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Effect of Sugar and Lime Juice Proportion on the Quality of Star Fruit Sorbet

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Abstract

Star fruit is a non-seasonal fruit that can be harvested three to four times a year. One possible way to process a star fruit is to make it into sorbet. Additional ingredients such as sugar and lime juice will help improve the quality of star fruit sorbet. The purpose of this study was to acquire the best formulation of star fruit sorbet by adding sugar and lime juice and to find out the effect of different concentrations of sugar and lime juice on the level of predilection, physical traits, level of vitamin C, and antioxidants activity. This study consisted of two phases; the production of lime essence in phase one and the making of star fruit sorbet in phase two as the main study. The result of best formulations selected based on an organoleptic test of panelists' level of predilection were formulations of 150 g sugar + 30 g lime, 90 g sugar + 60 g lime, and 120 g sugar + 60 g lime. Analysis of variance results indicated different formulation of star fruit sorbet had a significant effect ($P<0.05$) on colour, flavour, aroma, and overall but showed no difference in the texture of star fruit sorbet. Overall, the best formulation was 150 g sugar + 30 g lime juice with an overrun score of 23.52%, pH 4.20, the sugar content of 26.85 ^{o}Brix, melting time of 43.16 minutes, vitamin C content of 0.968 mg, and antioxidant activity of 320.86 ppm.

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Keyword
antioxidant activity, hedonic test, organoleptic test.

Introduction

Star fruit is a non-seasonal fruit that can be harvested three to four times per year (Wadud *et al.* 2017). The production of star fruit in 2016 in Tuban was up to 102,200 kg (Central Bureau of Statistics 2017). The abundance of star fruit production that was not matched by innovation in processing led to star fruit waste. According to Sumiasih *et al.* (2016), consumers reject star-fruits that were kept at room temperature after ten days due to a decline in quality and freshness. The innovation of star fruit products is developed to extend star fruit shelf life and retain star fruit freshness as well as increasing added value.

Sorbet can be used as one alternative of star fruit innovation product because sorbet is a processed product that is kept in low temperature, thus can extend shelf life. According

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to Sayuti and Yenrina (2015), vitamin C oxidation would be limited when vitamin C is kept in cold condition or at low temperature, around - 8 ^{o}C. Sorbet has a similar texture to ice cream, and this can increase its appeal to consumers to buy star fruit products. Sorbet also has advantages such as low-fat content, contains natural fruit fiber, and high in vitamin C (Sakawulan *et al.* 2014). The advantage of sorbet also opens up opportunities for sorbet to become functional food that relatively inexpensive and tasty (Silalahi *et al*. 2014).

Natural additional ingredients that can be used to improve star fruit sorbet taste and add acidity are sugar and lime juice. Lime juice addition is a right combination for star fruit sorbet because lime has a refreshing sour taste that can improve the overall taste as well as increase its nutrition value. Vitamin C content of lime is quite high, around 29.1 mg/ 100 g fruit (USDA 2018). According to Febrianti (2010), besides having high vitamin C content, lime also contains citric acid that can replace the use of commercial citric acid. A combination of fruits in producing sorbet had developed to improve or repair the quality of produced sorbet. A study conducted by Claudia *et al.* (2016) showed that the addition of pineapple in yellow pumpkin sorbet could improve freshness and reduce the pungent smell. The use of sugar in sorbet is not only to add flavor but also to form a balance between sour and bitter taste in a product (Putri 2016).

The addition of lime and sugar can affect the physical, chemical, and organoleptic properties of star fruit sorbet. Organoleptic tests using hedonic tests can represent how the product accepted by consumers. Physical and chemical analysis conducted to determine and to attain the quality parameter of the sorbet.

Materials and Methods

Time and Place

This research was conducted on June to July 2018. The research was conducted at the Food Process Engineering Laboratory of Trilogi University, Saraswati Indo Genetech (SIG) Laboratory, and Garda Dharma Technology Laboratory, Bogor.

Materials

The tools used in this research were oxone ox-315 scale, analytical balance KERN PL420-3F, knife, spatula, Oxone ox-863, sieve, gas stove Rinnay exotic, ice cream maker Cuisineart ICE-100BCHK, beaker glass IWAKI CTE33, pH meter pHep H198107, refractometer ATC, spectrophotometer Shiamdzu UV 1700, and other laboratory equipment. The materials used in the production of star fruit sorbet were star fruit, CMC (Carboxyl Methyl Cellulose), lime, sucrose sugar, DPPH solution, and other materials.

Research Method

The research consisted of two phases, the first phase was the production of lime juice and the second phase was production of star fruit sorbet as the main study. The experimental design used was Completely Randomized Factorial Design (CRFD) with two factors, namely concentration of sugar and the concentration of lime juice. Each factor consisted of three levels of treatments, which 15 %, 20 %, and 25 % of sugar and 5 %, 10 %, and 15 % of the lime juice ratio of fruit and water.

Production of Lime Juice

Production of Lime juice based on method developed by Jurianti *et al.* (2010) with some modification. Lime fruits were sorted and then washed with water until clean. Lime fruits were cut into two parts transversely using a knife and then squeezed using a citrus juice extractor. The juice then strained using sieve cloth. Lime juice then stored in a bottle. The modification of the process made in the lime had not turned into syrup and only extracting the juice.

Production of Star Fruit Sorbet

Production of Star Fruit Sorbet based on method developed by Rahmawati *et al.* (2010) with some modification. Star-fruits were sorted following criteria and washed until clean and then blanched. Blanching done to activate enzyme by steaming star-fruits for 5 – 10 minutes at 70 – 80 ^{o}C and then directly followed by cooling star-fruits in the refrigerator to bring the temperature down. Star-fruits then peeled and its pulp extracted, and then blended with water with 1:1 ratio of pulp: water. Star fruit pulp mixture then mixed with stabilizer, sugar, and lime juice according to treatments.

The next step was to freeze the mixture using an ice cream maker until sorbet formed, marked by the formation of soft ice crystal inside the mixture. Star fruit sorbet then stored in the freezer to attain better texture. The modifications of the process made in the steaming time that was 3 – 5 in previous research and also in straining the pulp, which not conducted in this research. Other modifications were in the aging process that was conducted in the production of star fruit sorbet and in the mixing process which was without heating the mixture.

The production of star fruit sorbet in this research used star-fruits, sugar, CMC stabilizer, and lime juice. The production of sorbet was using ten formulations, and one of them was control, which without treatment factors. The formulations of star fruit sorbet shown in Table 1.

Table 1. Star fruit sorbet formulation

Ingredients	Composition (g)									
	S0	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**S8**	**S9**
Star fruit pulp	300	300	300	300	300	300	300	300	300	300
Water	300	300	300	300	300	300	300	300	300	300
Sucrose sugar	0	90	120	150	90	120	150	90	120	150
CMC	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
Lime juice	0	30	30	30	60	60	60	90	90	90

Results and Discussion

Organoleptic Test

The organoleptic test was conducted to determine panelist predilection and acceptance level on star fruit sorbet. Parameters tested were color, taste, aroma, texture, and overall on star fruit sorbet products. Scoring scale used in this hedonic test was 1 (one) to 5 (five). The scoring or value given by panelists captures how much the panelists like the product. The higher the score the panelists give, the higher the acceptance level of the

product (Setyaningsih *et al.* 2010). Based on results from conducted hedonic test, there were three formulations with highest overall score from the panelists, which were S3 (150 g sugar + 30 g lime juice), S4 (90 g sugar + 60 gr lime juice), and S5 (120 g sugar + 60 g lime juice) with average of 3.60, 3.41, and 3.53 respectively, that were in neutral scale (Table 2 and Figure 1). The three best formulations then further tested against overrun, pH, sugar content, melting time, vitamin C and antioxidants, and compared to S0 as control.

Table 2. Scoring results from the hedonic test of star fruit sorbet

Formulation	Color	Teste	Flavour	Texture	*Overall*
S0 (G 0 g + JN 0 g)	3.32_{ab}±1.24	1.76_{ef}±0.77	2.72_{bc}±0.84	3.16_{a}±1.21	2.44_{cd}±1.04
S1 (G 90 g + JN 30 g)	2.96_{bc}±0.84	3.72_{a}±1.02	3.68_{a}±0.90	3.00_{a}±0.81	3.36_{ab}±0.81
S2 (G 120 g + JN 30 g)	2.24_{cd}±1.12	3.88_{a}±1.09	3.36_{ab}±0.95	3.12_{a}±0.78	3.40_{ab}±0.86
S3 (G 150 g + JN 30 g)	3.27_{ab}±1.10	3.88_{a}±1.05	3.52_{a}±0.77	3.36_{a}±0.81	4.00_{a}±0.70
S4 (G 90 g + JN 60 g)	3.88_{a}±0.92	3.08_{bc}±1.18	3.44_{ab}±0.71	3.16_{a}±0.89	3.52_{ab}±0.91
S5 (G 120 g + JN 60 g)	3.96_{a}±0.84	3.40_{ab}±1.22	3.52_{a}±0.87	3.24_{a}±0.77	3.52_{ab}±0.82
S6 (G 150 g + JN 60 g)	4.12_{a}±0.88	3.36_{ab}±1.25	3.40_{ab}±0.81	3.24_{a}±0.92	3.44_{ab}±0.91
S7 (G 90 g + JN 90 g)	3.92_{a}±1.07	2.32_{de}±1.06	3.28_{ab}±0.93	3.20_{a}±0.91	2.84_{bc}±0.85
S8 (G 120 g + JN 90 g)	3.72_{ab}±0.93	2.32_{de}±1.18	3.08_{ab}±0.70	2.96_{a}±1.13	2.84_{bc}±1.02
S9 (G 150 g + JN 90 g)	3.27_{ab}±1.06	2.60_{cd}±1.25	3.40_{ab}±0.86	2.84_{a}±1.02	2.92_{bc}±1.18

Note: S: sugar, LJ: lime juice, (1) dislike it very much, (2) dislike it a little, (3) neutral, (4) like it a little, (5) like it very much. Number followed by the same notation showed no significant difference at α= 5% in Tukey's Range Test.

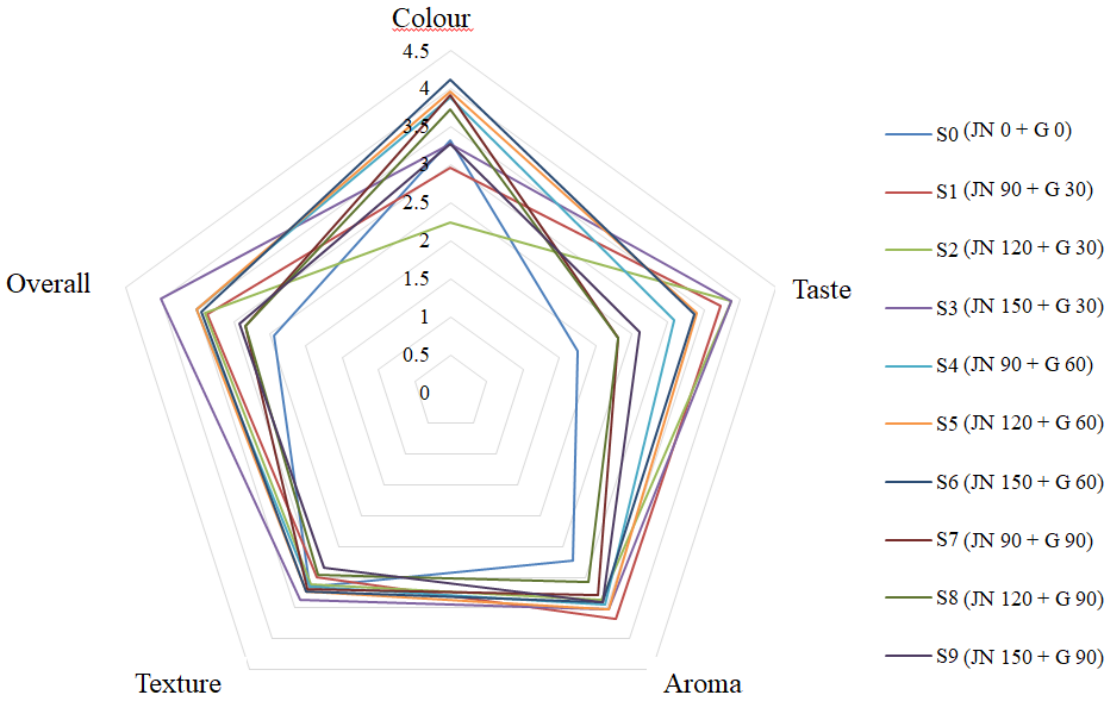

Figure 1. Spider web of the organoleptic test of star fruit sorbet

Color

The color of a product can affect the consumers' acceptance level of that product. Ways to retain the natural color of star fruit are by doing blanching star fruit before processing and also by adding lime juice. Lime juice acts as vitamin C and citric acid source (Febrianti 2010). According to Wulandari (2016), citric acid can help reduce the browning reactions.

Scoring on panelists' predilection of color is conducted by observing the color, and the highest score captures the color preferred by panelists (Setyaningsih *et al.* 2010). Based on color scoring for star fruit sorbet (Figure 2), there was an increase of preference score in products with added lime juice compared to control. Analysis of variance on color scores showed significant difference ($P< 0.05$), meaning that the addition of sugar and lime juice gave a significant effect in every formulation.

Panelists level of predilection on color parameter ranged from 2.24 to 4.12 scale of dislike a little to like a little. The most preferred formulation with a score of 4.12 was the S6 formulation with 150 g sugar + 60 g lime juice, which resulted in a bright yellow color. Formulation S2 with 120 g sugar + 30 g lime juice was the formulation with the lowest score of 2.24 which resulted in a dark yellow color. According to Kusumawati's study (2008) that the higher the amount of added citric acid in star fruit juice, the brighter yellow the result is. Lime juice contains around 7 % of citric acid (Prastiwi & Ferdiansyah 2017). Formulation S6 score (Table 2) followed by the same notation with control, S3, S4, S5, S7, S8, and S9, which means they were not significantly different.

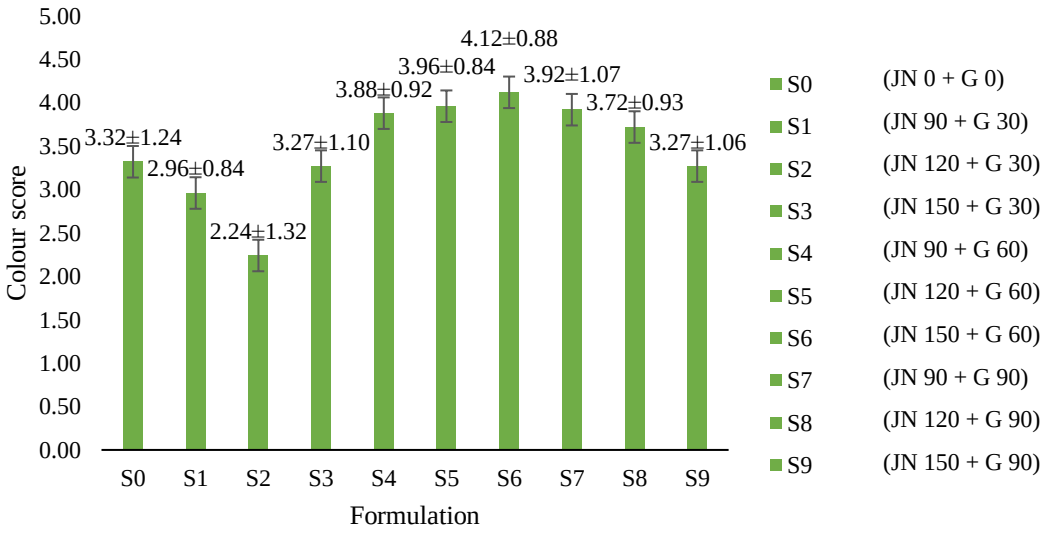

Figure 2. The scoring result of star fruit sorbet color

Taste

Taste is a factor that can affect consumers' predilection and acceptance level of a product. Scoring results from panelists on star fruit sorbet taste shown in Figure 3. Addition of lime juice and sugar in star fruit sorbet affected panelists' predilection level shown by the higher taste scores compared to control (S0). According to Hidayat *et al*. (2017) on the making of pumpkin syrup, the addition of lime juice improves the panelists' preference, on the syrup compared to control which without lime juice.

The higher amount of added lime juice, the lower panelists' predilection level because additional lime juice can increase sourness in star fruit product. While the addition

of sugar showed that the more sugar added, the higher panelists' score in taste attribute. According to Putri (2016) besides for adding flavor, sugar can also form a balance in taste with sourness and bitterness from a product. Analysis of variance on taste scores showed a significant difference (P< 0.05), meaning that the addition of sugar and lime juice gave significant effect in every formulation.

Panelists' scores on taste parameter ranged from 1.76 to 3.88, which was in the scale of dislike a little to neutral. Hedonic test score result showed the highest taste score was formulation S2 (120 g sugar + 30 g lime juice) and S3 (150 g sugar + 30 g lime juice) both had a score of 3.88 which was neutral. Formulation S2 and S3 scores followed with the same notation (Table 2) as formulation S1, S5, and S6, which means they were not significantly different.

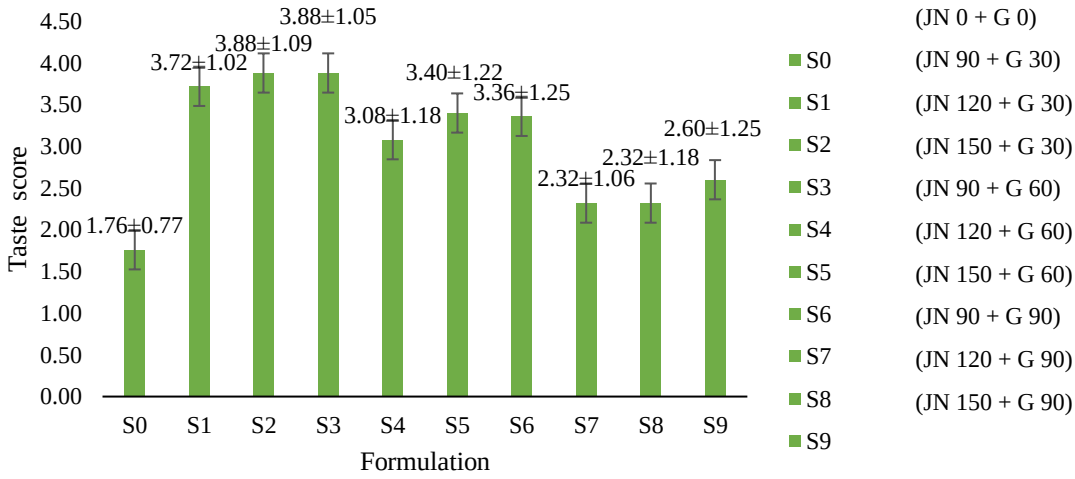

Figure 3. The scoring result of star fruit sorbet taste

Aroma

Aroma is one of the parameters that can determine consumers' level of acceptance of product quality. Aroma is usually the determining factor of the deliciousness of food products (Hidayat *et al*. 2017). The scoring result of aroma attribute on star fruit sorbet shown in Figure 4. The graph showed that aroma of star fruit sorbet score in this study increased with added lime juice. Aroma of sorbet with added lime juice was distinct lime aroma which gave fresh notes. Analysis of variance on aroma scores showed significant difference (P< 0.05), meaning that addition of sugar and lime juice gave significant effect in every formulation.

Panelists' score on aroma ranged from 2.72 to 3.68 that was in scale of dislike a little to neutral. The score on control was the lowest which was 2.72 compared to other formulations with added lime juice. The highest score was formulation S1 (90 g sugar + 30 g lime juice) with score of 3.68. Formulation S1 had the same notation with S2, S3, S4, S5, S6, S7, S8, and S9 which means they were not significantly different. This result was similar with previous research conducted by Hidayat *et al*. (2017) on pumpkin syrup, where addition of lime juice made pumpkin syrup aroma preferred by panelists compared to without added lime juice. According to study by Febrianti (2010), panelists preferred aroma of papaya jam with additional sugar and lime juice. Addition of sugar concentration in this study was not affecting aroma of star fruit sorbet sugar aroma was masked by lime juice aroma.

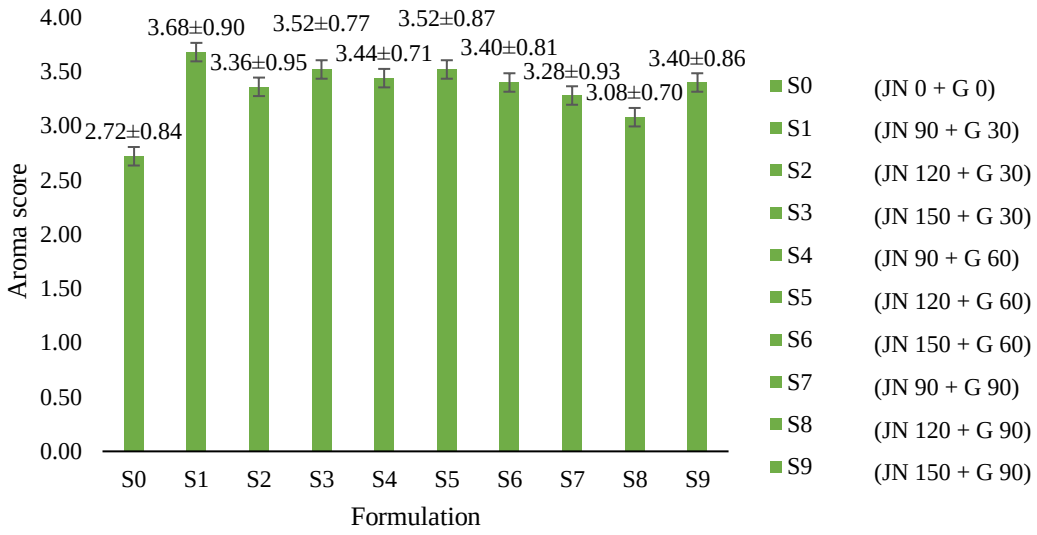

Figure 4. Scoring result of star fruit sorbet aroma

Texture

The scoring results of star fruit sorbet texture shown in Figure 5. According to Dewi (2010), besides act as sweetener, the addition of sugar can improve the texture of frozen products because sugar can deter the formation of big ice crystals in freezing process. Hence, the texture of the product is softer and preferred by panelists. According to Rahmawati (2017), a stabilizer is one of determining factors of sorbet texture, that the higher the stabilizer concentration, the softer the sorbet texture, and the more preferred by the panelists. In this study, stabilizer used was CMC with the same concentration for all formulations, which was 1.8 g. Novianti (2014) stated that CMS in the production of ice cream function as a binder, prevent crystallization, stabilizer, gel formation, added viscosity, and to improve texture.

Analysis of variance on texture scores showed no significant difference (P> 0.05), meaning that the addition of sugar and lime juice gave no significant effect in texture among every formulation. Scores from panelists ranged from 2.84 to 3.36, which was in the scale of dislike a little to neutral. The highest score was formulation S3 (150 g sugar + 30 g lime juice) with score of 3.36 or neutral. Formulation S3 score was followed by the same notation with all other formulations which mean they were not significantly different or had the same texture.

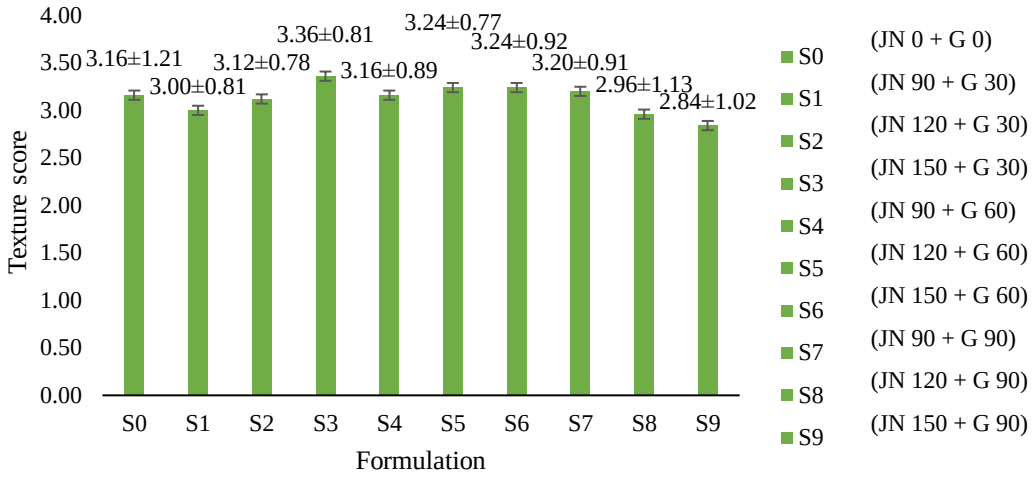

Figure 5. The scoring result of star fruit sorbet texture

Overall

The overall score included aspects such as color, taste, aroma, and texture from star fruit sorbet, which scored in unity by panelists. Scoring results from panelists (Figure 6) showed that addition of sugar and lime juice could increase panelists' predilection and preferences of star fruit sorbet in the overall aspect. This was because the lowest score was formulation S0 (control), which without additional sugar and lime juice. However, too much of lime juice caused overall score decline as sorbet taste became sourer. And in formulation with the addition of 90 g lime juice, there was some bitter aftertaste. Analysis of variance on overall scores showed a significant difference ($P< 0.05$), meaning that addition of sugar and lime juice gave significant effect in every formulation.

From all tested attributes such as color, taste, aroma, and texture, only taste attribute was affecting the overall score of star fruit sorbet. According to Hidayat *et al*. (2017), a food product that has right color, aroma, visual, and texture, will not be accepted by panelists or consumers if the taste of the product is not tasty or not preferred. The highest overall score was formulation S3 (150 g sugar + 30 g lime juice) with a score of 4.00 or like a little. Formulation S3 had the same notation with formulation S1, S2, S4, S5, and S6 meaning they were not significantly different.

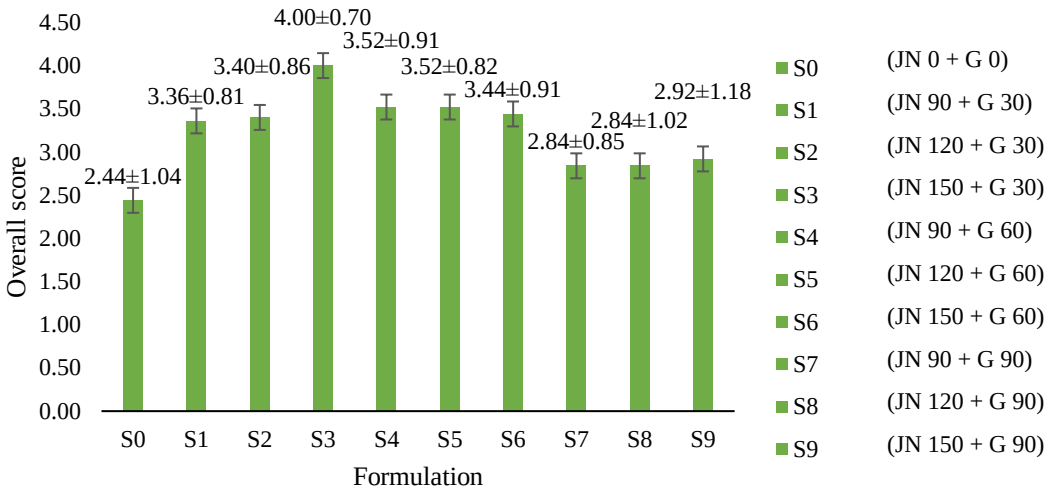

Figure 6. The overall scoring result of star fruit sorbet

Overrun

Overrun defined as the volume of sorbet or ice cream obtained in excess of the volume of the mix and is one of parameters in ice cream or sorbet industry. The higher overrun score means the better produced (Rahmawati 2017). Overrun test result for star fruit sorbet (Figure 7) showed score between 23.53 – 29.16 %. The lowest overrun score was formulation S3, which had highest sugar content of 150 g and 30 g lime juice. According to Maria & Zubaidah (2014), the addition of sucrose in high concentration can increase mixture thickness causing higher viscosity and make mixture harder to rise, in other words, has a low overrun. Formulation with the highest overrun score of 29.15 % was formulation S0 (control). Because in control formulation, there was no additional sugar and so the mixture has a low viscosity. According to Kesuma (2011), when mixture thickness is increasing, overrun will decrease. Aside from sugar, sorbet viscosity also affected by the use of a stabilizer. In this research, CMC stabilizer used with the same concentration in all treatments, which was 1.8 g, so it was not affecting obtained overrun score.

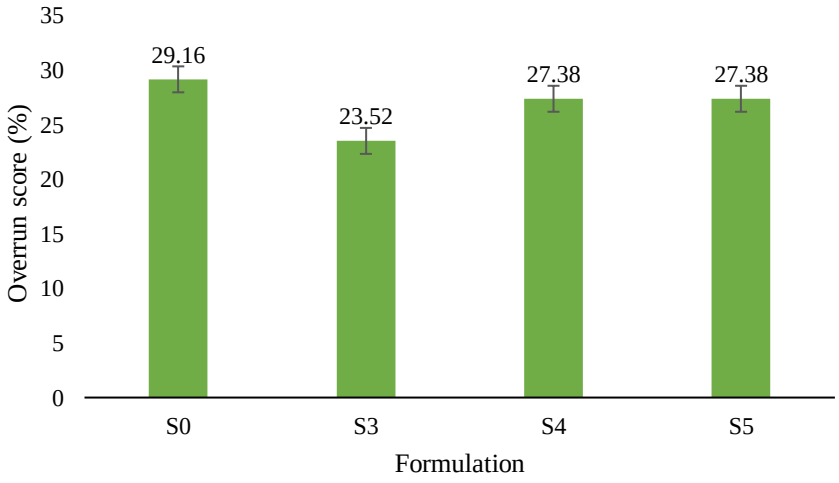

Figure 7. Overrun score result of star fruit sorbet

pH

The acidity of sorbet products is affected by the ingredients. Sorbet in this research were made from star-fruits with additional sugar and lime juice in every formulation. The result showed that the addition of lime juice affected the pH of the resulted star fruit sorbet. Figure 8 showed that the more lime juice added, the lower the pH of star fruit sorbet because lime juice contains citric acid and amino acids.

Formulation S0 (control) had a higher pH of 6.3 because there was no additional lime juice in the making of it. The lowest pH was in the formulation S4 that had an additional 90 g sugar and 60 g lime juice, with pH of 3.8. This due to lime juice contains citric acid that can affect the pH to be more acidic. Febrianti (2010), stated that additional lime juice significantly lowers the pH of papaya jam. According to Hidayat *et al*. (2017), the more lime juice added in pumpkin syrup product means, the lower the pH, because lime juice contains a lot of organic acids such as citric acid.

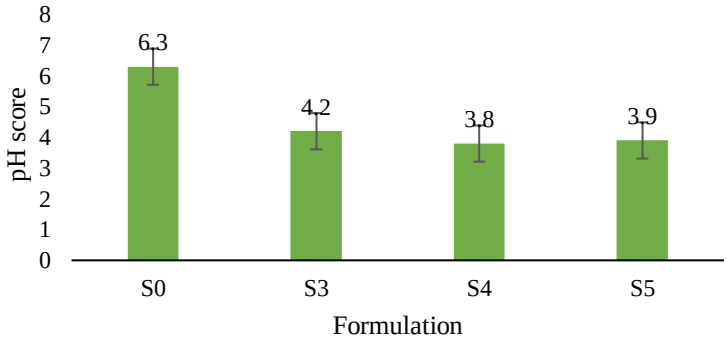

Figure 8. pH score result of star fruit sorbet

Sugar Content

The scoring results of star fruit sorbet texture shown in Figure 5. According to Dewi The formulation of star fruit sorbet in this research had a different concentration of sugar and lime juice. Results of sugar content analysis of star fruit sorbet shown in Figure 9. The lowest sugar content was formulation S0 (control) with a value of 5.95 ^{o}Brix because there was no additional sugar in it. The highest sugar content was formulation S3 with 26.85 ^{o}Brix because of the addition of 150 g sugar and 30 g lime juice. The result showed that the higher the sugar concentration used in the formulation, the higher the sugar content score of star fruit sorbet. According to Maria & Zubaidah (2014), the increase of sucrose concentration affects product sugar content. Addition of lime juice in sorbet was not significantly affect sugar content score result because lime had low sugar content.

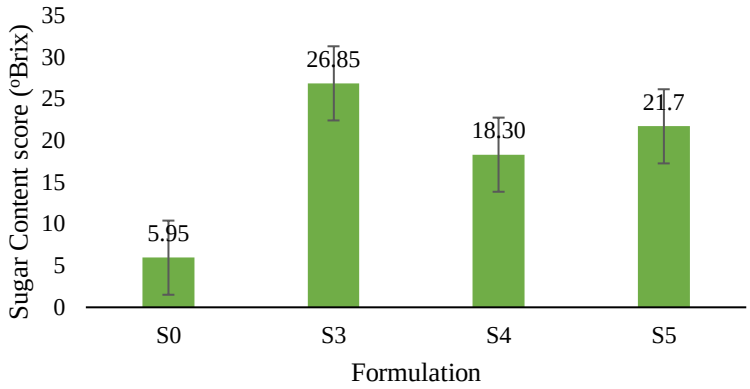

Figure 9. Sugar content score result of star fruit sorbet

Melting Time

Formulation with the shortest melting time was S0 (control) because control was made without additional sugar. Formulation with the highest melting time was S3 with additional 150 g sugar and 30 g lime juice. Results of the melting time testing of star fruit sorbet is shown in Figure 10. According to research by Maria & Zubaidah (2014), the higher sucrose content means, the longer melting time because sucrose can bind water in a product. Therefore, the higher sugar concentration, the more water-bound.

Another factor that can affect the melting time in the frozen products is the amount of stabilizer used. In this research, a CMC stabilizer used with the same concentration in all treatments, which was 1.8 g. The addition of stabilizers can increase viscosity and increase water binding ability so the product would not melt as quickly (Claudia *et al*. 2016).

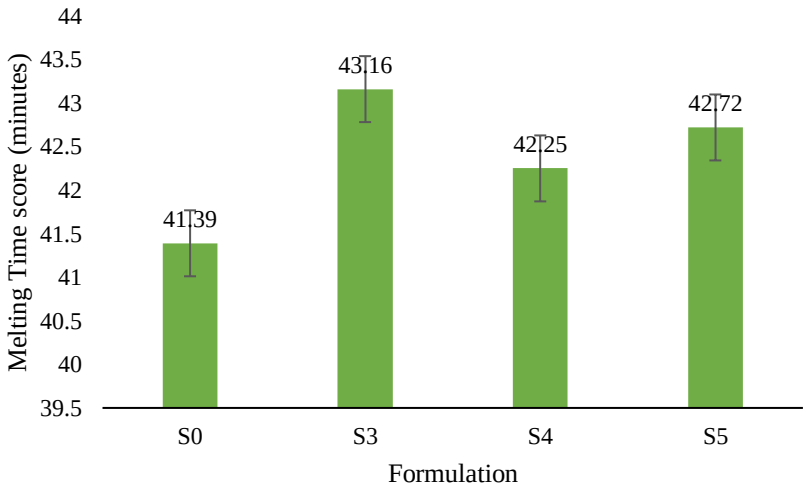

Figure 10. The melting time score result of star fruit sorbet

Vitamin C

Vitamin C is a very sensitive vitamin that can be easily broken down by heat and also a vitamin soluble in water. The addition of sugar and lime juice in star fruit sorbet affected vitamin C content. Vitamin C content in star fruit was in the range of 0.986 – 1.1144 mg. The highest vitamin C content of 1.144 mg was in formulation S4, which had an additional 90 g sugar and 60 g lime juice. While the lowest vitamin C of 0.968 mg was in S3 with 150 g sugar

and 30 gr lime juice (Figure 11).

Many factors can lower vitamin C in star fruit sorbet. According to Rahmawati (2017), a higher amount of added sugar can lower vitamin C content because vitamin C is oxidized. According to Sayuti & Yenrina (2015), vitamin C can also be lost in processing, such as blanching, washing, cutting, and blending, even in frozen storage. The addition of lime can contribute to increasing vitamin C content in star fruit sorbet because lime juice has a high vitamin C content of 29.10 mg/100 g (USDA 2018). According to Rachmayati *et al*. (2017), ripeness of star fruit as the ingredient can also affect vitamin C content because the riper the fruit means the lower vitamin C content.

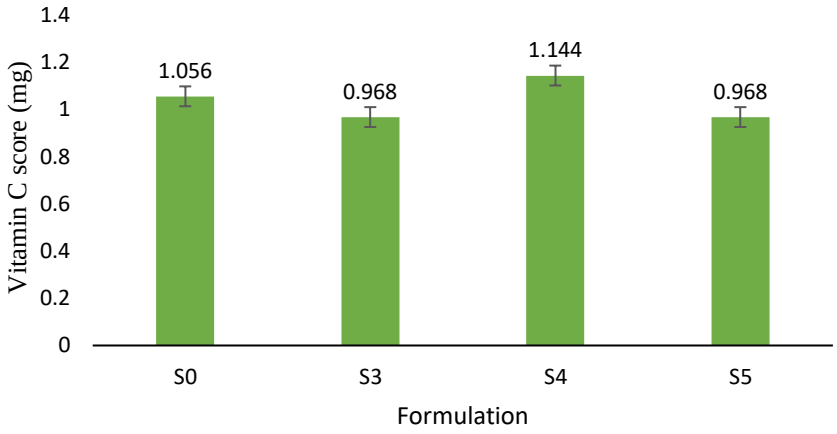

Figure 11. Vitamin C content result of star fruit sorbet

Antioxidant

The addition of lime juice and sugar in star fruit sorbet affected the antioxidant content of star fruit sorbet. Antioxidant activity measured using the DPPH method and grouped based on its IC50, where the smaller value means the higher its antioxidant activity. The half-maximal inhibitory concentration (IC50) is a measure of the effectiveness of a tested sample in inhibiting 50 % DPPH free radicals. IC50 in star fruit sorbet ranged from 228.81 to 314.84 ppm. The antioxidant activity test result shown in Figure 12. The highest antioxidant activity was in formulation S4 (90 g sugar + 60 g lime juice) with IC50 of 228.81 ppm. While the lowest antioxidant activity was in formulation S1 with IC50 of 320.86 ppm. According to Elon & Polancos (2015), lime juice beside high in vitamin C also contains flavonoid that contributes to antioxidant effect.

According to Rachmayati *et al*. (2017), aside from ripeness of the fruit, the addition of sugar also affected the antioxidant content of a product. The more sugar added means the lower its antioxidant content because sugar causing vitamin C as one of the antioxidant sources to be oxidized. The result showed that with the same lime concentration, different sugar concentration led to higher antioxidant activity in formulation with lower sugar that was S4 (90 d sugar + 60 g lime juice) with 228.81 ppm compared to S5 (120 g sugar + 60 g lime juice) with 255.4 ppm. Star fruit sorbet with the addition of lime juice had a higher antioxidant activity of 228.81 ppm, compared to mulberry sorbet in a study by Rahmawati (2017), which was 1657.540 ppm.

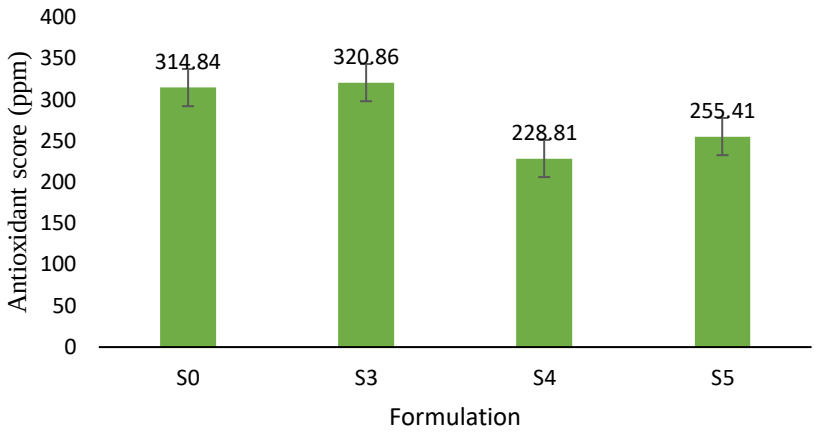

Figure 12. Antioxidant activity result of star fruit sorbet

Conclusions

The best formulations selected based on panelists' predilection in the organoleptic tests were the formulation of 150 g sugar + 20 g lime, 90 g sugar + 60 g lime, and 120 g sugar + 60 g lime. The best formulation from all test results was formulation with 150 g sugar + 30 g lime juice with overrun of 23.52%, pH of 4.20, sugar content of 26.85 ^{o}Brix, melting time of 43.16 minutes, vitamin C of 0.968 mg and antioxidant activity of 320.86 ppm. Analysis of variance showed a significant difference level ($P<0.05$). There were treatments with a significant difference in color, taste, aroma, and overall, but no significant difference in texture of star fruit sorbet. The physical appearance of formulation of 150 g sugar + 30 mg lime juice had soft texture and bright yellow color.

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