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## Antioxidative and Sensory Properties of Tea Made from Jambolan (*Syzygium cumini*) Fruit Peel

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## Antioxidative and Sensory Properties of Tea Made from Jambolan (*Syzygium cumini*) Fruit Peel

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**Abstract.** Jambolan fruit peel contains anthocyanin with purple-dark color. Jambolan fruit peel could be processed to become tea by a simple drying process. The aim of this study was to evaluate the effect of drying process both sun and oven drying to produce tea of jambolan fruit peel on the anthocyanin content, phenolic content, brewing efficiency, antioxidant activity, and hedonic-sensory property of tea. Jambolan fruit peel was dried using sun and oven drying at temperatures of 50 and 60°C. Jambolan fruit peel tea were extracted anthocyanin/polyphenol compounds using 0.1% HCl-methanol or brewed using hot water of 98°C by addition sucrose and citric acid. The tea products was determined anthocyanin and polyphenol contents, antioxidant activity by using DPPH (2,2-diphenyl-1-picrylhydrazyl) method, FRAP (ferric reducing antioxidant power), hydroxyl radical (OH<sup>•</sup>), and sensory characteristic. The results showed that drying temperature significantly affected content of anthocyanin and polyphenol, antioxidant activity, and sensory preference of jambolan fruit peel tea. The drying process using oven at temperature 50°C resulted better characteristic of tea with higher anthocyanin content, total phenolic content, and antioxidant activities than drying process of tea using sun drying and oven at temperature 60°C. The panelists most preferred tea made by oven drying at temperature 50°C based on the highest sensory score of color, aroma, taste, and overall attributes (score 3.12 - 4.28, moderate to like). Tea of jambolan fruit peel could be developed as functional food with high anthocyanin and antioxidant properties.

### 1. Introduction

Jambolan (*Syzygium cumini*), also known as jambolão, jambul, jamun, java plum, duhat, or jamblang is one of the tropical edible fruit, that is widely found in Indonesia. The jambolan fruits have a small size (2-4 cm length), egg-shaped, and purple-dark color peel when ripe. Several different phenolic classes, such flavonols, flavanonols, anthocyanins have been reported in the jambolan fruit in high amounts [1, 2, 3, 4]. Anthocyanins, water soluble pigment, are one of the main polyphenols present especially in the fruit peel with purple-dark color. The anthocyanin content of whole ripe jambolan fruit is 161 mg/100 g (fresh weight). The highest level of anthocyanin content was found in the jambolan fruit peel on an average of 731 mg/100 g (fresh weight) which was 4.5 fold greater than the whole fruit [5]. The type of anthocyanins contained in the jambolan fruit consists of 3,5-diglucoside derivatives of delphinidin, petunidin, malvidin, cyanidin, and peonidin [1, 3, 4, 5]. The existence and level of each type of anthocyanins depend on jambolan varieties. The potential biological activities of jambolan fruit had been highlighted, such antioxidant activity [2, 6, 7]. The antioxidant activity of jambolan fruit was contributed to its phenolic constituents, mainly to the high content of anthocyanins in the fruit peel.



The ripe jambolan fruits are usually consumed as fresh fruit and also prepared as processed foods, such wine, juice, frozen yoghurt, freeze-dried fruit, spray-dried fruit juice powder [8, 9, 10, 11, 12]. The jambolan fruit peel had been processed to powder for use as a natural colorant [13]. The anthocyanin extract of jambolan fruit peel was also used as natural colorant with addition copigment of cinnamic acid and rosemary polyphenolic to increase color intensity of jambolan anthocyanins [14]. The jambolan fruit peel with high anthocyanin content are still potential to be processed to other food products, such tea product by a simple drying process. The drying process could be done in a natural way (sun drying) or by an artificial drying method using a dryer such as an oven. Anthocyanins have low stability characteristic toward heat or temperature [15, 16]. Heating during drying process could degrade anthocyanins and caused changes in the anthocyanin levels or other polyphenol constituents, that it influenced the anthocyanin content of tea product after drying process. However, it has been known the temperature suitable for drying of jambolan fruit peel and effect of drying temperature on the anthocyanin and total phenolic contents, as well as antioxidant activity. The aim of this study is to evaluate the effect of drying process (sun and oven drying) to produce tea from jambolan fruit peel on anthocyanin and total phenolic contents, brewing efficiency, antioxidant activity, and hedonic-sensory characteristic of tea.

## 2. Materials and Methods

### 2.1. Materials and chemicals

The fully ripe Indonesian jambolan fruits were obtained from a local market at Jember district, East Java Province, Indonesia. Other ingredients were sucrose and citric acid obtained from modern market. Chemicals and reagents used for extraction and analysis were pro analysis purchased from Merck (Darmstadt, Germany) and Sigma-Aldrich (St. Louis, MO).

### 2.2. Production of tea from jambolan fruit peel

The jambolan fruits were selected for fully dark purple color peel and washed on tap water. The fruit peels were manually separated using stainless steel knife. The peels were placed on trays and subjected to dehydration at temperatures of 50 and 60°C for 20 hours using oven drying machine, and sun drying for 24 hours. The dried products were ground using a dry blender for particle size reduction and stored in polyethylene plastic bags at -20°C until further analysis (anthocyanin extraction and tea brewing).

### 2.3. Anthocyanin extraction of jambolan fruit peel tea

Anthocyanins were extracted with solvent of 0.1% HCl in methanol [17] by vigorous stirring. One gram of dried tea was extracted using 25 mL solvent for 1 hours at room temperature, then filtrated using filter paper Whatman No. 1. The extraction was performed four times with the same solvent until the filtrate obtained was nearly colorless. The extracts were combined and transferred to 100 ml volumetric flask. The extracts were determined total phenolic and anthocyanin to calculate brewing efficiency of dried tea.

### 2.4. Tea brewing preparation

Dried tea made from jambolan fruit peel was prepared to brewing with procedure according to household brewing condition. The dried tea (4 gram), sucrose (8 gram), and citric acid (0.2 gram) in glass cup were poured with 100 mL of hot water at 98°C and agitation with spoon for 10 minutes. Tea infusions were separated from the solid matrix by filtration and determined the content of total phenolic and anthocyanin, antioxidant activity.

### 2.5. Determination of total phenolic and anthocyanin content

The content of total phenolic was determined using the Folin-Ciocalteu method, based on the colorimetric oxidation/reduction reaction of phenols [18]. The total phenolic content were calculated based on the standard curve of gallic acid (GA) and expressed as milligrams of Gallic Acid Equivalents (GAE) per 100 mL of tea infusions (mg GAE/100 mL) or per g of dried tea (mg GAE/g).

The total anthocyanin content was determined using the pH differential method [19], which relies on the structural transformation of the anthocyanin chromophore as a function of pH. Absorbance was measured at 520 and 700 nm. Anthocyanin was calculated as cyanidin-3-glucoside using a molar extinction coefficient of 29600 and a molecular weight of 448.8. The total anthocyanin content was expressed as milligrams of Cyanidin-3-glucoside Equivalents (CyE) per 100 mL of tea infusions (mg CyE/100 mL) or per g of dried tea (mg GAE/g).

#### 2.6. Determination of antioxidant activity

The antioxidant activity was determined on the basis of ability of antioxidant compound to scavenge the stable radical DPPH, DPPH method [20], scavenge hydroxyl radical (OH<sup>•</sup>) [21], and reducing power, FRAP (ferric reducing antioxidant power) method [22] as indication of the potential antioxidant activity. The antioxidant activities of tea infusions or dried tea were expressed in term of trolox equivalent antioxidant capacity, TEAC (mmol trolox equivalents per 100 mL of tea infusions, mmol TE/100 mL or per g of dried tea, mmol TE/g).

#### 2.7. Sensory analysis

Sensory analysis of tea infusions was conducted by hedonic scoring method [23] and performed by 50 untrained panelists. The attributes of color, aroma, taste, and overall of tea infusions were used in the hedonic test with 1-5 grading score, dislike very much (score 1) to like very much (score 5).

#### 2.8. Statistical analysis

The experiments were carried out in triplicates. The values in the results were represented as mean  $\pm$  standard deviation. Statistical analysis was performed using one way - analysis of variance (SPSS version 17 statistical software). The significant differences in the total phenolic content, anthocyanin content, and antioxidant activities were verified based on Duncan's multiple range test. Differences at  $p < 0.05$  were considered to be statistically significant.

### 3. Results and Discussion

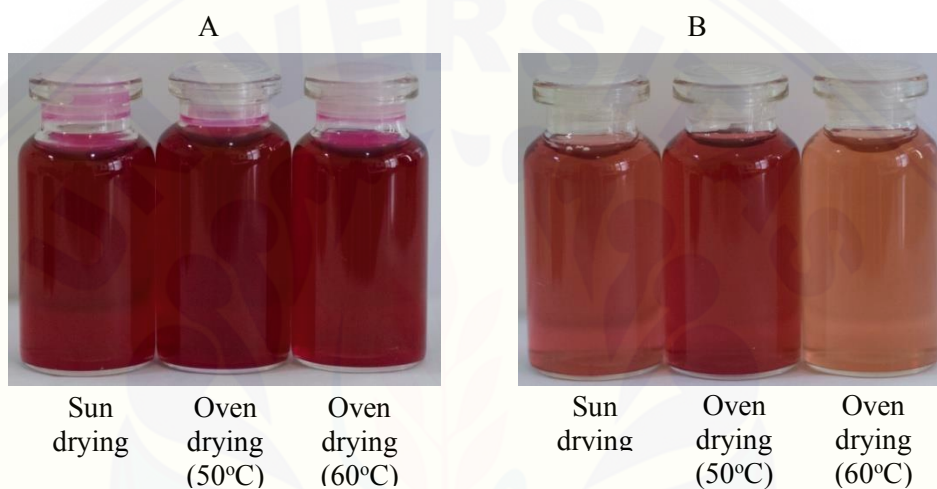
#### 3.1. Dried and infusion tea

Production of jambolan fruit peel tea was conducted by two drying methods, namely sun and oven (temperatures 50 and 60°C) drying. The dried teas of jambolan fruit peel are presented in Figure 1. The color of dried teas obtained by both sun and oven drying have no color difference (purple-dark color).

Anthocyanins in the dried tea of jambolan fruit peel were extracted using solvent of 0.1% HCl-methanol to determine brewing efficiency. Anthocyanins are polar compound, they are more soluble in polar solvents such methanol. The extracts of jambolan fruit peel tea are presented in Figure 2a. The color of extracts showed a deep red color and there is no difference on color of extract of dried tea made from 3 different drying process. Dried tea was also brewed according to household brewing condition to obtain tea infusion with addition of sucrose and citric acid. The tea infusions by brewing are presented in Figure 2b. Tea infusion from tea production using oven drying at temperature 50°C has deeper red color. Tea infusions from tea production using sun drying and oven drying at temperature 60°C have faded color and tends to brownish red color. Usage higher temperature of drying during tea production could degrade anthocyanins and cause higher color loss. Color loss and formation of brown color during drying occurs because of water nucleophilic attack in the position 2 of flavylium cation, resulting formation of the colorless carbinol (hemiketal), open chalcone forms, and subsequent color loss. Anthocyanin degradation continues to formation of brown colored compounds of alpha diketon in the presence of oxygen [24, 25, 26].



**Figure 1.** Dried tea of jambolan fruit peel



**Figure 2.** Anthocyanin extracts of dried tea by extraction using 0,1% HCl-methanol solvent (A) and tea infusions by brewing (B)

### 3.2. Total anthocyanin and phenolic content

The total anthocyanin and phenolic contents of jambolan fruit peel tea are presented in Table 1. The total anthocyanin contents were significantly different ( $p < 0.05$ ) among drying process (sun drying, oven drying at temperatures of 50 and 60°C) in the samples of dried tea and tea infusion, respectively. The highest anthocyanin contents were found in the tea sample made by oven drying at 50°C (5.09 mg CyE/g dried tea and 15.81 mg CyE/100 mL tea infusion), followed by sun drying (3.83 mg CyE/g dried tea and 11.51 mg CyE/100 mL tea infusion) and the lowest value was tea made by oven drying at temperature 60°C (3.12 mg CyE/g dried tea and 9.17 mg CyE/100 mL tea infusion). The brewing efficiency (based on anthocyanin content) ranged from 73.62 to 77.72% and the highest value was also found in the tea sample made by oven drying at temperature 50°C.

The total phenolic content of tea samples shown trend data similar with anthocyanin content. Jambolan fruit peel tea made by oven drying at temperature 50°C showed highest value of total phenolic content (11.38 mg GAE/g dried tea and 31.09 mg GAE/100 mL tea infusion) and brewing efficiency based on phenolic content (67.37%).

Increase in the drying temperature results in loss of anthocyanin and polyphenol concentration in the tea samples. Stability of anthocyanin and polyphenol are influenced by temperature. Increase in the drying temperature can stimulate the accumulation of anthocyanin degradation compounds such as chalcone and its colorless derivatives. This causes a decrease in anthocyanin content during drying process.

**Table 1.** Total anthocyanin and phenolic contents of tea made from jambolan fruit peel

Parameter	Tea process		
	Sun drying	Oven drying (50°C)	Oven drying (60°C)
<b>Total anthocyanin</b>			
Total anthocyanin content (mg CyE/g dried tea) <sup>1</sup>	3.83 ± 0.103 <sup>b3)</sup>	5.09 ± 0.030 <sup>c</sup>	3.12 ± 0.089 <sup>a</sup>
Total anthocyanin content (mg CyE/100 mL tea infusion) <sup>2</sup>	11.51 ± 0.224 <sup>b</sup>	15.81 ± 0.066 <sup>c</sup>	9.17 ± 0.151 <sup>a</sup>
Total anthocyanin content (mg CyE/100 mL tea extract) <sup>1</sup>	15.34 ± 0.410 <sup>b</sup>	20.34 ± 0.125 <sup>c</sup>	12.46 ± 0.357 <sup>a</sup>
Brewing efficiency- based on anthocyanin content	75.04 ± 1.343 <sup>a</sup>	77.72 ± 0.813 <sup>b</sup>	73.62 ± 0.905 <sup>a</sup>
<b>Total phenolic</b>			
Total phenolic content (mg GAE/g dried tea) <sup>1</sup>	7.38 ± 0.059 <sup>b</sup>	11.38 ± 0.110 <sup>c</sup>	6.51 ± 0.087 <sup>a</sup>
Total phenolic content (mg GAE/100 mL tea infusion) <sup>2</sup>	19.34 ± 0.658 <sup>b</sup>	31.09 ± 0.138 <sup>c</sup>	16.95 ± 0.060 <sup>a</sup>
Total phenolic content (mg GAE/100 mL tea extract) <sup>1</sup>	29.53 ± 0.235 <sup>b</sup>	45.51 ± 0.442 <sup>c</sup>	26.02 ± 0.347 <sup>a</sup>
Brewing efficiency -based on phenolic content	66.78 ± 0.646 <sup>a</sup>	67.37 ± 0.974 <sup>a</sup>	65.45 ± 0.824 <sup>a</sup>

<sup>1</sup> Determining on extract by extraction using 0.1% HCl-methanol solvent

<sup>2</sup> Determining on tea infusion by brewing using hot water (98°C)

<sup>3</sup> Data were expressed as a mean±standard deviation (SD). Different superscripts in the sama raw indicate significant differences based on Duncan's multiple range test ( $p < 0.05$ )

### 3.3. Antioxidant activity

Antioxidant activities of jambolan fruit peel tea, shown in Table 2 were determined based on DPPH and OH (hydroxyl) radical scavenging activities, ferric reducing antioxidant power (FRAP). The range of DPPH radical scavenging activity of tea samples was 1.11 to 1.76 mmol TE/g of dried tea and 4.11 to 6.02 mmol TE/100 mL of tea infusion. The range of hydroxyl radical (OH<sup>•</sup>) scavenging activity of tea samples was 3.13 to 5.52 mmol TE/g of dried tea and 9.06 to 17.97 mmol TE/100 mL of tea infusion. The value of ferric reducing antioxidant power ranged from 0.95 to 1.37 mmol TE/g of dried tea and 3.37 to 4.91 mmol TE/100 mL of tea infusion. Jambolan fruit peel tea made by oven drying at temperature 50°C had significantly ( $p < 0.05$ ) highest antioxidant activities determined by 3 different methods of antioxidant activity.

Antioxidant activity of tea samples were contributed by polyphenol especially anthocyanin compounds. Anthocyanin contained in the tea had ability to donate hydrogen atom to radical and as metal chelator. Anthocyanin are flavonoid class of polyphenol compound. The type of anthocyanins contained in the jambolan fruit peel consists of 3,5-diglucoside derivatives of delphinidin, petunidin, malvidin, cyanidin, and peonidin [1, 3, 4, 5]. Antioxidant activity of anthocyanin is influenced by hydroxylation and the presence of sugar group (glycoside). Anthocyanin in the form of aglycone is more active as antioxidant than the form of glycosides [27].

**Table 2.** Antioxidant activity of tea made from jambolan fruit peel

Parameter	Tea Process		
	Sun drying	Oven drying (50°C)	Oven drying (60°C)
<b>DPPH radical scavenging</b>			
Antioxidant activity (mmol TE/g dried tea) <sup>1</sup>	1.41 ± 0.033 <sup>b3</sup>	1.76 ± 0.020 <sup>c</sup>	1.11 ± 0.021 <sup>a</sup>
Antioxidant activity (mmol TE/100 mL tea infusion) <sup>2</sup>	5.11 ± 0.278 <sup>b</sup>	6.02 ± 0.109 <sup>c</sup>	4.11 ± 0.051 <sup>a</sup>
<b>OH radical scavenging</b>			
Antioxidant activity (mmol TE/g dried tea) <sup>1</sup>	4.07 ± 0.015 <sup>b</sup>	5.52 ± 0.018 <sup>c</sup>	3.13 ± 0.109 <sup>a</sup>
Antioxidant activity (mmol TE/100 mL tea infusion) <sup>2</sup>	13.53 ± 0.561 <sup>b</sup>	17.97 ± 0.448 <sup>c</sup>	9.06 ± 0.234 <sup>a</sup>
<b>FRAP (ferric reducing antioxidant power)</b>			
Antioxidant activity (mmol TE/g dried tea) <sup>1</sup>	1.25 ± 0.006 <sup>b</sup>	1.37 ± 0.004 <sup>c</sup>	0.95 ± 0.009 <sup>a</sup>
Antioxidant activity (mmol TE/100 mL tea infusion) <sup>2</sup>	4.45 ± 0.031 <sup>b</sup>	4.91 ± 0.052 <sup>c</sup>	3.37 ± 0.021 <sup>a</sup>

<sup>1</sup> Determining on extract by extraction using 0.1% HCl-methanol solvent

<sup>2</sup> Determining on tea infusion by brewing using hot water (98°C)

<sup>3</sup> Data were expressed as a mean±standard deviation (SD). Different superscripts in the same row indicate significant differences based on Duncan's multiple range test ( $p < 0.05$ )

### 3.4. Sensory preference

Sensory analysis was performed by hedonic scoring method to identify the tea product which most preferred by panelist. The characteristic of sensory preference on attributes of color, aroma, taste and overall was shown in Table 3. Table 3 showed that the panelists preferred tea made by oven drying at temperature 50°C based on the highest preference score of attributes color, aroma, taste, and overall (score 3.12 - 4.28, moderate to like). The panelist did not prefer tea made by higher temperature (60°C). This drying condition resulted a bitter taste, a more faded color and a less preferred aroma when the tea is brewed in the hot water.

**Table 3.** Sensory preference characteristic of tea infusion

Tea Process	Hedonic score of sensory attributes			
	Color	Aroma	Taste	Overall
Sun drying	2.98	2.88	2.98	2.86
Oven drying (50°C)	4.28	3.12	3.40	3.68
Oven drying (60°C)	2.70	2.60	2.36	2.52

Hedonic score 1=dislike very much, 2=dislike, 3=moderate (neither like nor dislike), 4=like, 5=like very much

## 4. Conclusion

The drying process using oven at temperature 50°C resulted better characteristic of tea with higher anthocyanin content, total phenolic content, and antioxidant capacity than drying process of tea using sun drying and oven at temperature 60°C. Panelists also preferred tea made by drying process using oven at temperature 50°C based on hedonic-sensory attribute of color, aroma, taste, and overall. Tea made from jambolan fruit peel can be developed as new functional food product with healthy properties.

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