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Product development of functional beverage from jambolan (*Syzygium cumini*) juice supplemented with rambutan syrup

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Abstract -This study developed beverage from jambolan juice supplemented with the rambutan syrup. The rambutan syrups were prepared from three varieties including Rong Rien, See Chom Puu, and See Thong. The juices were extracted by compression and concentrated by rotary evaporation to have total soluble solid (TSS) around 75 °Brix. Based on color and texture attributes, with the highest viscosity, rambutan syrup from See Chom Puu was selected for further use as an ingredient in jambolan juice beverage. The beverage developed from jambolan juice supplemented with rambutan syrup 13 °Brix had highest liking scores of taste, texture and overall liking that were 7.14±1.2, 7.08±0.76 and 7.23±1.67, respectively. Therefore, this condition was chosen to study the effect of temperature and time on the properties of jambolan juice supplemented with rambutan syrup. oBased on sensory evaluation results, the temperature and time did not affect color, aroma, texture and overall acceptability of the jambolan juice supplemented with rambutan syrup, whereas, there was an effect on taste when temperature and time increased. This finding suggested that developed jambolan juice supplemented with rambutan syrup could be considered as an alternative functional beverage for health-conscious consumers.

Keywords: Rambutan, syrup, jambolan, juice, properties

1. Introduction

Jambolan (*Syzygium cumini*) or Jambolan, Jamblon, Jamun, Jamman, Indian black plum, is commonly found in different regions in Brazil, India, Malaysia, Thailand and others (Carvalho *et al*., 2017). The jambolan fruit contains a purple seed with sour taste. In India, it has been used as the medicinal plant and functional foods for a long time (Tavares *et al*., 2016, Swami *et al*., 2012). Jambolan has been highlighted in biological activities and antioxidant capacity. It contains 75 individual phenolic compounds in edible parts including 9 anthocyanin (mainly base on delphinidin, petunidin and mulvidin), 9 flavanols (myricetin, laricitrin and syringetin glycosides, 19 flavononols (dihexosides of dihydromyricetin and its methylated derivatives), 8 flavan-3-ol monomers (mainly gallocatechin), 13 gallotannins and 13 ellagitanins Tavares *et al*., 2016; Oliveira *et al*., 2016). Moreover, Singh *et al*. (2016) reported that jambolan fruit polyphenol extract exhibited ambroad-spectrum antimicrobial activity against pathogenic strains (*Staphylococcus aureus*, *Escherichia coli*, *Klebsiella pneumonia* and *Candida albicans*). Additionally, Branco *et al*. (2016) founded that the pasteurization led to an increase in the levels of total soluble solid, phenolic compound, flavonoids and preserved anthocyanin. So, the antioxidant capacity and in vitro anti-proliferative effects increased. In addition, in the evolution during the maceration-fermentation process of jambolan wine showed that the concentration of phenolic compounds and tannins were increased by 30 and 27.4 %, respectively in the final product (Branco *et al*., 2017). In 2021, Campos *et al*. (2021) investigated the production jambolan juice by mixing with camu-camu (*Myrciaria dubia*). The developed juice blend showed a good acceptance and high bioactive compound contents. Soares *et al.* (2018) investigated the jambolan sherbets. They found that the developed jambolan sherbet presented high total phenolic compound and DPPH inhibition.

Rambutan (*Nephelium lappaceum*) has been widely cultivated in many regions such as Chaina, India, Thailand, Taiwan, Malaysia and Australia (Zee *et al*., 1998). In Thailand, rambutan is cultivated in several area of the east and south part such as Chanthaburi, Rayong, Trat, Nakhon Si Thammarat, Chumphon and others. This fruit is round to oval shape. The aril is translucent and sweet. In addition, this fruit is low price in the season and short shelf life. Therefore, rambutan is widely used for manufacturing as processing fruit juices, beverages, wines, and others. The investigation of rambutan sugar granule production process has been studied (Charoensuk *et al*., 2015). In 2020, Pratiwi and Setiawan (2020) monitored the formulation of rambutan leaf extract on syrup preparation. Roengwatcharin *et al.* (2018) studied the production of drinking yoghurt from rambutan juice. Results revealed that the optimal production formula of drinking yoghurt from concentrated rambutan juice and syrup were 90:10 ((yoghurt : concentrated rambutan juice; 85:15):syrup).

Since, many researches about jambolan and rambutan as mentioned above have been reported, particularly, from the nutritional point of view, it is interesting to develop functional beverage from jambolan juice supplemented with rambutan syrup. Therefore, the aim of this study was to optimize syrup making process from three rambutan cultivars and to develop process for production of jambolan juice supplemented with the rambutan syrup.

2. Materials and methods

2.1 Materials

Rambutan and jambolan fruits were purchased from a local farmer in the district of Kao Kitchakut, Chanthaburi province,Thailand and then transported to the laboratory and stored in the refrigerator (4°C) before study.

2.2 Optimization of rambutan syrup making process

Three cultivars of rambutan including Rong Rien, See Chom Puu and See Thong were used. The rambutan juice was extracted by using the screw compression machine (Sakaya, Japan) with the speed of 100kg/h. The obtained juice was boiled (100°C) and held for 5 minumin. Then, the rambutan syrup was produced by using rotary evaporator (Steroglass s.r.1. Purugia, model strike 2000, Italy). The rambutan juice was evaporated for 1 h, or until to have total soluble solid (TSS) around 75 °Brix. The rambutan syrup was then subjected sensory evaluation. The syrup was diluted to 12 °Brix before the evaluation.

2.3 Sensory evaluation

The three rambutan syrups were investigated for sensory attributes (color, aroma, taste, texture, and overall liking) by using a 9-point hedonic scales (Watts *et al*., 1989) with 50 untrained panelists from the staffs and students Department of innovation Business (Faculty of Agro-industrial Technology, Rajamangala University of Technology Tawan-ok, Chanthaburi Campus, Chanthaburi, Thailand).

2.4 Physical properties determination

Color of rambutan syrup was measured by using a color meter (Nippon Denshoku, ZE-2000, Japan). The equipment was calibrated with a standard plate. The color measurement was expressed in L*, indicating the lightness on a 0 to 100 scale from black to white and a* (+,-) indicated the redness or greenness whereas b* (+,-) indicated yellowness and blueness. Viscosity of the syrup was determined by using Brookfield (MA02346, USA).

2.5 Chemical properties determination

Total soluble solid (TSS) was analysed by using a hand refractometer (Atago, Japan). The pH was measured with a pH meter (Subtex, Taiwan.

2.6 Product development of jambolan juice mixed with rambutan syrup

Jambulan juice was prepared by mashing jambulan pulp through the sieve, adding with water (1kg pulp : 3 kg water) and boiling at 100 °C for 10 min prior to filtration by using filter clth.

Jambolan juice beverage was initially formulated by mixing 35 % w/v jambulan juice with 7.4 % w/v sugar, 0.1 %w/v salt, and 57.50 %v/v water. The optimal formulation was evaluated by varying selected rambutan syrup contents added in the beverage for 4 levels ;221, 246, 270, 295 and 320 g to reach 9,10,11,12 and 13 °Brix, respectively. The summary diagram of this process as shown in Figure 1. The experimental design was Randomized Complete Block Design (RCBD). Sensory quality in terms of color, aroma, taste, texture and overall liking was evaluated by using a 9 point hedonic scale scoring as mentioned above. The physical properties and chemical properties also determined as previously descrusly.

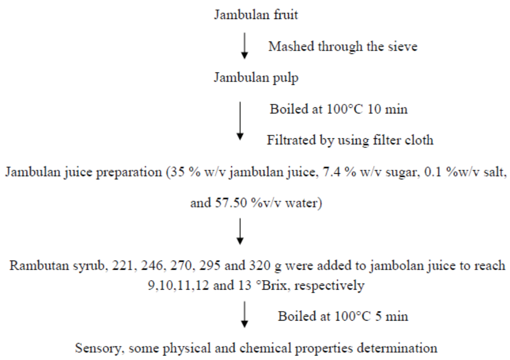

Figure 1. A schematic diagram of the product development of jambolan juice mixed with rambutan syrup

2.7 Pasteurization condition for the formulated jambolan juice beverage

Condition for pasteurization of optimal formulated beverage were opimized by varying three temperature levels including 80, 90 and 100 °C for 25, 30 and 35 minutes, respectively. The pasteurized jambolan juice were subjected to sensory evaluation, physical and chemical properties determination. Experimental design were 3^2 Factorial in Randomized Completely Block Design (RCB).

2.8 Determination of some properties of developed jambolan juice beverage

The pasturized jambolan juice beverage with best sensory property was selected for further investigation of physical, chemical and microbiological properies. The physical properties were investigated in terms of viscosity and color. The chemical properties were assessed for total soluble solid, pH, titratable acidity, total sugar, total sucrose and vitamin C. The total soluble solid was observed by using a hand refractometer (Atago, Japan). Total acidity expressed as percent lactic acid was determined by titrating with 0.02 N NaOH to pH 8.2. Total sugar and total sucrose were determined according to the method of Widdowson and McCance (1934). Vitamin C content was analysed by the titrimetric method evaluated based on reduction of 2,6-dichorophenolindophenol (DCPI) in a medium containing oxalic acid (Silva *et al*., 2017). For microbiological quality, total plate count, yeast and mold count, coliform and *Escherichai coli* were investigated. Total plate count and yeast and mold count reported as CFU/ml were detemined by plating onto Nutrient Agar and Potato Dextrose Agar incubate under 37ºC and 30ºC for 24-48 h, respectively (Yoon *et al*., 2003). Coliform bacteria and *Escherichai coli* were determioned by MPN (Most Probable Number) test. *E. coli* in the positive tubes were confirmed by streaking on EMB (Eosin Methylene Blue) agar plate, incubated for 24 h at 37°C (Feng *et al*., 1998).

2.10 Statistical analysis

All experiments were evaluated in triplicate using different lots of jambolan juice. Analysis of variance (ANOVA) ($p \leq 0.05$) were proceeded the data. Significant difference among means within each experiment were separated by Duncan's multiple range test (DMRT) at a significance level of $\alpha = 0.05$ by using computer software (Helge, 2009).

3. Results

Sensory properties of rambutan syrups made were evaluated. Results as shown in Table 1, acceptability was evaluated using a structured hedonic scale of 9 points, from 1 (dislike extremely) to 9 (like extremely).

Rambutan syrup produced from See Chom Puu cultivar had highest score in color and texture with the scores of 7.12±1.08 and 6.84±1.06, but did not differ significantly from Rong Rien. In contrast, rambutan syrup produced from Rong Rien had highest score in aroma, taste and overall liking with the scores of 6.64±0.98, 7.16±0.87 and 7.06±1.11 (like moderately); respectively, but, the value did not significantly difference from See Chom Puu.

Table 1. Sensory attributes of rambutan syrup produced from three varieties of rambutan

The varieties of rambutan	Likeness scores				
	Color	Aroma	Taste	Texture	Overall liking
Rong Rien	6.46±1.04^{b}	6.64±0.98^{a}	7.16±0.87^{a}	6.78±1.12^{a}	7.06±1.11^{a}
See Chom Puu	7.12±1.08^{a}	6.32±1.11^{ab}	6.74±1.04^{a}	6.84±1.06^{a}	7.00±1.24^{a}
See Thong	5.12±1.14^{c}	6.02±1.03^{b}	5.54±1.35^{b}	6.16±0.99^{b}	5.86±1.26^{b}

Physical and chemical properties of rambutan syrups from three varieties of rambutan as presented in the Table 2 were significantly different ($p \leq 0.05$). Rambutan syrup produced from See Chom Puu had significantly higher viscosity (3,582.66±0.03 centripoise) relative to the other syrups ($p \leq 0.05$). Also, this rambutan syrup exhibited value in lightness (L*) and yellowness (b*) with the data 15.15±0.14 and 10.03±1.10, respectively. For pH value that reflects the acceptability in taste attribute, syrup from Rong Rien had significantly higher pH (5.05±0.13) than See Chom Puu (4.93±0.23). However, sensory scores in term of taste of both cultivars were not significantly different. Overall, based on color, texture, viscosity and also the price aspect, rambutan syrup made from See Chom Puu was selected for further application in development of beverage from jambolan juice supplemented with rambutan syrup.

Table 2. Physical properties of rambutan syrup produced from three varieties of rambutan

The varieties of rambutan	Total soluble solid (°Brix)	Viscosity (Centripoise)	pH	Color parameters		
				L*	a*	b*
Rong Rien	75	485.730±0.05[c]	5.05±0.13[a]	8.87±0.24[c]	5.16±0.45[b]	6.21±1.11[c]
See Chom Puu	75	3582.66±0.03[a]	4.93±0.2[3]b	15.15±0.14[a]	1.09±0.98[c]	10.03±1.10[a]
See Thong	75	2236.66±0.10[b]	4.54±0.67[c]	9.30±0.55[b]	9.25±0.34[a]	6.51±0.14[b]

The sensory attributes of beverages made from jambolan juice supplemented with varying rambutan syrup at five levels including 9, 10, 11, 12 and 13 °Brix, was shown in Table 3. Results showed that color and aroma of all beverage formulas were not significantly different. Interestingly, jambolan juice supplemented with 13 °Brix rambutan syrup had highest score in taste, texture and overall liking with 7.14±1.2, 7.08±0.76 and 7.23±1.67 (like moderately), respectively.

Table 3. Sensory attributes of jambolan juice supplemented with various concentration of rambutan syrup

Formulas	Total s oluble solid (°Brix)	Likeness scores				
		color[ns]	Aroma[ns]	Taste	Texture	Overall liking
1	9	6.72±1.44	6.58±0.45	6.04±1.34[c]	6.30±1.25[c]	6.50±1.05[c]
2	10	6.88±1.35	6.50±0.67	6.20±1.45[c]	6.38±0.78[c]	6.62±1.34[c]
3	11	6.52±1.06	6.84±1.11	6.78±0.56[b]	6.64±2.33[bc]	6.90±0.35[ab]
4	12	6.88±0.67	6.82±1.06	6.96±0.34[ab]	6.76±1.33[b]	6.80±.155[b]
5	13	6.44±0.34	6.64±1.24	7.14±1.23[a]	7.08±0.76[a]	7.23±1.67[a]

According to results in table 4, jambolan juice supplemented with 13 °Brix rambutan syrup had significantly higher viscosity than the other formulas. Moreover, the addition of rambutan syrup tended to increase color parameter in lightness (L*), redness (a*) and yellowness (b*). The chemical properties of all beverage formulas were exhibited in Table 5. The rambutan syrup had no effect on titratable acidity. On the other hand, a slight decrease in pH was observed when the higher amount of rambutan syrup was added. Based on sensory evaluation, chemical and physical properties determination, therefore, formula 5 (jambolan juice supplemented with 13°Brix rambutan syrup) was chosen for further evaluation.

Table 4. Physical properties of jambolan juice supplemented with various concentrations of rambutan syrup

Formulas	Total soluble solid (°Brix)	Viscosity (Centripoise)	Color parameters		
			L*	a*	b*
1	9	1.70±0.04^{e}	8.66±0.44^{d}	7.28±1.02^{c}	2.08±0.11^{c}
2	10	1.74±0.46^{d}	8.98±0.22^{c}	7.27±0.05^{c}	2.13±0.08^{b}
3	11	1.80±0.12^{c}	8.64±0.13^{d}	7.00±0.12^{d}	2.01±0.05^{c}
4	12	1.87±0.22^{b}	9.14±0.25^{b}	7.38±0.16^{b}	2.21±0.12^{ab}
5	13	1.92±0.12^{a}	9.32±0.11^{a}	7.61±0.65^{a}	2.27±0.15^{a}

Values with a different letter are significantly different ($p \leq 0.05$) according to Duncan's multiple range test.

Table 5. Chemical properties of jambolan juice supplemented with various concentrations of rambutan syrup

Formulas	Total soluble solid (°Brix)	Titratable acidity^{ns} (%)	pH
1	9	0.16±0.41	4.04±0.03^{a}
2	10	0.16±0.11	3.93±0.05^{ab}
3	11	0.16±0.23	3.92±1.23^{ab}
4	12	0.17±0.45	3.74±1.45^{b}
5	13	0.18±0.02	3.73±1.04^{b}

Values with a different letter are significantly different ($p \leq 0.05$) according to Duncan's multiple range test.

The formulas 5 (jambolan juice supplemented with 13°Brix rambutan syrup) was made for use in the study of the effect of temperature (°C) and time (min) on jambolan juice supplemented with of rambutan syrup. Nine treatments were conducted and then subjected to sensory evaluation. The results are represented in Table 6. From sensory evaluation, the color, aroma, texture and overall acceptability in the selected formula heat-treated under different conditions were not significantly different. However, the score of taste tended to decrease when the temperature and time increase.

Table 6. Effect of the temperature and time on sensory evaluation of jambolan juice supplemented with of rambutan syrup

Treatment	Tenperature (°C) : time (min)	Likeness scores				
		Color[ns]	Aroma[ns]	Taste	Texture[ns]	Overall liking [ns]
1	80:25	7.10±1.23	6.66±1.65	7.00±1.22[a]	6.30±1.23	6.88±0.12
2	80:30	7.02±1.44	6.67±1.66	6.58±0.45[ab]	6.32±1.45	6.58±0.15
3	80:35	7.08±1.56	6.42±0.23	6.54±0.55[ab]	6.20±0.34	6.62±1.01
4	90:25	6.94±1.05	6.56±0.65	6.64±0.12[ab]	6.28±1.22	6.78±0.34
5	90:30	6.82±1.09	6.36±0.33	6.70±0.44[ab]	6.18±0.34	6.64±0.15
6	90:35	6.96±1.33	6.74±0.04	6.66±0.13[ab]	6.26±0.06	6.70±0.56
7	100:25	6.96±1.76	6.62±0.08	6.68±0.06[ab]	6.28±0.78	6.78±1.56
8	100:30	6.84±1.45	6.50±0.23	6.56±0.07[ab]	6.22±0.23	6.80±0.12
9	100:35	6.84±1.78	6.56±0.05	6.50±0.78[b]	6.38±0.45	6.66±0.23

Effects of the temperature and time on physical properties of jambolan juice supplemented with of rambutan syrup are presented in Table 8. The temperature and time exhibited their effects on viscosity and color parameters.

Table 8. Effect of the temperature and time on physical properties of jambolan juice supplemented with of rambutan syrup

Treatments	Temperature (°C) : time (min)	Viscosity (Centipoise)	Color parameters		
			L*	a*	b*
1	80:25	1.56±0.34[b]	9.72±0.03[a]	6.52±0.77[bc]	1.90±0.03[c]
2	80:30	1.57±0.23[b]	9.52±0.15[ab]	6.88±0.34[a]	2.06±0.86[b]
3	80:35	1.61±0.11[a]	9.81±0.34[a]	6.79±0.37[a]	2.08±0.34[ab]
4	90:25	1.57±0.12[b]	9.73±0.87[a]	6.71±0.44[ab]	2.12±0.35[ab]
5	90:30	1.55±0.13[bc]	9.80±0.34[a]	6.76±0.22[ab]	2.16±0.12[ab]
6	90:35	1.56±0.04[bc]	9.66±0.34[ab]	6.69±0.45[ab]	2.08±0.11[ab]
7	100:25	1.55±0.11[cd]	9.59±0.33[ab]	6.39±1.02[cd]	2.08±0.13[ab]
8	100:30	1.52±0.23[d]	9.40±0.44[ab]	6.32±1.34[cd]	2.23±0.14[a]
9	100:35	1.53±0.34[cd]	9.38±0.89[b]	6.22±0.14[d]	2.17±0.45[ab]

Effects of the temperature and time on some chemical properties of jambolan juice supplemented with of rambutan syrup are showed in Table 9. The results demonstrated that temperature and time had no effect on titratable acidity and pH.

Table 9. Effect of the temperature and time on chemical properties of jambolan juice supplemented with of rambutan syrup

Treatments	Temperature (°C) : time (min)	Titratable acidity^{ns} (%)	pH^{ns}
1	80:25	0.29±0.34	4.11±0.35
2	80:30	0.29±0.23	4.13±0.23
3	80:35	0.29±0.09	4.12±0.33
4	90:25	0.28±0.56	4.14±0.22
5	90:30	0.29±0.12	4.15±0.12
6	90:35	0.29±0.22	4.12±0.14
7	100:25	0.29±0.45	4.13±0.44
8	100:30	0.28±0.23	4.15±0.56
9	100:35	0.29±0.23	4.14±0.67

The properties of developed beverage from jambolan juice supplemented with rambutan syrup under heat-treated process from treatment 1 (pasteurized at 80 °C, 25 min) was selected to determine final product properties as exhibited in table 10. The physical properties of developed jambolan juice, its viscosity was 1.56 centipoise and color parameter in lightness, redness, yellowness were 9.72, 6.52 and 1.90; respectively. For the chemical properties, total soluble solid, pH, titratable acidity, total sugar, total sucrose and vitamin C content were 13°Brix, 4.11, 0.29%, 2.69%, 29.64% and 5.05 mg./100 ml., respectively. For microbiological properties, total plate count, coliform, *Escherichia coli* and yeast and mold were < 10^4 CFU/ml, 2.2 MPN/100 ml, not detected and <10 CFU/ml, respectively.

Table 10. The properties of developed beverage from jambolan juice supplemented with rambutan syrup

The properties of developed beverage from jambolan juice	Average values
Physical properties	
- Viscosity (Centripoise)	1.56
- Color parameters	
Lightness(L*)	9.72
Redness(a*)	6.52
Yellowness(b*)	1.90

Table 10. The properties of developed beverage from jambolan juice supplemented with rambutan syrup (cont.)

The properties of developed beverage from jambolan juice	Average values
Chemical properties	
-Total soluble solid (°Brix)	13
- pH	4.11
- Titratable acidity (%)	0.29
- Total sugar(%)	2.69
- Total sucrose(%)	29.64
- Vitamin C content (mg./100 ml.)	5.05
Microbiological properties	
- Total plate count (CFU/ml)	$<10^4$
- *Coliform bacteria*	2.2 MPN/100 ml
- *Escherichia coli*	-
- yeast and mold(CFU/ml)	<10

4. Discussion and conclusion

From the study of the sensory and physico-chemical properties of rambutan syrups, rambutan syrup produced from See Chom Puu cultivar had higher score in color and texture. This could be due to the color of See Chom Puu cultivar syrup appeared bright golden yellow that could be the factor affecting those two attributes more than the other syrups. Although, the three cultivars of rambutan showed the same brix (75°Brix), the differences in viscosity were observed. Since initial total soluble solid of each rambutan cultivar were different, particularly, the initial TTS of Rong Rien cultivar was high, up to approximately 21 °Brix (data not shown). Therefore, the evaporation time in making this rambutan syrup was significantly shorter than the other 2 cultivars, allowing the syrup to have lowest viscosity relative to others. In addition, the color intensity of rambutan might affect refractive index of TSS in term of brix value (Winkler & Knoche, 2018). Thus, the identical TSS value observed as 75°Brix by refractometer might not reflect the actual TSS in the syrup. Based on color, texture with highest in viscosity and also the low-price aspect, See Chom Puu was a potential alternative selected for making syrup and used as beverage supplement.

The addition of rambutan syrup tended to increase color parameters in lightness(L*), redness(a*) and yellowness (b*). The color parameters were increased depending up on amount of rambutan syrup addition. Furthermore, it was observed that pH was slightly decreased when rambutan syrup was added with higher amount (Table 5). The pH changes could be influenced by organic acids naturally present in rambutan such as protocatechuic acid, syringic acid, caffeic acid, and chlorogenic acid that could be significantly concentrated a long with TSS during process of evaporation (Hernandez-Hernandeza *et al.*, 2019).

Based on sensory, chemical and physical properties, formula 5 (jambolan juice supplemented with 13°Brix rambutan syrup) was chosen for evaluation of the effect of temperature and time on properties of jambolan juice supplemented with rambutan syrup. In this study, the score of taste tended to decrease when the temperature and time increase. High temperature and long time of pasteurization cause degradation of vitamins, the softening of texture, loss of color, development of off-flavors, and destruction of enzymes that could associate to the decrease of taste acceptance score of the consumers (Sun, 2009).

In conclusion, rambutan syrup produced from See Chom Puu cultivar had higher scores in color and texture and was selected for syrup making. The beverage made from jambolan juice adding with 13 °Brix rambutan syrup had best sensory attributes in taste, texture and overall liking. Interestingly, this is the first report in production of beverage from jambolan juice supplemented with rambutan syrup instead of sugar. This research could be an alternative to utilize and preserve rambutan which is a short shelf-life fruit and also value adding of the fruit that will help resolve the problem of oversupply in some seasons. However, bioactivity compounds associated to health promotion such as antioxidant activity and polyphenol, flavonoids, anthocyanin contents, and other bioactivities of the beverage developed from jambolan juice require further invesigation.

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