice (HPBJ) produced from inner (HPBJI) and outer (HPBJO) sheaths of banana blossoms were examined.

Materials and methods

1. Materials

Fresh Namwa banana blossom (*Musa sapientum* Linn.) sheaths used in this study was a waste material after harvested from Bang Ta Then Sub-district, Song Phi Nong District, Suphanburi Province during June 2021. The banana blossom sheath was cleaned and then cover was separated. Banana sheaths were classified into 2 types, the light-yellow inner (Fig. 1a) and the pink-red outer (Fig. 1b).

2. Physical properties and chemical compositions of inner and outer sheaths

Color values L*, a*, b* and h° of fresh banana blossom sheaths with different skin colors were measured on the surface using colorimeter (WF30, FRU, U.S.A.). The color parameters were L* (L* = 0, black and L* = 100, white), a* (-a* = greenness and +a* = redness), b* (-b* = blueness and +b* = yellowness) and h° (color

(a) (b)

Fig. 1 The fresh banana blossom sheaths (a) inner (b) outer

shade) were recorded. The colorimeter was calibrated with a white calibrate tile before measuring.

The moisture content was measured by air-oven methods according to AOAC Method 964.22 (AOAC, 2019). Crude protein was measured by a Kjeldahl method according to AOAC Method 992.15 (AOAC, 2019) using the conversion factor of 6.25 to convert nitrogen content to crude protein. Crude fat was measured according to AOAC Method 922.06 (AOAC, 2019) using a Soxtec apparatus and hexane as the solvent. Crude ash was determined by using AOAC Method 942.05 (AOAC, 2019). And then, total carbohydrates were calculated by 100 - (moisture (%) + fat (%) + protein (%) + ash (%)). Crude fiber was measured according to AOAC Method 985.29 (AOAC, 2019) using a Fibertec apparatus. All chemical compositions were measured in duplicate.

3. Production of healthy pasteurized banana blossom juice (HPBJ)

The HPBJ samples were produced using the modified method of Rabie et al. (2014). The inner and outer sheaths were soaked in 2% citric acid (Food grade, INS 330, CT Laboratory Co., Ltd., Thailand) at the ratio of 1:2 for 30 min to inactivate the enzymatic browning reaction. Washed twice with clean water and drained for 5 min. The 32.99 g of inner or outer sheath were then boiled with 65.97 g water for 20 min. The filtered was mixed with 0.99 g of brown sugar (Mitr Phol, Mitr Phol Sugar Corp., Ltd., Thailand) and 0.05 g of salt (Prung Thip, Thai Refined Salt, Co., Ltd., Thailand) and then pasteurized at 90°C for 10 min. Both pasteurized juiced were hot filled into 200 mL PE plastic bottle and cooled to room temperature. Samples were stored in a refrigerator at 4°C until used.

4. Pasteurized banana blossom juice properties

The physico-chemical properties, of both juices were analyzed. The color values L*, a*, b* and h° were measured using colorimeter. The pH was measured using digital pH meter (Orion 2 Star benchtop, Thermo Scientific, U.S.A.). Total soluble solids (TSS) were analyzed according to the method of AOAC (2000) using a Hand-Held Refractometer 0-33°Brix (Master-M, ATAGO, Japan).

5. Phytochemical properties

5.1 Determination of total phenolic content

The total phenolic contents of pasteurized juices were determined by using Folin-Ciocalteu reagent method modified from Maizura et al. (2011). The 0.4 mL of pasteurized juice was transferred into a test tube and then mixed with 2 mL of 10% (v/v) Folin-Ciocalteu reagent and left for 4 min. The 1.6 mL of 5% (w/v) sodium carbonate was added. The mixtures were agitated with a vortex mixer (G-560 E, Vortex-2 Genie, U.S.A.) then allowed to stand for 30 min in the dark. The absorbance was measured at 765 nm using UV-visible spectrophotometer (T60 U, PG Instrument, England). Results were calculated using regression equation of gallic acid (0-100 ppm). The total phenolic contents were expressed as mg of gallic acid equivalents per 100 mL (mg GAE/100 mL).

5.2 Determination of total anthocyanin content

The total anthocyanin content of pasteurized juices were determined using pH-differential spectrophotometric method modified from Giusti and Wrolstad (2005). Absorbance was measured by using a spectrophotometer at 510 and 700 nm in a 0.025 M potassium chloride buffer (pH 1.0) and 0.4 M sodium acetate buffer (pH 4.5). The absorbance (A) of the diluted sample was then calculated as follows: $A = [(A_{510}-A_{700})$ pH 1.0 - $(A_{510}-A_{700})$ pH 4.5]. The total anthocyanin content was expressed as mg of cyaniding-3-glucoside equivalents per 100 mL (mg cy-3-glu/100 mL). Calculated via the following formula:

$$\text{Anthocyanin content (mg/L)} = (A \times MW \times DF \times 1{,}000)/(\varepsilon \times L)$$

MW = cyanidin-3-glucoside molecular weight (449.2); DF = dilution factor; ε = cyanidin-3-glucoside molar absorptivity (26,900); L = cell pathlength (1 cm)

5.3 DPPH radical scavenging assay

Free radical scavenging activity in pasteurized juices were determined by using the highly stable free radical 2,2-Diphenyl l-1-picrylhydrazyl (DPPH), which has an intense violet color. This method was modified from Du et al. (2009). The 1 mL of pasteurized juices were transferred into a test tube and then mixed with 1 mL of DPPH radical solution (200 µM in 50% (v/v) ethanol) and allowed to stand for a further 30 min in the dark. The absorbance was measured by using a spectrophotometer at 515 nm. Results were calculated using regression equation of Trolox (0-100 µmol). The scavenging activity was expressed as µmol of Trolox equivalents per 100 mL (µmol TE/100 mL).

6. Microbiological quality

Microbiological quality was analyzed according to the standard criteria of the Notification of Ministry of Public Health (No. 356) B.E. 2556 (2013) regarding beverages in sealed containers and the Notification of Ministry of Public Health (No. 416) B.E. 2563 (2020) regarding quality or standards. The terms, conditions and methods for analyzing food for pathogenic microorganisms were also followed (Notification of Ministry of Public Health (No. 416) B.E. 2563, 2020), including:

- Total microbial amount (Total Plate Count) according to the standard method specified in BAM online chapter 3 (BAM, 2001a)
- Yeast and mold amounts according to the standard methods specified in BAM online chapter 18 (BAM, 2001b).
- *Escherichia coli* (*E. coli*) and coliform using the multiple-tube fermentation technique (MPN) (APHA, 2017)
- *Salmonella* spp. according to the standard method ISO 6579-1:2017 (2017)
- *Staphylococcus aureus* (*S. aureus*) standards specified in BAM online chapter 12 (BAM, 2016)
- *Bacillus cereus* (*B. cereus*) according to the standard method specified in BAM online chapter 14 (BAM, 2001c)
- *Clostridium perfringens* (*C. perfringens*) according to the standard method specified in BAM online chapter 16 (BAM, 2001d)

7. Statistical analysis

The statistical analysis was performed by comparing the differences between the means of 2 independent samples using t-test for independent samples and analyze statistical variance with analysis of variance (ANOVA) using the statistical computer program SPSS for Windows at the level of 95 % confidence. Each treatment had two replicates.

Results and discussion

1. Physical properties and chemical compositions of inner and outer sheaths

1.1 Physical properties

The color values L*, a*, b* and h° on the surface of inner and outer banana blossom sheaths are shown in Table 1. As expected, inner and outer resulted in significantly different color values L*, a*, b* and h° ($P \leq 0.05$). When considering L* values (brightness), it was found that inner had a higher brightness value than outer. This may be due to the pigmentation of anthocyanin in the inner which is low, while the outer has a high anthocyanin pigment, which results in the outer being opaquer than the inner. This is consistent with the color value a* (red) finding of the outer having a red color 5.08 times greater than the inner. This information is consistent with Sujithra and Manikkandan (2019) who confirmed that the red outer sheath of the banana blossom comes from the pigment anthocyanin. Most of which are cyanidin-3-rutinoside (Cyanidin-3-rutinoside). When considering the b* (yellow) color value, it was found that the inner has a yellow color value up to 6.67 times higher than the outer. This may be due to the inner banana blossom sheath being in the raw stage. Meanwhile, the outer sheath of the banana blossom is the part that is approaching maturity or increasing in age, so it changes color to red. This is consistent with Serradilla et al. (2011) who found that the synthesis of anthocyanin increases as plants approach maturity. When considering the value h°, which is a value that represents the color shade, it was found that both the inner and outer had shades in the range of red to yellow (0-90°), indicating that the inner had a color in shades of yellow more than red, while the outer were in shades of red more than yellow. The ho values of both types of banana sheaths corresponded to the color that appeared on the surface of the sheaths that covered the banana blossoms. When viewed with the naked eye, the inner are light-yellow and the outer are pink-red.

Table 1 Physical properties of inner and outer banana blossom sheaths

Color values	Banana blossom sheaths	
	Inner (light-yellow)	Outer (pink-red)
L*	71.92 ±1.36[a]	31.24±0.79[b]
a*	2.79±0.88[b]	14.16 ±1.22[a]
b*	31.01±0.61[a]	4.65±0.27[b]
h°	82.26±4.01[a]	18.26±1.02[b]

Remark: Mean ± standard deviation (n=2)
Means value ± SD with different small letters in the same row are significantly different (P ≤ 0.05)

1.2 Chemical compositions

The chemical compositions in terms of nutritional value, including moisture, fat, protein, crude fiber, ash, and total carbohydrates of inner and outer banana blossom sheaths are shown in Table 2. Significant differences (P ≤ 0.05) were found in the levels of all chemical compositions between the inner and outer samples. Both inner and outer banana blossom sheaths contained 90.83 – 93.41% of moisture, which were similar to results of other studies (89.42-90.58%) from banana flowers of two cultivars (Sheng et al., 2010), (88.75%) from banana flowers in India (Kavya et al., 2023). Both the inner and outer banana blossom sheaths contained 90.83% to 93.41% moisture, similar to the findings of other studies. These studies reported moisture levels ranging from 89.42% to 90.58% for banana flowers of two cultivars (Sheng et al., 2010) and 88.75% for banana flowers in India (Kavya et al., 2023).

The outer contained significantly (P ≤ 0.05) higher content of crude lipid, crude ash, total carbohydrate and crude fiber than the inner. Meanwhile, the content of crude protein in the inner was significantly (P ≤ 0.05) higher than the outer. The content of crude protein in both banana blossom sheaths were similar to the reported values by Sheng et al. (2010), Hardoko et al. (2022) and Kavya et al. (2023). Based on previous studies, the content of crude lipid of banana blossom varied from 0.3 to 0.6% (Sheng et al., 2010; Hardoko et al., 2022; Kavya et al., 2023), however, the crude lipid in two banana blossom sheaths were lower than the reference values. A lower lipid content is mainly due to different gene types. The higher crude ash content was found in the outer which is significantly different in comparison to the inner. The content of crude ash in both banana blossom sheaths were lower than that from banana flowers (1.19-1.24%) from China (Sheng et al., 2010).
It is also well known that the higher content of crude fibers corresponds to the hard texture, the Outer are a source of crude fiber and total carbohydrates resulting in consumers dislike of eating. Therefore it is often discarded as food waste in cooking and industrial processing. However, a higher content of crude fiber and total carbohydrates indicates that outer banana blossom sheaths can be consumed as fiber supplements. In addition, Hardoko et al. (2022) reported that banana blossoms are classified as a food with a low glycemic index, which is important for diabetic patients. This is because banana blossoms, especially the outer sheaths that are pink to red, are a source of complex carbohydrates that have a beneficial effect on increasing blood sugar levels to be stable and consistent. Moreover, banana blossom sheaths are commonly used to produce alternative protein in plant-based food products for consumers who follow a flexible vegetarian diet (flexitarian). This is because the texture of banana blossom sheaths is similar to that of cooked fish. Furthermore, the banana blossom sheaths possess primary and secondary minerals, including potassium,

Table 2 Chemical compositions of inner and outer banana blossom sheaths

Chemical compositions (%)*	Banana blossom sheaths	
	Inner (light-yellow)	Outer (pink-red)
Moisture	93.41±0.80[a]	90.83 ± 0.38[b]
Crude protein	1.71±0.04[a]	1.22 ± 0.04[b]
Crude lipid	0.29 ±0.01[b]	0.34 ± 0.03[a]
Crude ash	0.97±0.01[b]	1.01 ± 0.00[a]
Total carbohydrate (by calculation)	3.62±0.05[b]	6.60 ± 0.06[a]
Crude fiber	0.96±0.01[b]	2.14± 1.01[a]

Remark: *Based on fresh weight basis
Mean ± standard deviation (n=2)
Means value ± SD with different small letters in the same row are significantly different (P ≤ 0.05)

sodium, phosphorus, calcium, magnesium, zinc and iron, high dense fibers and low energy (Sheng et al., 2010; Elaveniya & Jayamuthunagai, 2014).

2. Pasteurized banana blossom juice properties

The HPBJ from inner (HPBJI) and outer (HPBJO) are shown in Fig. 2. The color values L* (lightness), a* (red) and b* (yellow) of the HPBJ as shown in Table 3 were significantly different ($P \leq 0.05$), while the h° color value (shade) was not significantly different. In the range of red to yellow (0-90° has shades of red to yellow), the color values L*, a*, b* and h° of both, consistent with their appearance when viewed with the naked eye. It was found that the color values of both pasteurized juices were not only affected by the different sheaths color but also the brown sugar added during the process. The HPBJI has a higher L* value, but lower a*and b* values than the HPBJO. Moreover, changes in the color values L*, a*, b* and h° of juices are often greatly affected by thermal processing conditions and plant composition (Manzoor et al., 2020).

(a) (b)

Fig. 2 The healthy pasteurized banana blossom juice (HPBJ) (a) inner (HPBJI) and (b) outer (HPBJO)

The physico-chemical properties of both pasteurized juices are shown in Table 3. It was found that the pH values and the amount of total soluble solids (TSS) were not significantly different ($P > 0.05$). Average pH was in the range of 4.87-5.82 and can be classified as low-acid foods (pH>4.6) (Notification of Ministry of Public Health (No. 416) B.E. 2563, 2020). The result is different from Amornlerdpison et al. (2021) who found that a ready-to-drink banana blossom juice drink for breastfeeding mothers had pH value of 3.54 and Kaweewong and Sombutma (2020) who found that the ready-to-drink banana blossom milk drink had pH value in the range of 3.50-3.70, which pH value was adjusted with citric acid in order to be classified as highly acidic (pH<4.6) and able to be stored at room temperature. The TSS were in the range of 4.13-4.87 (°Brix) which was lower than that of apple juice (11.5°Brix) Bananas (22.0°Brix), grapes (16.0°Brix), oranges (11.8°Brix), mangos (11.8°Brix) and pomegranates (16.0°Brix). However, it is near to lemon juice (4.5°Brix) (Clemens et al., 2015).

Table 3 Physico-chemical properties of pasteurized banana blossom juices

Physico-chemical properties	HPBJI	HPBJO
Color values		
L*	24.56±0.44[a]	20.74±0.46[b]
a*	2.43±0.08[b]	4.70±0.04[a]
b*	18.34±0.67[b]	24.32±1.29[a]
h° [ns]	79.41±0.19	79.06±0.27
Chemical compositions		
pH[ns]	4.87±0.07	5.82±0.06
Total soluble solid (°Brix)[ns]	4.87±0.06	4.13±0.12
Total phenolic content (mg GAE/100 mL)	254.00±0.12[a]	124.00±0.38[b]
Total anthocyanin content (mg cy-3-glu/100 mL)	0.19±0.23[b]	15.01±0.35[a]
DPPH radical scavenging assay[ns] (μmol TE/100 mL)	2,280.49±0.45	2,156.53±0.78

Remark: HPBJI = The healthy pasteurized banana blossom juices produced from inner sheath, HPBJO = The healthy pasteurized banana blossom juices produced from outer sheath
Mean ± standard deviation (n=2)
Means value ± SD with different small letters in the same row are significantly different ($P \leq 0.05$)
Means value ± SD with ns letters is not significantly different ($P > 0.05$)

3. Phytochemical properties

It was found that all phenolic compounds and the total anthocyanin content of both pasteurized juices were significantly different ($P \leq 0.05$), while the antioxidant properties using the DPPH method were not significantly different ($P > 0.05$). These results were consistent with Sheng et al. (2011) and Amornlerdpison et al. (2021) who found that beverages containing banana blossom extract are rich in total phenolic compounds (124±0.38 mg gallic acid equivalent per 100 mL sample) and have high antioxidant properties. By substances that have antioxidant properties that are soluble in water, most banana blossoms belong to the group of phenolic compounds. Flavonoid compounds have antioxidant potential and it was found that both pasteurized juices had higher amounts of total phenolic compounds (254± 0.12 and 124 mg gallic acid equivalent per 100 mL sample, respectively) than black currant juice, rainbow and green tea (108 and 85 mg gallic acid equivalent per

100 mL sample, respectively), but had lower total phenolic compounds than commercial grape juice (10,241 mg gallic acid equivalent per 100 mL sample, respectively) (Zujko & Witkowska, 2014; Wern et al., 2016). Total anthocyanin content of HPBJI and HPBJO (0.19±0.23 and 15.01±0.35 mg cyanidin-3-glucoside equivalents per 100 mL sample) were higher than the juice from germinated black glutinous rice (0.05 mg equivalent of cyanidin-3-glucoside per 100 mL of sample) (Jongrattanavit et al., 2021) and has antioxidant properties (2,280.49±0.45 and 2,156.53±0.78 µmol equivalents of Trolox per 100 mL sample, respectively) were higher than fresh grape juice and freshly squeezed guava juice (708.52 and 770.12 µmol of Trolox equivalent per 100 mL sample, respectively), but had lower antioxidant properties than commercial pomegranate juice (2,705.01 µmol equivalent of Trolox per 100 mL sample) (Wern et al., 2016).

4. Microbial quality

The microbiological quality of both pasteurized juices passed the specified standard criteria and had no pathogenic microbial contamination as shown in Table 4. Total amount of microorganisms (Total Plate Count, TPC) of not more than 1 x 10^4 colonies in 1 mL of sample. Coliform bacteria (Coliform) were detected as less than 2.2 in 100 mL of sample by the MP method. Most Probable Number: MPN: *Escherichia coli* (*E. coli*) bacteria were not detected in 100 mL of sample. Less than 100 colonies of yeasts and molds were detected in 1 mL of sample and must not be found. Most Probable Number (MPN) Analysis: *E. coli* bacteria were not detected in a 100 mL sample. Less than 100 colonies of yeasts and molds were detected in 1 mL of the sample and should not be present. Microorganisms that cause disease shall be in accordance with the announcement of the Notification of Ministry of Public Health (No. 416) B.E. 2563 (2020) regarding food standards for microorganisms that cause disease in liquid beverage products with pH greater than 4.3, only those that have undergone a heat sterilization process using pasteurization or other equivalent methods, including *Salmonella* spp. No colonies must be found in 25 mL of sample. *Staphylococcus aureus* and must not exceed 100 colonies in 1 mL of sample. *Bacillus cereus* must not exceed 100 colonies in 1 mL of sample and *Clostridium perfringens* and must not exceed 100 colonies in 1 mL of sample. These results indicated that the healthy pasteurized banana blossom sheath juice produced from skin-colored banana blossom sheaths is safe for consumers.

Table 4 Microbial quality of pasteurized banana blossom juice from inner light-yellow sheath and outer pink-red color

Microbial quality	HPBJI	HPBJO
Total plate count (CFU/ mL)	<1	<1
Yeasts/ Molds (CFU/ mL)	<1	<1
Escherichia coli (MPN/100 mL)	N.D.	N.D.
Coliform (MPN/100 mL)	<1.1	<1.1
Salmonella spp. (in 25 mL sample)	N.D.	N.D.
Staphylococcus aureus (CFU/ mL)	<1	<1
Bacillus cereus (CFU/ mL)	<1	<1
Clostridium perfringens (CFU/ mL)	<1	<1

Remark: HPBJI = The healthy pasteurized banana blossom juices produced from inner sheath, HPBJO = The healthy pasteurized banana blossom juices produced from outer sheath
N.D. = Not Detected

Conclusion

Different parts of the banana blossom sheaths were influenced their physical properties and chemical compositions. The physical properties and chemical compositions of different parts of the banana blossom sheaths were influenced by their respective characteristics. The inner and outer could be source of plant protein and crude fiber, respectively. Both parts could be used as raw material for nutritional pasteurized juice production. The healthy pasteurized banana blossom sheath juice contained high amount of phytochemical and is safe to drink due to the qualified microbiological quality.

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