The effect of sucrose and citric acid concentration of Candi banana peels jam on physico-chemical and sensory characteristics

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Abstract. Jam is one of complementary foods which has the viscous texture and usually prepared from fruit puree. The fruit contains pectin in which it will be combined with sucrose and acid to form gel. Banana peel also contains the pectin. This current study aims to investigate the effect of citric acid and sucrose concentration on physico-chemical and sensory characteristics of Candi banana peels jam. Completely Randomized Block Design was assigned to investigate the main factors. Factor I is the citric acid concentration (0.2% and 0.4% w/v). Factor II is the concentration of sucrose (50%, 60%, and 70% w/v). Each treatment was replicated 3 times. “Candi” banana peels jam with combination 0.2% of citric acid and 70% of sucrose is considered as the best treatment. The best Candi banana peels jam has been characterised by 48.80% water content; 4.97 pH values; 45.10 °Brix total dissolved solids; and the spreading length is 9.3 cm. While the sensory attributes intensity were 8.8 for sweetness; 2.4 for sourness; 3.4 for astringency; 8.9 for color; 5.5 for firmness; 10.5 for spreadibility; and 8.4 for spreading length.

1. Introduction

Banana production in Indonesia is very abundant, banana is one type of horticultural commodity that has high economic potential and value for both imports and exports. The total banana production in Indonesia in 2015 was 7,299,275 tonnes, in East Java it contributed 1,628,437 tonnes, in Malang Regency it contributed 690,135.7 tonnes, while in Malang City in 2014 it contributed 213.3 tonnes [1]. Candi banana (Musa paradisiaca) is a type of banana which is often used as raw material for banana processing by fried banana traders, which are widely circulated in almost every area that is crowded with resident’s house and used as banana chips products in Small and Medium Enterprises (SMEs) in 2 urban areas and district. Banana peel is rich in nutritional value and is classified as high in pectin content so that it can be processed or developed into economical value products, one of which is made from jam products.

To obtain jam with good quality, the ingredients required for gel formation in jam are pectin, acid and sucrose. The purpose of adding acid to jam reduces the pH of fruit pulp because the gel structure only forms at low pH and avoids sucrose crystallisation [2]. The purpose of adding sucrose also serves to obtain good texture, appearance and aroma, as well as preservatives for various kinds of food products [2].
There are three types of sensory evaluation methods, including affective tests that are assessed based on acceptance or preference, discriminative tests used to determine whether there are differences between samples, and descriptive tests used to determine product characteristics and intensity of product characteristics [3]. Among these tests, the descriptive test is often used in profiling the attributes of a food product. One of the descriptive tests is spectrum method. This method is faster than QDA as the relevant attributes definition is trained to the panelist as suggested by literatures.

Descriptive method is the most extensive method of utilization, where the results obtained can provide a complete description of the sensory characteristics of food products. Analysis of descriptions is generally more widely used by social sciences. However, this method began to develop in the assessment of the food sector. In the food industry, many sensory descriptive analyzes are used to determine consumer acceptance of products, quality control and product development.

Thus, to obtain high quality jam from Candi banana peels, it is necessary to investigate the influence of concentration of citric acid and sucrose on Candi banana peel jam. This research is expected to be an alternative for managing banana peel waste.

2. Materials and Method

2.1. Materials
The materials used in this study were Candi banana peels except the tip and base with yellow characteristics and slightly brown spots with mature harvesting age and thick skin, commercial citric acid, sugar, water, distilled water. For organoleptic analysis used materials such as commercial strawberry jam with two different brands, commercial peanut butter, caffeine powder, MSG, salt, and white bread.

2.2. Method
The research included the process of making Candi banana peel jam, analysis of physicochemical and organoleptic characteristics by sensory spectrum. The sensory analysis involved 15 trained panelists. Physicochemical analysis includes analysis of the water content of the oven method [4], pH analysis with pH meters [5], color analysis method L* a* b* hunter [6], topical analysis, total dissolved solid analysis [5], while organoleptic analysis includes attributes of sweetness, sour taste, bitter taste, sandy texture, color, topical power, and spreading length.

3. Results and Discussion

3.1 Physicochemical characteristics of Candi banana skin jam
The moisture content of banana peel jam ranged from 40.67 - 53.55% (Figure 1) which showed that the addition of citric acid and sugar concentrations had a significant effect (α = 0.05) on moisture content. This shows that the higher the concentration of citric acid and sugar, the lower the moisture content. This is also supported by previous studies that the effect of the concentration of added sugar on moisture content that the higher the sugar added, the moisture the water content, because the larger surface area of sugar in food, the water is easily evaporated during heating [7, 8]. Addition of sugar will affect the balance of pectin with water, this pectin is found naturally in acidic fruits. The higher the sugar added, the less water is held by the jam structure in an acidic atmosphere, the colloid will stabilize and form a structure in the form of fine fibers capable of trapping water as its solvent. While the effect of the concentration of citric acid addition to the water content that the higher the concentration of citric acid, the lower the water content. This is because citric acid will release hydrogen ions (H⁺), the higher the concentration of citric acid, the more hydrogen ions are released so that the amount of water trapped by the structure in the jam becomes less and less [8].
The pH value of banana peel jam ranged from 4.57 - 4.97 (Figure 2) which showed that the addition of citric acid and sugar concentrations did not have a significant effect ($\alpha = 0.05$) on the pH. On banana peel jam when compared with literature and commercial jam it has not fulfilled the optimum conditions on jam. According to FAO, the banana peel used is a low methoxyl pectin, so for gel formation it takes a pH ranging from 2.5 to 6.5. This is presumably because banana peels have a pH value of 5 [9] so that the optimum condition of jam formation is rather difficult to achieve, except with the addition of higher citric acid concentrations. But with the addition of sugar can help gel formation and maintain the durability of jam, so the use of 0.2% citric acid concentration and 0.4% still can be used for making banana peel jam.
Figure 3. The mean total solids dissolved of banana skin jam of banana peel jams on the effect of citric acid and sugar concentration

Total dissolved solids of banana peel jam ranged from 38.50 - 57.57°Brix (Figure 3) which showed that the addition of citric acid and sugar concentrations had a significant effect ($\alpha = 0.05$) on total dissolved solids. This shows that the higher the concentration of citric acid and sugar, the higher the total dissolved solids. According to Yulistiani [10], the higher the addition of sugar the higher the total dissolved solids, this is because sucrose is a constituent component of total dissolved solids. According to Winarno [11], glucose and fructose have a very large solubility, so that the higher the concentration of citric acid and sugar, the higher the glucan and fructose (reducing sugar) that are formed, so that the amount of sugar dissolved and the total dissolved solids there is increasing jam. According to Desrorier [7], the total content of dissolved solids in a material includes reducing sugars (e.g. glucose and fructose), non-reducing sugars (e.g. sucrose), organic acids (e.g. citric acid, acetic acid), pectin, and protein. So that the higher addition of citric acid will also increase the total value of dissolved solids. The atmosphere of an increasingly acidic solution will also facilitate the hydrolysis process, so that the total value of dissolved solids is also increasing [12].

The length of banana peanut butter spreads between 8.5 - 9.833 cm (Figure 4) which shows that the addition of citric acid and sugar concentrations has a significant effect ($\alpha = 0.05$) on the length of the topical. This is presumably because the addition of sugar to the jam affects the thickness of the gel formed, because sugar will reduce the thickness, so the more sugar is added, the jam will become thinner and harder to polish, if the sugar is added too little the jam will become too thick and hard to apply. The more addition of citric acid the thicker the jam and jam the more acidic because it has a low pH. The effect of pH on gel formation is that the lower the pH, the more gel will form harder and the less amount of pectin needed [11].
Figure 4. The mean spreading length of banana skin jam on the effect of citric acid and sugar addition concentration

3.2 Sensory Characteristics of Candi Banana Skin Jam

The panelist training stages with attribute references were carried out. As suggested, for the final selection of panelists the analysis of the spectrum method was as many as 15 panelists [13] out of 20 recruited panelists. In the training phase, 5 sessions were conducted. The attribute references used in the study are as follows (Table 1).

| Attributes         | Descriptions                        | References                              | Intensity* |
|--------------------|-------------------------------------|----------------------------------------|------------|
| Sweet Taste [14]   | Taste caused by sucrose             | Sucrose solution 10%                   | 10         |
| Sour Taste [14]    | Taste caused by citric acid         | Citric acid solution 0,15%             | 10         |
| Bitter [14]        | Taste caused by caffeine             | Caffeine solution 0,05%                | 10         |
| Astringency [14]   | Dry sensation on the surface of the tongue | 8 g coffee in 250 ml distillation water | 6         |
| Firmness [15-18]   | The force needed to condense the sample between tongue and the palate | 1/4 tablespoon of peanut butter | 11         |
| Grainingness [15-18]| The level of the sample contains fiber due to the small surface of the particle | Low: mocca topping High: peanut butter |            |
| Color [15-18]      | Color intensity or strength from bright to dark | Bright: peanut butter Gelap: mocca topping |            |
| Spreading strength [15-18] | Easy distribution of samples on bread | Use a knife to spread the sample as much as 5 grams on 1 sheet of bread (2x3 inch), peanut butter |            |

*intensity based on a 15 cm structured scale

After 5 training sessions and being declared consistent in assessing an attribute, the panellists were able to enter the final stage, namely assessing attributes on banana peel jam consisting of sweet, sour, bitter, astringency, color, sandy sensation, graininess (firmness), topical power, and topical length. At the time of product evaluation, panellists were faced with 6 sample codes for 6 treatments in one
assessment presentation, namely 0.2% citric acid treatment + 50% sugar, 0.2% citric acid + 60% sugar, 0.2% citric acid + 70% sugar, 0.4% citric acid + 50% sugar, 0.4% citric acid + 60% sugar, 0.4% citric acid + 70% sugar.

The response of the attribute of bitter taste and graininess is a result that is not significantly different indicating that the panelists cannot feel the difference in the intensity of the attribute significantly in all combinations of treatments. While the response of sweetness, sour taste, astringency, color, firmness, topical, and topical length attributes are significantly different (significant), which means that the panelists can feel the difference in the intensity of these attributes in all treatment combinations. This is shown in the spider chart (Figure 5).

![Spider chart of Candi banana peel sensory characteristics](image)

**Figure 5.** Spider chart of Candi banana peel sensory characteristics

The highest sweetness attribute with the highest intensity is found in the combination of 0.2% citric acid and 70% sugar. It was suggested that sweetness derived from high sugar concentrations can suppress other tastes, this is because sweetness is identical to carbohydrates which are the main energy source for the body so indirectly the body prioritizes carbohydrates to be accepted in the body [19].

The highest sour taste intensity was observed for the jam with combination of 0.4% citric acid and 50% sugar. Panelists tend to be able to feel acids with high concentrations, this is presumably because the trained panelists were dominated by women. This is supported by the literature in which states that women are more sensitive to the sour taste stimulus given, because women have more papillae than men [12]. Papillae is a cell receptor that plays a role in detecting basic tastes.

The highest intensity of astringency was observed for the jam with combination of 0.4% citric acid and 70% sugar. Astringency is a complex sensation that arises with a characteristic shrinking sensation, providing a wrinkling sensation from the epithelium as an effect of compounds such as tannins [12]. It was suggested that banana peels positively contain tannin compounds [13], and thus the banana peel jams.

The highest intensity of color was observed for the jam with combination of 0.4% citric acid and 70% sugar. Color is a factor that cannot be controlled even though the addition of sugar is done repeatedly on the manufacture of a food product [13]. The highest intensity of firmness was also observed at the same condition. This is because the high concentration of sugar can change gel
formation, the higher the concentration of sugar, the more solid or stronger the gel is formed on a food ingredient [19].

The highest topical intensity was observed for peel jam with 0.2% citric acid and 60% sugar. As suggested, the more acid added will cause more water to bind with thicker gel [2] and thus the water content in the jam will also be lower. At this combination, the panelists can still assess the ease of topical power.

4. Conclusions
Addition of different concentrations of citric and sucrose gave a significant effect on the water content, total dissolved solids, color and length of topping. Those are related to sensory attributes of sweetness, acidity, astringency, color, firmness, topical power and length. The selection of the best treatment using the Zeleny method suggest that the combination of the addition of citric acid with a concentration of 0.2% and sucrose with a concentration of 70% provide the best physico-chemical characteristics for Candi banana peel jam.

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