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Development of Banana Stem Juice from *Musa* × *paradisiaca L*

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Abstract: Development of banana stem juice is an attempt to address the problem of sugary beverages and nutrient deficiency in the market. The study aims to produce a low-calorie banana stem juice and to evaluate its sensory properties. The antioxidant activity, physicochemical characteristics, and nutritional composition of banana stem juice are investigated in this study. The sample preparation process was used chestnut banana stems from species *Musa acuminata*, jackfruit banana stems from species *Musa x paradisiaca*, and horn banana stems from species *Musa x paradisiaca* to produce a yield of banana stem extract. Next, the juice was formulated by adding several ingredients to produce a desirable juice. Then, the banana stem juice undergoes a sensory evaluation test, antioxidant properties and physicochemical analysis which are pH, sugar brix, colour and titratable acidity. Based on the sensory evaluation, all of the formulations showed significantly different ($p < 0.05$) in terms of overall acceptance. Formulation 2 (containing jackfruit banana stems from species *Musa x paradisiaca)* has the highest degree of overall acceptance with 6.7 ± 1.76. Meanwhile, the least favourable sample by panelists is the control sample with 5.8 ± 1.91. For the antioxidant activity, the highest percentage of scavenging activity is Formulation 4 (containing all three types of banana stems). The banana stem juice has a low pH and low total soluble solid. The study reveals a low-calorie banana stem juice can be produced so that customers can enjoy a refreshing drink with a range of nutrients.

Keywords: Banana Stem, Beverage, Sensory, Antioxidant, Physicochemical.

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1. Introduction

Banana is one of the most popular fruits in Malaysia as it is rich in fibre, iron, potassium, vitamin C, vitamin B6 and manganese [1]. But, on the other hand, the banana stem was left behind and became waste once the fruit was harvested [1]. The banana stems are normally just being dumped in the soil plantation to be used as organic material and later on will lead to the environmental problem [2]. Besides the fruit itself, banana stems also have so many benefits and uses to humans. It is a rich source of nutrients such as fiber, potassium, and vitamin B6 which can help control body weight and aids in detoxifying the body [1]. Aside from preventing kidney stones, the banana stem juice was widely used as a traditional cure for diabetic people in several tropical countries since a long time ago [3]. But there are still not many people who are aware about the benefits of the banana stem for the human body.

To increase the consumption of banana stem among Malaysians, the best way can be done is by converting the banana stem into a commercial beverage. The beverage industry nowadays is growing day by day. But, some of the beverages have a low nutritional benefit and lack of micronutrients, vitamins and minerals [4]. This is because the beverages mostly contain synthetic colour and flavor that are not good to be consumed regularly [5]. Besides, what is more worrying is the high sugar content in the beverage that is associated with an increase of health diseases such as obesity, diabetes mellitus, metabolic syndrome, caries, osteoporosis and cancer [6]. So, four (4) formulations of banana stem juice using chestnut banana stems from species *Musa acuminata*, jackfruit banana stems from species *Musa x paradisiaca*, and horn banana stems from species *Musa x paradisiaca* were developed as an effort to overcome the problem of beverages with nutrient deficiency in the market, the banana stem juice is an effort made to ensure that customers can enjoy a refreshing drink besides receiving a variety of nutrients from the banana stem. Furthermore, the other important aspect of this banana stem juice is it is produced with low calories to enhance its nutritional value and thus will make this beverage different from other beverages commonly available in the market.

2. Materials and Methods

2.1 Materials

The mature banana stem used for this research which are chestnut banana stems from species *Musa acuminata*, jackfruit banana stems from species *Musa x paradisiaca*, and horn banana stems from species *Musa x paradisiaca* were collected from a plantation near Pagoh, Johor. The sucralose, stevia, sorbitol, citric acid, guar gum, sodium benzoate and salt were food grade.

2.2 Methods

2.2.1 Preparation of banana stem juice

The different varieties of banana stem were weighed (1 kg) and washed thoroughly [7]. Then, the outer layer of the banana stem was removed because only the inner part of the banana stem is used. Next, the chopped banana stem was blend in a blender (Panasonic). The banana stem extract was filtered using a muslin cloth.

2.2.2 Product formulation

The extracted banana stem juice was sweetened by no calories sweetener such as sucralose, stevia and sorbitol. Citric acid, sodium benzoate and guar gum were also added in the juice as an acidulant, preservative and thickener. Table 1 shows the formulation of banana stem juice were prepared

Table 1: Experimental design for the formulation of banana stem juice

Ingredients	Water (%)	Banana stem extract			Sucralose (%)	Stevia (%)	Sorbitol (%)	Citric acid (%)	Guar gum (%)	Salt (%)
		Chestnut banana stem (%)	Jackfruit banana stem (%)	Horn banana stem (%)						
F1	99.3	35	0	0	0.05	0.05	0.1	0.2	0.1	0.2
F2	99.3	0	35	0	0.05	0.05	0.1	0.2	0.1	0.2
F3	99.3	0	0	35	0.05	0.05	0.1	0.2	0.1	0.2
F4	99.3	12	12	12	0.05	0.05	0.1	0.2	0.1	0.2
Control	99.3	0	0	0	0.05	0.05	0.1	0.2	0.1	0.2

2.2.3 Sensory analysis

The sensory characteristics of banana stem juice were evaluated by using affective test which is a 9-point hedonic scale (9 = liked extremely to 1 = disliked extremely). A panel consisting of 50 semi-trained panelists were randomly chosen to undergo this sensory test and evaluate six characteristics of the juice which are appearance, colour, aroma, taste, sweetness and overall acceptance.

2.2.4 Antioxidant properties

The DPPH test was performed with slight modifications [8]. Firstly, 4 mg DPPH was added to 100 mL methanol to make a 0.004 percent DPPH solution. After that, the mixed sample was left in the dark for 40 minutes at room temperature, and the sample light absorbance was measured at 517 nm. The absorbance readings of the samples were compared to a gallic acid standard curve. The standard curve for gallic acid was constructed in the concentration range of 0.02 to 0.1 mg/mL. The experiment was carried in triplicate.

2.2.5 pH analysis

The 3 mL of the sample was used to measure the pH using an electronic pH-meter (EUTECH Instrumentals). The pH reading was performed in triplicate to obtain an accurate result.

2.2.6 Brix analysis

One drop of the banana stem juice was measured the brix (total soluble solid) using refractometer at 17℃.

2.2.7 Colour measurement

The colour of banana stem juice was measured using a colorimeter (MiniScan EZ, USA). The coordinates of the colour is measure in terms of L* (lightness/darkness), a* (positive value for redness and negative value for greenness) and b* (positive value for yellowness and negative value for blueness) [9]. The measurements were performed in triplicate.

2.2.8 Statistical analysis

All the data were presented as mean values and standard deviations (SD). The statistical significance was calculated at a 95% confidence level. As a result, ($p > 0.05$) denotes that the model terms have a significant on the response.

3. Results and Discussion

3.1 Sensory analysis

The data that were obtained through the sensory test are being presented in spider web plot as in Figure 1.

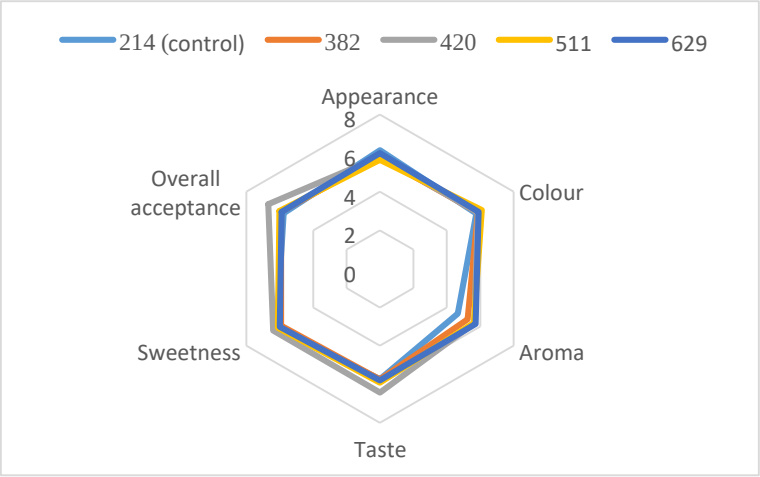

Figure 1: Spider web chart for five (5) coded sample

The results revealed about the four (4) samples in terms of appearance, colour, aroma, taste, sweetness and overall acceptance including the control (no banana stem extract). The results were tabulated in Table 2.

Table 2: Mean scores for each sensory attribute by the panelists

Attributes	F1	F2	F3	F4	Control
Appearance	6.0 ± 1.66	5.8 ± 1.65	5.7 ± 1.43	5.8 ± 1.32	6.2 ±1.94
Colour	5.9 ± 1.65	5.9 ± 1.52	6.1 ± 1.39	5.9 ± 1.31	5.8 ± 2.07
Aroma	5.7 ± 1.91	5.6 ± 1.58	5.6 ± 1.85	5.2 ± 1.87	4.6 ±1.81
Taste	5.8 ± 1.90	6.4 ± 1.71	5.9 ± 1.75	5.7 ± 2.05	5.7 ±2.18
Sweetness	6.0 ± 1.64	6.4 ± 1.47	6.1 ± 1.61	5.9 ± 1.64	6.2 ± 1.76
Overall acceptance	5.9 ± 1.67	6.7 ± 1.76	6.0 ± 1.68	5.9 ± 1.87	5.8 ± 1.91

As can be seen in Table 2, control has the highest mean score which is 6.2 ±1.94 compare to other formulated banana stem juice. The result shows that the panelists were not really attracted to the aappearance of the juices due to the juices containing some fibre from the banana stems. Besides, there is no colouring used in the formulation of the banana stem juices and thus may be the reason why the juices were dull and not appealing. Meanwhile, aside from control, the sample that has high mean is F1 (contain 35% of chestnut banana stem extract from species *Musa acuminata*) with 6.0 ± 1.66. Next, based on the colour, F3 (contain 35% horn banana stem extract from species *Musa x paradisiaca*) has the highest mean with 6.1 ± 1.39. But, all the sample was found to be not significant ($p > 0.05$) because the mean score for each of the sample were close. Colour has a significant effect on the other sensory characteristics. An attractive color and flavor will make unique and better drinks that ensure quality and overall acceptability [10]. In terms of the aroma, F1 has the highest mean with 5.7 ± 1.91 while control has the least mean score value which is 4.6 ±1.81. This is because, control sample did not contain any banana stem extract which can release the aroma like other samples. Besides, F3 also was found to have significantly ($p < 0.05$) highest degree of liking for taste attribute with 5.9 ± 1.75. Meanwhile, for the sweetness attributes, there are no significant differences ($p > 0.05$) among the samples. But, the sample that has the highest mean in terms of the sweetness is F2 (contain 35% of jackfruit banana stem extract from species *Musa x paradisiaca*) with 6.4 ± 1.47. Lastly, F2 also showed the significantly different ($p < 0.05$) highest degree of overall acceptance with 6.7 ± 1.76. A study found that the amount of sugar in a combination of soy and grapes in the proportions of 1:1.5 and 1:2 impacted with consumer acceptance of taste attributes and overall acceptance. The beverages with the greatest sugar concentration (14 ˚Brix)

being the most acceptable. This practise illustrates customers' desire for sweeter beverages [11]. The major drawback seen in banana stem juice was from the aroma of the product, so introduction of other flavouring agents could possibly increase consumer acceptance [12,13].

3.2 Antioxidant analysis

The antioxidant activity of DPPH was calculated by using the standard curve of gallic acid from formula in Eq. 1 (R^2 = 0.9833) varied from 40 to 100 µg/ml. Meanwhile, the antioxidant activity of the sample was measured as shown in Figure 2. Based on Figure 3, the highest percentage of scavenging activity is Formulation 4 which is 48.2%. The formulation consists of all three types of banana stem extract and that is why it has higher antioxidant activity. These results can be explained because Formulation 4 contains the highest amount of banana stem extract [14]. The effect of scavenging increased with increasing the sample's concentration and also will increase the percentage of inhibition [15]. The potent antioxidant activity of the beverage may be associated with the vitamin C content in the composition of banana stem [16].

$$Inhibition\ (\%) = \frac{(Absorbance\ sample - Absorbance\ control) \times 100}{Absorbance\ sample} \quad \text{Eq.1}$$

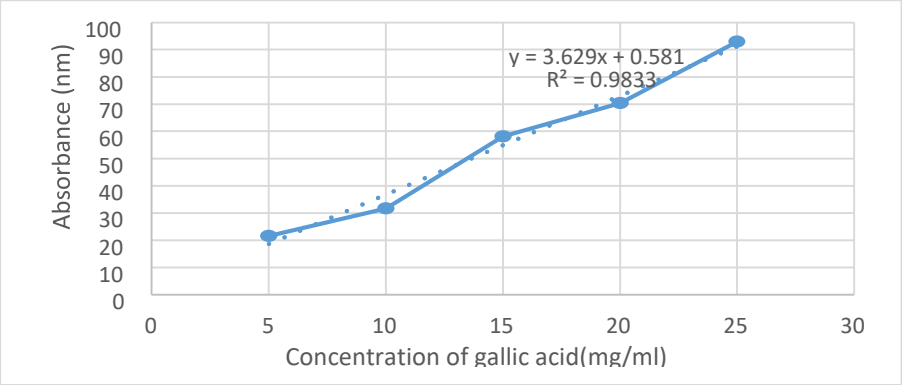

Figure 2: Gallic acid standard curve

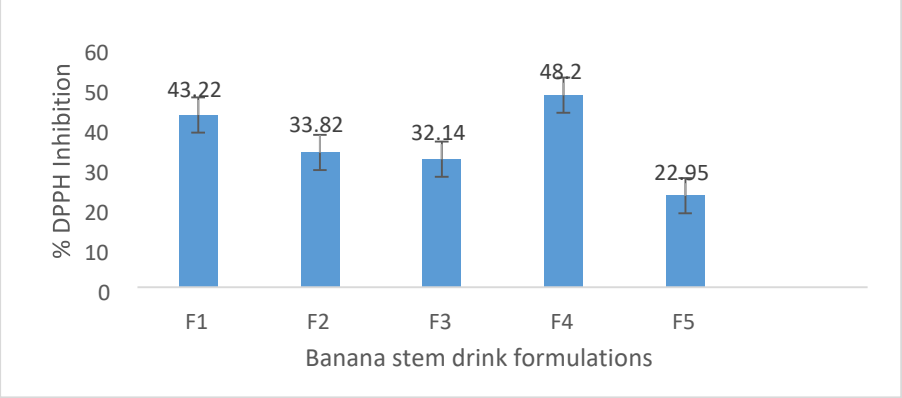

Figure 3: Percentage of DPPH inhibition of banana stem juices

3.3 pH

As shown in Table 3, the pH of the formulated banana stem juices was around 3.40 – 3.60 and the formulated banana stem juice that has higher pH is F3. F3 is the sample containing horn banana stem

extract. The combination of citric acid with banana stem juice produces the acidic and biting taste in the soft drink [17]. Moreover, citric acid which is an acidulant gives the sourness and increases thirstquenching effects in soft drinks [17]. That is why all of the formulated banana stem juice have lower pH and have an acidic nature. On the other hand, control has lower pH due to the drink not containing banana stem extract.

Table 3: pH of banana stem juice and control

Sample	pH
F1	3.41 ± 0.02
F2	3.44 ± 0.02
F3	3.58 ± 0.01
F4	3.43 ± 0.06
Control	2.67 ± 0.03

3.4 Sugar brix

Based on Table 4, all of the formulated banana stem juice has low total soluble solid. The sugar brix value is only around 0.8 to 1.7 %. The low value of sugar brix is due to the use of zero calorie sweeteners which are sucralose, stevia and sorbitol. Besides, all of the sweeteners were used only in small quantities. Compared to the control, the formulated banana stem juice has a little bit higher total soluble solid. This is because the banana stem may contain a carbohydrate that can increase the total soluble solid in the banana stem juice. Besides, the total soluble solid increased with gradual passage of storage time, which might be due to hydrolysis of polysaccharides into monosaccharide and oligosaccharides [18].

Table 4: The sugar brix value of banana stem juice and control

Sample	Sugar brix (%)
F1	1.20 ± 0
F2	1.20 ± 0
F3	1.67 ± 0.05
F4	1.1 ± 0.10
Control	0.8 ± 0

3.5 Colour

The reading of *LAB was recorded in Table 5. The data values were obtained in triplicate and expressed as mean ± SD.

Table 5: The colour value for banana stem juice and control

Sample	Colour
F1	L* = 64.47 ± 0.49 a* = 0.65 ± 0.017 b* = 2.61 ± 0.20

F2	L* = 58.44 ± 0.88 a* = 1.11 ± 0.18 b* = 9.74 ± 0.43
F3	L* = 63.83 ± 0.70 a* = 0.90 ± 0.18 b* = 4.01 ± 2.90
F4	L* = 62.94 ± 1.51 a* = 0.85 ± 0.12 b* = 6.61 ± 1.00
Control	L* = 62.72 ± 1.98 a* = 0.95 ± 0.03 b* = -2.07 ± 0.096

Colour provides a means of correctly presenting a beverage to the consumer, so that the perceived organoleptic attributes are correctly ordered in a sequence of appreciation [19]. Based on Table 5, L* axis shows brightness level where negative value indicates darker colour while positive value indicates lighter colour. For a* axis, negative values indicate green while positive values indicate red. On the other hands, for b*axis, negative values indicate blue and positive values indicate yellow. Based on the L*, a* and b* value of the banana stem juices, it can be described as a beverage with brighter colour, less red and more yellow than control. The yellowish colour of the juice that can be proved by the higher b* value may be related to citric acid interaction with pigments of the juices, resulting in the decrease in the color intensity [20]. Besides, control has negative value of b*, so, it indicates that the control sample has lighter colour than banana stem juice.

4. Conclusion

In conclusion, the low-calorie banana stem juice is able to produce with the used of low-calorie sweetener which are sucralose, stevia and sorbitol. Based on the results obtained, banana stem juice is a beverage with low pH, low sugar content and high nutritive value. It also has brighter colour, less red and more yellow than the control sample. From the findings, Formulation 2 (containing jackfruit banana stems from species *Musa x paradisiaca)* highest degree of overall acceptance with 6.7 ± 1.76, the antioxidant value of 33.82 percent, the pH of 3.44 ± 0.02 and sugar brix value of 1.20 ± 0. The results of this study indicate that the banana stem juice formulation can be a successful attempt to address the problem of sugary beverages and nutrient deficiency beverage in the market.

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