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Physico-chemical properties and organoleptic acceptability of star fruit (*Averrhoa bilimbi* Linn.) jam with variations of natural sweeteners

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ABSTRACT

Belimbing wuluh (*Averrhoa bilimbi* Linn.) is a fruit plant from Indonesia that has a very sour taste because it contains citric acid and oxalic acid. This sour taste is why this fruit has yet to be optimally utilized. This study aimed to determine the effect of natural sweetener variations on *wuluh* star fruit jam's physico-chemical and organoleptic properties. This study used an experimental method in which the experiment was designed in a completely randomized design (CRD) with 4 treatments and 3 repetitions. The results of this study showed that the addition of natural sweeteners to *wuluh* star fruit jam had a significant effect ($p < 0.05$) on viscosity (9143 – 9450 mpa.s), sineresis (1.295 – 4.592 mg), vitamin C test (17.540 – 25.629 mg/100g), moisture content (23.57 – 31.19%), total sugar content (58.01 – 69.41%wb) and which had no significant effect ($p>0.05$) on pH (3.38 – 3.64%). Meanwhile, organoleptic testing did not significantly affect taste, color, texture, aroma, and spreadability parameters.

Keywords: *Belimbing wuluh*, Cassava sugar, Corn sugar, Honey, Jam

INTRODUCTION

Belimbing wuluh fruit or *wuluh* star fruit (*Averrhoa bilimbi* Linn.) is very sour and rarely eaten raw. This fruit is usually used as a food flavoring to give a sour taste. Belimbing *wuluh* has a short shelf life and low selling price, so its development and utilization have not been maximized (Ikram et al., 2009). *Belimbing wuluh* fruit contains citric acid and oxalic acid, which taste sour. The sour taste of this fruit has not been maximally utilized (Carina et al., 2012). *Belimbing wuluh* is a source of natural antioxidants that can be used as a functional food. *Belimbing wuluh* contains minerals, vitamin C, flavonoids, saponins, glucosides, calcium, and potassium.

Belimbing wuluh, which is still young and green in color in the processing of jam, is due to its juice and the content of bioactive compounds that act as antioxidants. The high vitamin C content of *belimbing wuluh* at the raw maturity level is 60.95 mg/g (Lima et al., 2001). Vitamin C levels decrease with increasing fruit maturity, where the higher the level of fruit maturity, the more organic acid components such as ascorbic acid will be converted into simple sugars. The ascorbic acid content in ripe fruit will tend to decrease (Mahmood et al., 2012). Young star fruit contains bioactive compounds such as tannin 4.5 g/100 g and proanthocyanidin 2.2 g/100, which act as antioxidants. Young star fruit contains high pectin, which is 5% (dry weight) (Patil et al., 2010). The level of maturity of the star fruit will affect the gel formation process and the physicochemical properties of the resulting food product. The low pH of star fruit makes it suitable as an ingredient for jam (Sidauruk, 2011). *Belimbing wuluh* fruit contains a high acid content with a pH of 2 (Aminonatalina et al., 2016).

Organic acids in star fruit that cause low pH also have anti-microbial activity. Therefore, processing *belimbing wuluh* into jam was chosen to preserve the fruit and get health benefits. It is an effort to process food that utilizes local fruit.

Jam is a semi-solid food produced from fruit juice mixed with sugar. Generally, fruits and vegetables can be made into jam (Palupi et al., 2009). According to Indonesian National Standard (SNI)

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01-3746-2008, a good quality jam has a pH level of 3.5 – 4.5, a maximum moisture content of 35%, a minimum sugar content of 55%, an ideal pectin content of 0.75% – 1.5%, a total soluble solids of at least 65%, a soft texture, consistency, taste, aroma, and color of natural fruit (BSN, 2008). The addition of pectin in jam-making is done to overcome the problem of failed gel formation in the jam-making process because pectin is a polymer compound that can bind water, form gels, or thicken liquids with sugar and acids (Puspitasari et al., 2008).

Sucrose functions as a sweetener and gelling agent due to the balanced interaction of pectin and water, thus forming a solid gel. However, the drawback is its high-calorie content of 3.94 Kcal/g, which can increase blood sugar levels. Therefore, alternatives to sucrose, such as cassava sugar, corn sugar, and honey, can make jam with low sugar content.

Cassava sugar is a low-calorie liquid sugar made from cassava starch. This sugar is liquid, odorless, and colorless. Cassava liquid sugar has calories of 1.06 Kcal/g, so it is safer to avoid excessive blood sugar. It can also be used as an alternative to replace granulated sugar during dieting (Rahmawati et al., 2014). The fructose and glucose content in cassava sugar is 38% and 60%, respectively. The glycemic index of cassava sugar is 25 (Rubio-Arraez et al., 2015).

Corn sugar is a sugar resulting from the hydrolysis of corn starch. The main content of corn sugar is fructose and glucose. Corn sugar has a 50 – 70% sweetness level and calories of 2.6 Kcal/g (Listyaningrum et al., 2018). Corn sugar's fructose and glucose content are 55% and 42%, respectively (Gultom et al., 2022). The glycemic index of cassava sugar is 54 (Soylu, 2018).

Honey is a natural liquid that generally has a sweet taste produced by honey bees from plant flower juice (*Flora nectar*) or other parts of the plant (*Extra flora nectar*) or insect excretion and has low-calorie properties (Gebremariam & Brhane, 2014). According to Sakri (2017), the calorie content is 3.04 kcal/g. The fructose and glucose content of honey are 38% and 31% respectively (Handayani et al., 2022). The glycemic index of honey is 25 (Situmorang et al., 2023).

Sucrose is a sweetener and binds water from pectin to form pectic bonds and gels (Belović et al., 2017). So, sucrose sugar substitutes with different sugar types can affect the jam's quality parameters. Physico-chemical tests used to manufacture star fruit jam are pH, viscosity, sineresis, water content, vitamin C content, total sugar content, and organoleptic test. Based on this background, this study aims to determine the "Physico-chemical properties and organoleptic acceptance of *wuluh* star fruit (*Averrhoa bilimbi* Linn.) jam with variations of natural sweeteners."

RESEARCH METHOD

Materials

The tools used in this research are frying pan, stove, knife, spoon, bowl, cutting board, spatula, ohaus analytical balance, ohaus pH meter, NDJ-5S viscometer, GEA S-006 thermometer, 250 ml beaker glass, 5 ml beaker glass, 50 ml measuring cup, 100 ml measuring cup, 1ml measuring pipette, 100 ml buried, stative, 100 ml Erlenmeyer, test tube, (with pyrex brand), 2 ml pro pipette, blender (Miyako brand), filter paper, oven (Memmert), baking sheet, and porcelain cup, spectrophotometer, funnel, and funnel.

The materials used in this study were star fruit sugar (Gulanas brand), cassava sugar (Garva brand), corn sugar (Fructose brand), honey (Acacia brand), pectin (no brand), and amylum 1%, iod standard solution, nelson reagent, arsenomolybdate reagent, standard glucose, distilled water.

Methods

The procedure used in manufacturing *wuluh* star fruit jam refers to research conducted by Wardhana et al. (2013), which has been modified. The first stage is done before the *wuluh* star fruit is used, first sorting the *wuluh* star fruit, which still has a hard texture and is green without any defects or rotten, then washing the *wuluh* star fruit as much as ± 600 g with running water to remove dirt. After washing, the *wuluh* star fruit is cut into small pieces, and the seeds are removed. Next, the *wuluh* star fruit is pulverized using a blender. The mashed *wuluh* star fruit weighed as much as 50 g and was added with various natural sweeteners (granulated sugar, corn sugar, cassava sugar, and honey) as much as 49.5% and 0.5% pectin. The pureed *wuluh* star fruit was weighed and put back into the pot. Natural sweeteners (granulated sugar, corn sugar, cassava sugar, and honey) and pectin were added according

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to the formulation. Then, it was heated at 65 – 70 ˚C for ± 15 minutes on low heat while stirring so as not to burn. The following is a table of formulations for making *wuluh* star fruit jam with the essential formulation source by Dipowaseso et al. (2018), modified according to treatment, as seen in Table 1.

Table 1. The formulation for making *wuluh* star fruit jam (in%)

Material	**F0**	**F1**	**F2**	**F3**
Belimbing wuluh	50	50	50	50
Sugar	49.5	-	-	-
Corn sugar	-	49.5	-	-
Cassava sugar	-	-	49.5	-
Honey	-	-	-	49.5
Pectin	0.5	0.5	0.5	0.5
Total	**100**	**100**	**100**	**100**

Data Analysis

The data obtained were then analyzed using One-Way Analysis of Variance (ANOVA) to determine the significance of the average value of the existing data groups. If the treatment significantly affects the variable, proceed with the Duncan Multiple Range Test (DMRT) with a significant level of $\alpha = 0.05$ using SPSS 23 to determine which groups have significant differences. The DMRT test is used because it is more thorough and can be used on many treatments.

RESULT AND DISCUSSION

Physical Properties

The results of physical analysis in the form of viscosity, syneresis, and pH tests of *wuluh* star fruit jam with natural sweetener variations can be seen in Table 2.

Table 2. Results of Physical Analysis of *Wuluh* Star Fruit Jam.

Sample	**Physical Analysis**		
	Viscosity (mpa.s)	**Syneresis (mg)**	**pH**
F0	9420 ± 52.92b	1.295 ± 1.095a	3.380 ± 0.251a
F1	9450 ± 229.13b	1.240 ± 0.413a	3.647± 0.199a
F2	9317 ± 15.28ab	3.254 ± 1.494b	3.507 ± 0.133a
F3	9143 ± 117.19a	4.592 ± 0.286b	3.560 ± 0.056a

Viscosity

This viscosity test aims to determine the viscosity level in a jam, where viscosity or viscosity states the resistance of a liquid to flow. Viscosity is essential because it can affect the parameters of spreadability and release of active substances from the gel. After all, the gel has an optimal viscosity that can hold the active substances dispersed in the gel base and increase the concentration of the gel. In this viscosity test, pectin is used as a thickener. According to Yuliani (2011), pectin has properties that can form a gel. The more pectin added, the harder the resulting gel. This causes the resulting jam to become thick.

Based on the ANOVA data analysis, all variations have significantly different values. The addition of natural sugar variations in *wuluh* star fruit jam affects viscosity. Table 2 shows that all viscosity formulations are significantly different: F0, F1, F2, and F3. The average value of viscosity of *wuluh* star fruit jam with the addition of granulated sugar (F0) 9420 (mpa.s), corn sugar (F1) 9450 (mpa.s), cassava sugar (F2) 9317 (mpa.s), and honey (F3) 9143 (mpa.s). This follows the research of Rizka et al. (2019), making Ginger Leaf Extract (*Zingiber officinale*) syrup with different types of sweeteners (sorbitol, sucrose, and honey) produces different viscosity values. Fajri et al. (2017) state that the different uses of sugar result in different viscosity values.

According to research by Ellis et al. (2019), viscosity is higher in materials that contain higher fructose, based on the fructose content of corn sugar at 55%, cassava sugar at 38%, and honey at 38%.

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Hence, the level of water binding in fructose sugar is higher. The gel formation is better and more stable, and the viscosity of jam is influenced by pectin; pectin will gelatinize when heated, increasing viscosity. Viscosity is influenced by pH. The lower the pH value, the more the viscosity value will increase (Siddiqui et al., 2015).

The result and discussion should be combined in the manuscript. Separating the result and discussion into different sections is unnecessary, but they can be separated into subtopics. The discussion should be described concisely. Text, tables, and figures must be internally consistent. Discussion should involve the significant findings presented with relevant and extensive discussion.

The factor that significantly influences the variability of the final viscosity of jam is the processing process, which is closely related to processing control, especially the determination of the time of stopping the thickening process, the level of heat used during cooking, stirring, and the length of the cooking process (Ropiani, 2006).

pH

Measuring pH value is one of the parameters used to measure the acidity level of a food product. *Belimbing wuluh* fruit contains a high acid content with a pH of 2 (Aminonatalina et al., 2016). Adding a variety of natural sugars to *wuluh* star fruit jam does not affect pH. The research data in Table 2 shows that all pH formulations are not significantly different, whether F0, F1, F2, or F3. The average pH value of *wuluh* star fruit jam with the addition of granulated sugar (F0) was 3.380, corn sugar (F1) 3.647, cassava sugar (F2) 3.507, and honey (F3) 3.560. The average pH value of the wuluh star fruit jam meets the reasonable quality requirements according to the Indonesian National Standard (SNI) 01-3746-2008; the jam has a pH level of 3.5 – 4.5. Research Rizka et al. (2019) made Ginger Leaf Extract (*Zingiber officinale*) syrup with different types of sweeteners (sorbitol, sucrose, and honey), resulting in the use of different types of sweeteners giving different pH values to the syrup. This is because the pH value of sweeteners as raw materials is different before being mixed with other raw materials.

Viscosity influences the pH of jam, and the pH value is one of the parameters for gel formation when making jam (Putri, 2014). According to Fatonah (2002), the effect of pH on gel formation with the addition of pectin is that the lower the pH (acid), the more complex the gel will be. However, if the pH is too low, it will cause syneresis, namely the release of water in the gel, whereas if the pH is too high (the more alkaline), it will cause the gel to break (Winarno, 2008).

The test results of fresh *wuluh* star fruit had a pH of 2.5 after making the jam. The resulting pH ranged from 3.38 to 3.64. The increase in pH value was influenced by the sour taste of the *wuluh* star fruit, which caused the pH to increase and was also caused by pectin because pectin would be hydrolyzed to become pectic acid and pectin acid so that the acidity value becomes greater (Fahrizal & Fadhil, 2014).

Syneresis

Syneresis is when water comes out from the gel matrix formed during storage. Syneresis occurs after a certain period. Syneresis testing was conducted to determine the gel's ability to retain water (Phillips & Williams, 2009).

Based on one-way ANOVA data analysis, *wuluh* star fruit jam with variations of natural sweeteners is significantly different. The addition of variations in natural sugar to *wuluh* star fruit jam affects syneresis. The research data in Table 2 shows that all syneresis formulations are significantly different, including F0, F1, F2, and F3. The average value of syneresis of *wuluh* star fruit jam with the addition of granulated sugar (F0) was 1.295 (mg), corn sugar (F1) 1.240 (mg), cassava sugar (F2) 3.254 (mg) and honey (F3) 4.592 (mg). According to Hartati & Djauhari (2017), in their research on ginger jelly drinks, adding sugar to making ginger jelly drinks significantly affected the synthesis of ginger jelly drinks. This is because acidity, sugar, and pectin levels greatly influence jelly drink products' texture and gel formation process.

The level of syneresis of jam is influenced by several factors, namely acidity, pH, and water holding capacity (Krisnaningsih et al., 2018). Apart from that, syneresis is also influenced by water content and viscosity level because a low viscosity level indicates that the water content in the jam is high, the formation of hydrocolloids is less compact, and the rigidity of the gel is not muscular, so the

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jam syneresis process will occur quickly during storage. The syneresis process shows the level of damage to the jam; the higher the water content is contained, the faster the damage will occur. According to (Winarno, 2008), during storage, a syneresis process occurs in the gel, which results in the longer the storage being carried out, the higher the water content in the jam. The syneresis value decreases as pectin is added because pectin can form a firmer gel. The gel becomes more potent because the number of hydrogen bonds increases and causes the gel formed to be more able to maintain gel stability and release water in smaller amounts.

Chemical Properties

The results of chemical analysis in the form of water content analysis, vitamin C analysis, and total sugar analysis of *wuluh* star fruit jam with various natural sweeteners can be seen in Table 3.

Table 3. Results of chemical analysis of *wuluh* star fruit jam.

Sample	Chemical parameters		
	Water content (%)	**Vitamin C levels (mg/100 g)**	**Total sugar content (% wb)**
F0	31.193 ± 0.021d	21.170 ± 0.364c	69.413 ± 0.423c
F1	26.760 ± 0.699b	19.777 ± 0.193b	69.650 ± 0.144c
F2	28.033 ± 0.606c	17.540 ± 0.271a	68.597 ± 0.151b
F3	23.570 ± 0.716a	25.627 ± 0.251d	58.013 ± 0.154a

Water Content

Moisture content is an essential ingredient component because water can affect the texture and flavor of food. The water content in the jam also plays an essential role in its texture. The moisture content of food ingredients determines their freshness and durability (Syarief & Halid, 2013). Based on one-way ANOVA data analysis, *wuluh* star fruit jam with natural sweetener variations is significantly different. The average value of total sugar content of *wuluh* star fruit jam with the addition of granulated sugar (F0) is 31.193%, corn sugar (F1), 26.760%, cassava sugar (F2), 28.033%, and honey (F3), 23.570%. Research by Sapriyanti et al. (2014) made tomato Velva with honey sweetener, decreasing water content due to the increase in total solids in the dough to reduce the percentage of water contained in tomato Velva products. This is in line with the opinion of Winarno (2008), which states that sugar absorbs water where the material added to sugar will experience osmosis pressure, namely the pressure of sugar molecules on the fruit cell wall until the sugar solution enters it. As a result, the water in the fruit cells comes out.

The viscosity level of jam products can affect the jam's high and low water content. Low viscosity indicates the strength in binding water is weak, resulting in the gel formed being easily subjected to syneresis or water release. Thus, the water content of the material will increase. The moisture content of jam is influenced by the binding power of water-soluble fibers in the form of thickeners used against jam. According to Silvira & Pato (2018), the higher the water content, the stickiness of the jam increases, and the water content of the jam is influenced by the raw materials used in the form of *wuluh* star fruit and also the use of different types of sweeteners during the jam making process. Sugar added to foodstuffs can dehydrate water molecules so that much water is evaporated when cooking. The increase in water content in a jam is caused by *wuluh* star fruit and different sweeteners in making jam which has different water content so that it affects water content in jam, and this follows the opinion of Lamban et al. (2017) that water content increases if the more significant the proportion of *wuluh* star fruit used and the difference in water content is influenced by the water content in the main raw materials used. The primary raw material used is *wuluh* star fruit, whose water content ranges from 94.2 – 94.7% (Zakaria et al., 2007).

Vitamin C Levels

Fruits have a lot of antioxidant content that is good for the human body, one of which is antioxidant substances commonly found in fruits is vitamin C. Vitamin C content helps improve immunity and maintain the health of cells in the body (Fitriyana, 2019). Based on one-way ANOVA data analysis, *the variation of wuluh star fruit jam with natural sweetener* is significantly different. The

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average value of vitamin C content of *wuluh* star fruit jam with the addition of granulated sugar (F0) 21.170 (mg/100g), corn sugar (F1) 19.777 (mg/100g), cassava sugar (F2) 17.540 (mg/100g) and honey (F3) 25.627 (mg/100g). These results follow the research of Mechanics (2007). Watermelon albedo jelly candy with the addition of honey results in the addition of honey, which can increase the content of vitamin C and, in quality, will add sweetness. These results show that vitamin C levels show an increasing trend along with the increasing addition of honey.

Belimbing wuluh fruit contains vitamin C of 25 mg/100 g; the decrease in vitamin C can be influenced by heating during processing (cooking process). Cooking temperature can cause the degradation of vitamin C, which can accelerate its oxidation (Agustin & Putri, 2014). Vitamin C content in corn sugar is 12.0 mg, honey vitamin C content is 67.4 mg (Buba et al., 2013), cassava sugar vitamin C content is 31 mg (Septian, 2023). The effect of sugar content on vitamin C content is that during the osmosis dehydration process, vitamin C degradation occurs so that the sugar content in the jam increases, and the vitamin C content in the jam will decrease. Vitamin C is easily damaged when cooked, processed, and exposed to air and light. In addition, the decrease in vitamin C content is also due to the activity of ascorbic acid oxidase during storage, which will break down ascorbic acid in the fruit.

Total Sugar Content

Total sugar content is the overall sugar content in a food consisting of reducing and non-reducing sugars. Types of total sugar are monosaccharides, disaccharides, oligosaccharides, and polysaccharides. So, reducing and non-reducing sugar is calculated as the total sugar content (Rohman & Sumantri, 2013). Based on one-way ANOVA data analysis, *the variation of wuluh star fruit jam with natural sweetener* is significantly different. The average value of total sugar content of *wuluh* star fruit jam with the addition of granulated sugar (F0) 69.413 (%wb), corn sugar (F1) 69.650 (%wb), cassava sugar (F2) 68.597 (%wb) and honey (F3) 58.013 (%wb). Based on the average value of the total sugar content of *wuluh* star fruit jam with variations of natural sweeteners, it has met the requirements (SNI) 01-3746-2008, a minimum sugar content of 55%. These results follow previous research conducted by Ramadhani et al. (2017). Avocado jam with various natural sweeteners (palm sugar, granulated sugar, and honey) provides different values.

The high total sugar in *wuluh* star fruit jam is due to a decrease in water content, and the mass of the material will also decrease. The decrease in water content and increase in sugar content in *wuluh* star fruit jam products aim to extend shelf life and provide a sweet taste (Carina et al., 2012). According to (Octaviani & Rahayuni, 2014), sugar content affects vitamin C; the higher the sugar content, the lower the vitamin C value. According to Kartika & Nisa (2015), sugar content increases with adding sugar in the osmosis solution, causing the amount of sucrose owned or added to the product. The addition of too much sugar will crystallize on the surface of the gel, and the increasing sugar concentration causes the total sugar content of the fruit jam to increase.

Organoleptic Acceptance Test

The results of the organoleptic analysis of *wuluh* star fruit jam with variations of natural sweeteners can be seen in Table 4.

Table 4. Organoleptic result of *wuluh* star fruit jam.

Sample	Parameters				
	Flavor	**Aroma**	**Color**	**Texture**	**Spreadability**
F0	2.58 ± 1.03ab	2.87 ± 1.02a	2.97 ± 0.91a	3.26 ± 0.73a	3.45 ± 0.62a
F1	2.94 ± 1.09b	2.94 ± 0.81a	3.10 ± 0.79a	3.32 ± 0.79a	3.35 ± 0.66a
F2	2.65 ± 0.80ab	2.81 ± 0.95a	3.16 ± 0.78a	3.35 ± 0.61a	3.29 ± 0.78a
F3	2.39 ± 0.96a	2.68 ± 1.05a	3.10 ± 0.75a	3.00 ± 0.89a	3.39 ± 0.72a

Flavor

Taste is a factor that affects the acceptance of food products. If the color and texture components are suitable but consumers do not like the taste, consumers will not accept these food products

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(Rakhmah, 2012). The taste of *wuluh* star fruit jam is influenced by adding natural sweeteners such as regular sugar, corn sugar, cassava sugar, and honey. The purpose of adding natural sweeteners is to disguise or reduce the sour taste of *wuluh* star fruit when panelists taste *wuluh* star fruit jam. Table 4 states that the assessment of the taste of wuluh star fruit jam with a variety of natural sweeteners is significantly different because each column is different. The average value obtained is 2.39 – 2.94.

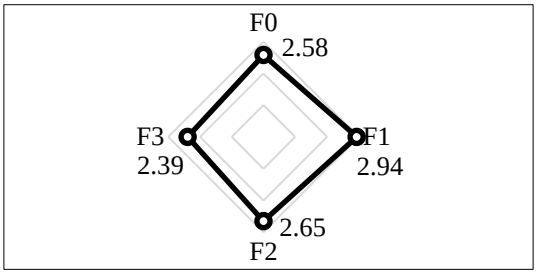

Figure 1. Organoleptic Acceptance Spider Diagram of Taste

Figure 1. shows that the highest favorability value is obtained in the corn sugar treatment (F1) with a value of 2.94 ± 1.09, which means that panelists favor the F1 sample with a sour taste and the lowest favorability value is obtained in the honey treatment (F3) with a value of 2.39 ± 0.96, which means that panelists rather like the very sour taste of *wuluh* star fruit jam. Panelists liked the jam with the addition of corn sugar, which has a sour taste because the sample with the addition of corn sugar has a vitamin C content of 19.777 (mg/100g); the sour taste is the result of a combination of the flavors of the ingredients used. According to Lima et al. (2001), the sour taste in *wuluh* star fruit is caused by ascorbic acid, acetic acid, and other acids. *Wuluh* star fruit has 60.95mg/100g of ascorbic acid.

Aroma

Aroma is an essential organoleptic assessment in determining a food ingredient's acceptability. According to Winarno (2008), the aroma or odor of food has a role that can determine the delicacy of the food. The aroma of a food ingredient can be recognized through the olfactory organ or nose. Table 4 states that the assessment of the aroma of *wuluh* star fruit jam with variations of natural sweeteners shows no significant difference, with the average value obtained 2.68 – 2.94.

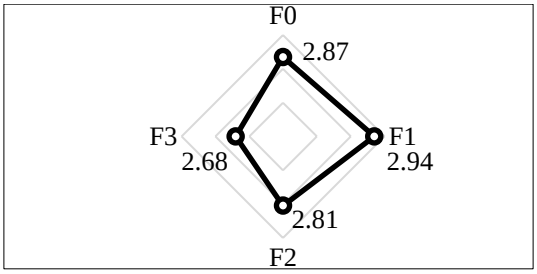

Figure 2. Aroma for Organoleptic Acceptance Spider Diagram

Figure 2. shows that the highest favorability value was obtained in the treatment of corn sugar (F1) with a value of 2.94 ± 0.81, which means that panelists favored the F1 sample with the scent of *wuluh* star fruit and the lowest favorability value was obtained in the treatment of honey (F3) with a value of 2.68 ± 0.96, which means that panelists somewhat like the aroma of *wuluh* star fruit jam. The aroma of a food ingredient can be recognized through the organ of smell or nose. Based on SNI 3746: 2008, the characteristic aroma of jam is to have a usual aroma standard, namely if there is a distinctive smell of jam material used. This study's distinctive jam aroma is the aroma of *belimbing wuluh* fruit. Dewi (2014) explains that several components affect the aroma of jam, namely the essential ingredients of jam and sugar. The addition of sugar concentration can affect the organoleptic value of jam aroma. Sugar will give a distinctive aroma to the jam when the sugar is warmed up with the *wuluh* star fruit produced.

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Color

Color is essential in determining a food item's quality or acceptability. Determination of the quality of a food ingredient generally depends on color because color appears first Winarno (2008). Table 4 states that the color assessment of *wuluh* star fruit jam with variations of natural sweeteners shows no significant difference, with the average value obtained 2.97-3.16.

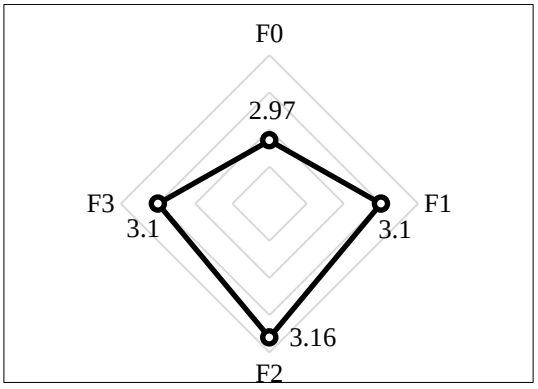

Figure 3. Color for Organoleptic Acceptance Spider Diagram

Figure 3. shows that the highest liking value is obtained in the cassava sugar treatment (F2) with a value of 3.16 ± 0.78, which means that the F2 sample is liked by panelists with a brownish yellow color and the lowest liking value is obtained in the regular sugar treatment (F0) with a value of 2.97 ± 0.91 with a brownish yellow color, which means that panelists like the color. The color of this *wuluh* star fruit jam is also the natural color of the *wuluh* star fruit itself, and the addition of sugar. There is no addition of food coloring ingredients. This follows the quality requirements of fruit jam based on SNI 3746:2008, which states that the color requirements of fruit jam are standard. Changes in the primary color to a brown color, often called caramelization, generally occur in foods processed with added sugar and processed by heating. Sugar will undergo a caramelization process to form a browning or brownish process. The use of sugar also influences the color of the jam because sugar has properties that can cause the jam to turn brown.

Texture

Texture is one of the most essential components determining the final quality of jam. Texture is a sensation of pressure that can be enjoyed with the mouth or fingers. Table 4 states that the texture assessment of *wuluh* star fruit jam with natural sweetener variations shows no significant difference in the average value obtained 3.00 – 3.35.

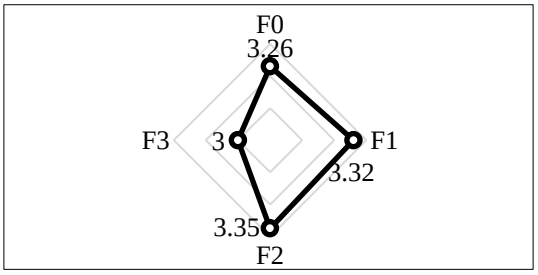

Figure 4. Texture for Organoleptic Acceptance Spider Diagram of Texture

Figure 4. shows that the highest favorability value was obtained in the cassava sugar treatment (F2) with a value of 3.35 ± 0.61 with a thick texture, meaning that the F2 sample was favored by panelists and the lowest favorability value was obtained in the honey treatment (F3) with a value of 3.00 ± 0.89 with a slightly thick texture, meaning that panelists liked the texture. Based on the results of the texture acceptance of *wuluh* star fruit jam, it can be seen in Table 4.4 that the preferred texture is jam with a thick texture following the results of the organoleptic test form on texture, where panelists

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prefer a thick texture on jam. Panelists like to jam with cassava sugar, which has a thick texture due to the viscosity level of 9317 mpa.s. The texture of the jam is influenced by the gel formation that occurs in the jam. Gel formation occurs due to the cross-linking of polymer chains, so the gel captures water and forms a strong and rigid structure. The hardness of the gel in a jam depends on the concentration of sugar and pectin.

Spreadability

Spreadability is one of the essential properties of jam products. Spreadability is the ability of jam to be spread evenly on bread (Agustina & Handayani, 2016). Table 4 states that the assessment of spreadability of *wuluh* star fruit jam with variations of natural sweeteners shows no significant difference with the average value obtained 3.29 – 3.45.

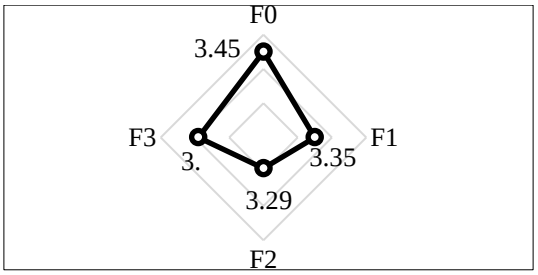

Figure 5. Spreadability for Organoleptic Acceptance Spider Diagram

Figure 5. shows that the highest favorability value was obtained in the treatment of granulated sugar (F0) with a value of 3.45 ± 0.62 with easy spreadability, meaning that the panelists liked the F0 sample and the lowest favorability value was obtained in the treatment of cassava sugar (F2) with a value of 3.29 ± 0.78 with very easy spreadability, meaning that the panelists liked the spreadability. Panelists like jam with the addition of granulated sugar to have easy spreadability due to 9420 mpa.s viscosity. Generally, panelists like to jam with a soft texture, not stiff, and easy to spread on bread. According to Muryanti (2011), a good jam texture can be seen from the ease with which the product spreads on bread. According to Fahrizal & Fadhil (2014), the addition of pectin and sugar affects the balance of pectin and water and reduces the quality of pectin in forming fine fibers so that the gel formed is not too hard; thus, the spreadability of the jam produced becomes longer.

CONCLUSION

Variations of natural sweeteners in *wuluh* star fruit jam (*Averrhoa bilimbi* Linn.) affect viscosity and sineresis and do not affect pH. Variations of natural sweeteners in *wuluh* star fruit jam (*Averrhoa bilimbi* Linn.) affect vitamin C, water content, and total sugar. The best organoleptic acceptance for taste and aroma attributes is in sample F1 (corn sugar), color and texture attributes are in sample F2 (cassava sugar), and spreadability attributes are in sample F0 (granulated sugar).

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