Journal of Applied Food Technology

Home page: https://ejournal2.undip.ac.id/index.php/jaft

Characteristic of Red Dragon Fruit Marmalade with Different Types of Sweeteners

Siti Susanti*, Fajar Fikri Najar, Nurwantoro

Food Technology Department, Faculty of Animal and Agricultural Sciences, Diponegoro University, Semarang, Indonesia

*Corresponding author (sitisusanti5678@gmail.com)

Abstract

Red dragon fruit, a popular in Indonesia, has 30-35% portion of skin that has not been used and mostly become a waste. Previous study showed that the skin of red dragon fruit can be used for orange marmalade production. This study objectives are to analyze physical, chemical, and hedonic characteristic of red dragon fruit marmalade (RDFM) with different types of sweeteners. Physical characteristics were evaluated using L*a*b* colorimeter for color intensity, hand refractometer for total soluble solid, and cup and bob viscometer for viscosity. Whereas, chemical characteristics evaluation was carried out using aw meter for water activity, and hedonic characteristic testing by hedonic test. The results showed that the use of different types of sweeteners had a significant effect on the physical, chemical, and hedonic characteristics of RDFM. RDFM made with High-Fructose Syrup (HFS) had the highest brightness, RDFM with sorbitol had the highest redness and water activity (aw), RDFM with honey had the highest yellowness, RDFM with sucrose had the highest Total Soluble Solids (TSS), viscosity, overall hedonic test and the lowest water activity. It can be concluded that sucrose is the best sweetener to use for RDFM because of the highest overall hedonic test so that the final product will be easier to be accepted compared to the other sweeteners.

Article information:
Received: 16 July 2020
Accepted: 26 February 2021
Available online: 13 March 2021

Keywords:
marmalede
red dragon fruit
sweetener
physical
hedonic

doi: 10.17728/jaft.8507

Introduction

Dragon fruit is a fruit that popular in Indonesia and have several famous variants such as red dragon fruit (*Hylocereus polyrhizus)* and white dragon fruit (*Hylocereus undatus*) (Wisesa and Widjanarko, 2014). Part of the dragon fruit that is widely used is the pulp, on the other hand dragon fruit has a skin with portion of 30-35% of all parts of the fruit and is still rarely used and has the red color which indicates the presence of natural pigments contained in the skin of the dragon fruit. One of the flavonoids contained in the skin of a dragon fruit is betasianin (Shofiati *et al.*, 2014). Previous study showed that the skin of red dragon fruit can be used for making orange marmalade to analyze its chemical properties using one type of sugar (Susiloningsih and Nurani, 2019).

Marmalade is a semi-solid food made from fruit juices with additional slices of fruit skin (Inam *et al.*, 2013). Basic ingredients of marmalade are fruit juice, fruit skin, pectin, sugar, acids and water. Pectin added to marmalade acts as a gelling agent. Sugar is the largest ingredient added in marmalade which acts as a sweetener, gelling agent, and preservative (Jaya and Apriyani, 2017). The making of marmalade is carried out at a high temperature so that gel formation can occur. Marmalade that has finished cooking can be put into a sterile glass bottle and left to stand for 24 hours until jellification occurs in the package (Ruiz and Campos, 2019).

There are two sweetener types, natural and artificial sweeteners. Natural sweeteners made from natural source like animal and plant. Example of natural sweeteners are sucrose, glucose, and fructose whereas sucrose and glucose can be obtained in form of granulated sugar, palm sugar, or coconut sugar, and fructose can be obtained from honey. Artificial / synthetic sweeteners are food additives that can give sweetness that has no or almost no nutritional value. Various kinds

of artificial sweeteners include saccharin, cyclamate, synthetic sorbitol, and many more (Karunia, 2013).

Previous study using orange as a main ingredient of marmalade and only using one type of sugar so the study to use the whole red dragon fruit and use another sweetener is needed because it will certainly produce different food characteristics so this research is focused on observing the physical, chemical, and hedonic characteristics of RDFM.

Materials and Methods

Materials

Red dragon fruit obtained from local market in Tembalang, Semarang, 5 types of sweetener including sucrose with brand "Rose Brand" with 0.22% moisture content, palm sugar with 8.98% moisture content, honey with brand "Nusantara" with 19.69% moisture content purchased from PT. Super Indo, sorbitol with 27.54% moisture content obtained and High-Fructose Syrup with 20.72% obtained from online (Subur Kimia Jaya, Bandung, Jawa Barat), pectin was obtained from online, citric acid, mineral water, aquadest, blender, filter, knife, pan, spoon, analytical scales, spatula, cup and bob viscometer (RION, Japan), a_w meter (Novasina, Switzerland), L*a*b* colorimeter (CS-10, China) and hand refractometer.

Methods

The production of Red Dragon Fruit Marmalade (RDFM)

The formulation of RDFM can be seen in Table 1. Preparation of RDFM was initiated with the production of red dragon fruit juice. Red dragon fruit washed with running water then the pulp separated from the skin. The pulp then was crushed with the blender with the proportion of 1:1 pulp:water. The crushed pulp is then filtered. The skin of the dragon fruit that has been separated and then sliced with a length of 2 cm and a width of 5 mm. Marmalade was made by red dragon fruit juice mixed with the skin of red dragon fruit then heated. Pectin and 5 different sweeteners were added, namely sucrose, brown sugar, honey, sorbitol and HFS which is done at a temperature of 95^{o}C in 6 minutes. Marmalade was put in a sterile jam jar and left for 24 hours where marmalade gel forming took place (Ruiz and Campos, 2019).

Table 1. Formulation of Red Dragon Fruit Marmalade (RDFM).

Ingredients	Composition (%)				
	T1	T2	T3	T4	T5
Red Dragon Fruit Juice	42.75	42.75	42.75	42.75	42.75
Red Dragon Fruit Skin	5	5	5	5	5
Pectin	2	2	2	2	1,5
Citric Acid	0.25	0.25	0.25	0.25	0.25
Sweetener	50	50	50	50	50

The treatment is carried out using the type of sweetener in sequence, namely sucrose, brown sugar, honey, sorbitol, and High-Fructose syrup (HFS).

Physical characteristics measurement

Measurement of color intensity using the Colorimeter with units L*, a*, and b*. The L* value indicates the brightness level with a value of 100 for perfect white to 0 for black. a* values indicate red to green with positive values indicating increasingly reddish colors and negative values indicating increasingly greener colors. The b* value indicates yellow to blue with a positive value indicating increasingly yellow color and negative values indicating a color that is increasingly directed towards blue (Rao et al., 2016). Total soluble solids measurement is done by hand-refractometer. Sample with weight 1 g was prepared then dissolved in 10 ml of aquadest and then stirred until it is homogeneous. The refractometer prism was rinsed with aquadest then wiped by soft cloth. The sample was dripped onto the refractometer prism and the result is a degree of Brix which is equivalent to the percentage of sucrose contained in the sample (Ramadhani *et al.*, 2017). The viscosity test was carried out with a cup and bob viscometer. The cup is filled with samples then the viscometer rotor is placed right in the middle of the cup containing the sample. The rotor will rotate and the viscosity needle will move to the right. Once stable, the viscosity is read on the scale of the rotor used in the test (Parera *et al.*, 2018).

Chemical characteristics measurement

Water activity analysis using an a_w meter. The sample was put into the container and then entered to the a_w meter, the on button was pressed and wait for the tool to sound and read the water activity values listed on the display (Murtius, 2016).

Hedonic characteristics measurement

The hedonic characteristics measurement was done by hedonic test. The hedonic rating test is done by asking panelists to give an assessment based on their preferences using a scale (Miskiyah *et al.*, 2011). The hedonic test in this study included the color, taste, texture, smear, and overall of the RDFM using a scale of 1-5 that presented very disliked, disliked, neutral, liked, and very liked (Peranginangin *et al.*, 2015).

Data Analysis

Data obtained from physical and chemical characteristic was analyzed by ANOVA with a significance level of 5% and continued with the Duncan Multiple Range Test (DMRT) if there were differences. The hedonic characteristic was analyzed by Kruskall-Wallis test with a significance level of 5% and continued with the Mann-Whitney test if there were differences. All data analyzes were calculated with the computer program SPSS 25.0 for Windows.

Results and Discussion

Physical Characteristic

Physical characteristic that was analyzed in this study were color intensity, Total Soluble Solids (TSS), and viscosity that presented in Table 2. Based on Table 2, ANOVA analysis results showed that the use of sucrose, brown sugar, honey, sorbitol, and HFS sweeteners had a significant effect on the L*, a*, and b* values of RDFM. Statistical results showed that the L* value of sucrose sweetener marmalade was not significantly different from honey sweetener marmalade and honey sweetener marmalade was not significantly different from HFS sweetener marmalade. Brown sugar and sorbitol sweetener marmalade showed significant differences, but no significant differences between them. Statistical results of the a* value indicate that between samples sorbitol and HFS sweetener marmalade are similar (P> 0.05) and in other samples there were significant differences. Statistical results of the value of b* show that all samples were significantly different except for sucrose and HFS sweetener which were not significantly different.

Table 2. Physical characteristic of RDFM

Physical Characteristic	Various Sweeteners				
	Sucrose	BS	Honey	Sorbitol	HFS
Color					
*L** value	27.45±2.56^{b}	20.00±2.44^{c}	30.80±1.67^{ab}	23.25±3.43^{c}	32.66±1.60^{a}
a* value	14.68±2.19^{c}	2.62±0.05^{d}	36.53±2.26^{b}	44.15±3.17^{a}	43.32±2.95^{a}
b* value	-0.42±0.13^{d}	2.19±1.09^{b}	3.53±0.30^{a}	-0.53±0.04^{d}	0.42±0.27^{c}
Total Soluble Solids (%)	78.00±4.00^{a}	74.00±2.83^{b}	66.00±2.31^{c}	60.50±1.00^{d}	64.50±1.91^{c}
Viscosity (Pa s)	119.25±7.41^{a}	90.63±6.29^{b}	1.20±0.29^{c}	2.9±0.69^{c}	1.85±0.31^{c}

Results are mean±standard deviation; Different superscript letters in the same column indicates the significant differences ($p < 0.05$); BS = Brown Sugar; HFS = High-Fructose Syrup.

The highest L* value is marmalade with HFS sweetener and the lowest is marmalade with brown sugar sweetener. The highest L* value in marmalade with High-Fructose Syrup (HFS) sweetener can occured because HFS is a sweetener that can retain the moisture of a food. The humidity of the marmalade during maintained heating can inhibit the evaporation of water in the marmalade so that heat that can degrade the color of the red dragon fruit can be reduced. White (2009) stated that High-Fructose Syrup can maintain food moisture so as to produce smooth and moist results. The lowest L* value is found in samples with sweetener brown sugar. This can happen because brown sugar has a dark brown color which affects the final result of RDFM so that it has the lowest L * value. In accordance with the results of Karseno and Setyawati (2013) that nutmeg jam added with sweetener coconut sugar (brown sugar) has a dark color which is the effect of the brown color which is owned by coconut sugar with a high reducing sugar content.

The highest a* value was found in marmalade with the treatment of sorbitol sweetener with an average value of 44.15 followed by HFS with an average value of 43.32. A higher value of a* indicates a higher redness value. RDFM with sorbitol sweetener has the highest red color compared to other sweetener because sorbitol can develop the color of a product. According to Vilela et al. (2015) sorbitol significantly improves color on the quality of cherry jam. The value of a* in marmalade with sucrose sweetener shows a lower a* value of 14.68. This is due to the formation of a good gel between pectin and sucrose on the RDFM thereby reducing the reddish color produced by the red color producing betalain pigment. This is supported by the opinion of Melgarejo et al. (2011) that pectin can cause color loss in strawberry jam because pectin performs differently from the anthocyanin pigment contained in strawberry. The red color of RDFM is due to the content of betalain pigments possessed by dragon fruit. The pigment is responsible for the formation of red color in processed food products from dragon fruit or food ingredients that get a mixture of dragon fruit in it. According to Priatni and Pradita (2015) betalain is a pigment contained in dragon fruit that has a derivative namely betacyanin which produces purplish red color and betaxanthin which produces orange-yellow color. Pigments contained in dragon fruit will be degraded in making marmalades because there is a cooking process that uses heat. According to Yang et al. (2018) pigments contained naturally in fruits and vegetables such as carotenoids, betalain and chlorophyll but these components are sensitive to heat so they will be degraded in processing

products.

The highest b* value was found in marmalade with honey sweetener while the b* value was lowest in marmalade with sorbitol sweetener. The higher value of b* indicates higher yellowness while the lower value of b* indicates higher blueness. Marmalade with honey sweetener had a high yellowness value due to the influence of the addition of yellowish honey sweetener. This is in accordance with the opinion of Seth and Mishra (2011) that the yellowish index in candy products increases with the addition of honey due to the color of honey which is yellow. The highest b* value after honey sweetener marmalade was found in brown sugar sweetener marmalade. Brown sugar can increase the yellowness value of RDFM because the brownish yellowish brown color affects the final color of the RDFM. According to Naufalin et al. (2013) sugar from coconut juice has a brownish color due to the content of the reducing sugars it contains in which the reducing sugars can contribute to browning through the maillard reaction.

Based on the Table 2 it can be seen that the use of different types of sweeteners has a significant effect on the value of Total Soluble Solids (TSS) of RDFM with the type of sweetener sucrose, brown sugar, honey, sorbitol, and HFS each has TSS values of 78%, 74%, 66%, 60.5% and 64.5% respectively. Statistical results show that all samples had significantly different TSS from each other except between honey and HFS sweetener marmalade which were similar ($P>0.05$). Solids that are counted as total soluble solids in RDFM are sugar and pectin content. Susiloningsih and Nurani (2019) stated that the total value of soluble solids of marmalade is influenced by the presence of added sugar and pectin content. The difference in TSS in each marmalade is caused by differences in the physical characteristics of the types of sweeteners used in this research which have different moisture content. Sucrose that used in this research has a moisture content of 0.22%, brown sugar has 8.98% moisture content, honey 19.69% moisture, sorbitol 27.54% moisture, and HFS 20.72% moisture. According to Ramadhani et al. (2017) the physical difference in the type of sweetener that is the difference in water content causes differences in the physical characteristics of the products produced.

The highest TSS was found in marmalade with the use of sucrose sweetener with a value of 78% due to the form of sucrose used in the form of solids in the form of sugar with a moisture content of 0.22%. The low water component contained in granulated sugar causes high total solids so it caused higher TSS in the marmalade compared to the marmalade with other types of sweeteners. The lowest TSS was found in marmalade with sorbitol sweetener with a value of 60.5% because it was influenced by the highest moisture content of sorbitol than the other sweetener moisture content which was 27.54%. This is supported by the opinion of Susanto & Setyohadi (2011) that the food component is composed of total solids and water so that the component that affects the water content of a food is the amount of solids. High TSS in marmalade with the use of sucrose sweetener caused not only by the low water content of sucrose but also sucrose is a water-soluble component and is counted as TSS. This is in accordance with the opinion of Arumaningrum et al. (2015) that the total soluble solid increases with the addition of sucrose because sucrose soluble in a solution has a high TSS.

TSS in honey and HFS sweetener marmalade was lower than sucrose and brown sugar sweetener marmalade but higher than sorbitol sweetener marmalade because in honey and HFS there were water soluble compounds namely fructose. According to Vaclavik and Christian (2008) honey is a sweetener produced from flower nectar which has a water content of about 20% and contains a mixture of fructose and glucose and HFS is a syrup produced from 3 processes namely hydrolyzed, refined, and concentrated which can produce as much as 42% to 55% fructose. Doğan (2011) also stated that fructose and glucose are important solids found in honey which is the most dominant monosaccharide with 60-85% proportion.

Based on the Table 2, it can be seen that the use of different types of sweeteners had a significant effect on the viscosity of RDFM that the type of sweetener sucrose, brown sugar, honey, sorbitol, and HFS each had a viscosity of 119.25 Pa s, 90.63 Pa s, 1.20 Pa s, 2.9 Pa s and 1.85 Pa s. Statistical results showed that sucrose and brown sugar sweetener marmalade showed significant differences with other samples while the rest marmalades were similar. The highest viscosity was found in marmalade with sucrose sweetener. This is due to the high TSS in marmalade with sucrose sweetener, causing their viscosity to increase. This is in accordance with Kurniawati et al. (2019) that total soluble solids (TSS) affects the viscosity of the jam product where the higher the TSS will increase the viscosity of the produced product. Sucrose can increase viscosity not only due to highest TSS but also due to sucrose acts as an adjuvant in the formation of gels carried out by pectin in the process of making marmalade. According to Basu et al. (2011) pectin forms a biopolymer bond which forms a gel and requires sucrose as an adjunct in the formation of the gel. Marmalade with sweeteners of honey, sorbitol and HFS produces lower viscosity than sweeteners of sucrose and brown sugar. Marmalade with honey sweetener has the lowest viscosity caused by honey sweetener which has a higher water content and has the ability to increase humidity. This is in accordance with the opinion of Vaclavik and Christian (2008) that honey has a water content of about 20% and has a fructose content that is hygroscopic so that the addition of honey to a food will increase its humidity.

Chemical Characteristic

Chemical characteristic of RDFM that was analyzed in this research was a_w value that presented in

Figure 1. Based on the Figure 1 it can be seen that the use of different types of sweeteners has a significant effect on the a_w value of RDFM with the type of sweetener sucrose, brown sugar, honey, sorbitol, and HFS respectively 0.595, 0.626, 0.649, 0.675 and 0.654. Statistical results showed that there were significant differences between samples against a_w values of RDFM but between honey and HFS sweetener were not significantly different.

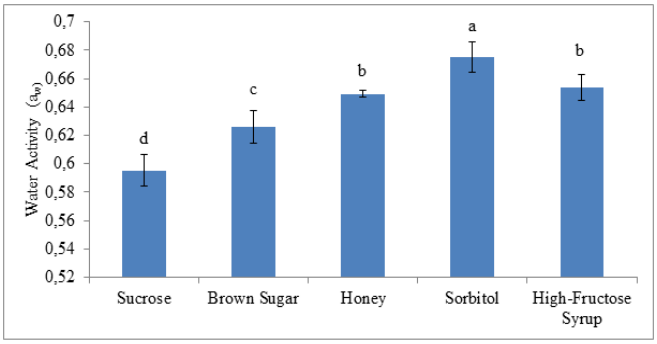

Figure 1. Water activity (a_w) value of RDFM. The superscript shows significantly difference using Duncan's Multiple Range Test.

The value of a_w on RDFM was lower than previous studies. According to Rubio-Arraez et al. (2016) commercial lemon marmalade has a water activity of around 0.8. This happened because in previous studies the total value of soluble solids was set to a maximum of 65%, whereas in this study the total soluble solids varied to exceed 65%. The higher value of soluble solids can reduce the value of aw because more free water is bound by soluble solids so that less free water. This is in accordance of Novita et al. (2017) that pectin and sugar can bind water which plays a role in the formation of gels in making marmalades. RDFM had a low a_w due to the addition of sweeteners with a concentration of 50% which could reduce a_w. This is in accordance with the opinion of Kuwada et al. (2010) that the making of marmalade uses sugar with high concentrations so as to produce conditions of low water activity.

Marmalade with sucrose sweetener had the lowest a_w compared to other sweetener marmalade. This was occured because sucrose is hygroscopic which can bind free water so that the water activity which is free water content that can be used by microorganisms to grow is decreased. Fajarwati (2017) stated that sucrose is a hygroscopic compound that is able to bind free water so that more sucrose is added to the free water bound food material. The lowest water activity of a marmalade with sucrose is also due to the difference in Total Soluble Solids (TSS). The highest TSS was found in marmalade with sucrose sweetener caused water activity or free water content to be low. Susanto & Setyohadi (2011) stated that the food component is composed of total solids and water so that the component that affects the water content of a food is the amount of solids.

Hedonic Characteristic

The results of the hedonic test of RDFM included colour, taste, texture, smear, and overall were presented in Table 3. Hedonic test results of RDFM with the use of sucrose, brown sugar, honey, sorbitol, and HFS sweeteners had a significant effect on the color preference. RDFM with sorbitol was the most preferred by panelist compared to other types of sweetener marmalade. Statistical results showed that sorbitol, sucrose sweetener and honey sweetener marmalade were not significantly different, sucrose and honey sweetener were not significantly different from HFS marmalade. However, brown sugar sweetener showed a significant difference in the likeness of the color of the RDFM. RDFM with brown sugar sweetener was the most disliked by panelists with an average score of 2.56 which entered the criteria for disliked. This is caused by the basic color of the sugar sweetener itself which affects the final result of RDFM. This is in accordance with what happened in Karseno and Setyawati (2013) research on nutmeg jam making that nutmeg added with coconut sugar sweetener (brown sugar) has a dark color which is the effect of the brown color possessed by coconut sugar with high reducing sugar content. Brown sugar has a dark brown color so that it produces dark-colored marmalade that panelists don't like. According to Naufalin et al. (2013) sugar from coconut juice has a brownish color due to the content of the reducing sugars it contains in which the reducing sugars can contribute to browning through the Maillard reaction.

RDFM with sorbitol was the most preferred color by panelist compared to other types of sweeteners. Distinctive red color of RDFM was influenced by betalain pigments contained in red dragon fruit. This is in accordance with the opinion of Priatni and Pradita (2015) that betalain is a pigment contained in dragon fruit that has a derivative namely betacyanin which produces purplish red color and betaxanthin which produces orange-yellow color. RDFM with sorbitol sweetener is the most preferred because sorbitol is able to maintain the red color in the final result of RDFM. The a* value parameter in this study also showed that sorbitol showed the highest value, which means the redness value of marmalade with sorbitol sweetener was the highest. This is in accordance with the results of research Vilela et al. (2015) that sorbitol significantly improves color on cherry jam quality. Color is an important food indicator because color can be directly assessed by consumers through the sense of sight without having to touch or taste the food and will affect the liking of a food. According to Winarno (2004), the color factor in food material will visually appear first compared to other food factors so as to determine the quality of food. This is supported by Wahyuni (2011) which stated that color is an indicator that can be directly observed by consumers who are able to influence consumer tastes so as to arouse appetite.

Table 3. Hedonic characteristic of RDFM

Hedonic Atributes	Various Sweetener				
	Sucrose	BS	Honey	Sorbitol	HFS
Color	4.24±0.779[ac]	2.32±1.108[b]	4.04±0.735[ac]	4.40±0.500[a]	3.96±0.611[c]
Taste	3.92±0.909[a]	3.04±1.020[b]	3.48±0.872[ab]	3.80±0.816[a]	3.84±0.746[a]
Texture	3.44±1.083[a]	2.56±1.044[b]	3.48±0.823[a]	3.76±0.831[a]	3.24±1.012[a]
Smear	3.84±1.028[a]	2.56±1.003[b]	3.36±0.952[a]	3.80±0.913[a]	3.48±0.770[a]
Overall	4.16±0.943[a]	2.76±0.779[b]	3.52±0.823[c]	4.08±0.862[ad]	3.76±0.663[cd]

Results are mean±standard deviation; Different superscript letters in the same column indicates the significant differences ($p < 0.05$); BS = Brown Sugar; HFS = High-Fructose Syrup.

Based on the table 3, it can be seen that the results of hedonic test of RDFM by using sucrose, brown sugar, honey, sorbitol, and HFS sweetener had a significant effect on the taste preferences of RDFM. Statistical results showed that sucrose, sorbitol and HFS sweetener marmalade were not significantly different. Brown sugar sweetener was significantly different from those three sweeteners but it was not significantly different from honey sweetener.

The type of sweetener influenced the preference for the taste of RDFM by panelists because each sweetener has a different sweetness level. Each panelist's preference for sweetness is also relative because there are panelists who like sweet and do not like sweet which are influenced by panelist eating habits. This is supported by the opinion of Hasanah et al. (2014) which stated that the existence of eating habits will be a factor influencing a preference for one's basic taste. RDFM with sucrose sweetener was the most preferred panelist compared to other types of sweetener marmalade. Sucrose sweeteners are the most commonly used sweeteners and used as a standard for sweetness with other sweeteners. This is in accordance with the opinion of (Faradillah *et al.*, 2017) that sucrose is used as a standard sweetness level for other types of sweeteners with 100% level of sweetness. The preferred flavor of RDFM after sucrose is HFS sweetener marmalade. HFS which has a higher sweetness value than sucrose affects the panelists' preference for the taste of RDFM. According to Qonitah et al. (2016) HFS has a sweetness level 1.8 times higher than sucrose with a calorific value of 3.9 calories / gram. Marmalade with sweetener sorbitol has a value of 3.80 which is a neutral-liked criteria. Marmalade with a type of sucrose sweetener has a rather low sweetness compared to sucrose because sorbitol has a sweetness level of 50% below the sucrose that affects the taste of RDFM. According to Syafutri et al. (2010) sorbitol sweetener has a sweetness level of 50-70% below sucrose with calorie content of 2.6 calories / gram.

RDFM with the lowest taste preference value was found in RDFM with brown sugar sweetener. That could happen because brown sugar has a distinctive taste and aroma of brown sugar in the form of caramel and a little acid so that it affects the flavor of marmalade which seems to make marmalade that uses brown sugar sweetener become less preferred. According to Sutrisno & Susanto (2014) brown sugar has a slightly sour taste resulting from the organic acids it contains and also has a distinctive flavor that smells of caramel. The color of the dark RDFM due to the influence of the color of the brown sugar used can also affect the taste preference. According to Winarno (2004) a nutritious, delicious, well-textured foodstuff will not be eaten if it has an unsightly color and deviates from the color it should.

Based on the Table 3 it can be seen that the hedonic test results of RDFM with the use of sucrose, brown sugar, honey, sorbitol, and HFS sweeteners had a significant effect on the texture preferences of the red dragon fruit. Statistical results showed that the brown sugar produced a significant difference in preference for the texture of the RDFM. The texture is related to the viscosity of RDFM. Brown sugar sweetener marmalade had viscosity of 90.63 Pa s which showed a thick texture which panelists did not like. This is supported by the study of Arslaner et al. (2020) about yogurt added marmalade that viscosity significantly affects the texture of yogurt. The most preferred texture is marmalade with sorbitol sweetener. Marmalade made with sweetener sorbitol produces a texture that is not too thick so it feels soft in the mouth. According to Agustina and Handayani (2016) panelists generally like a type of jam product that has a soft texture, not stiff, and easily applied to the surface of the bread. The soft texture of marmalade with sorbitol sweetener is influenced by the viscosity of 2.9 Pa S. This is in accordance with the opinion of Singgih and Harijono (2015) that the lower the viscosity of food dough, the resulting texture will be soft.

Based on the Table 3 it can be seen that the hedonic test results of RDFM with the use of sucrose, brown sugar, honey, sorbitol, and HFS sweeteners had a significant effect on the preference of the RDFM smear. Statistical results showed that brown sugar sweetener gives a significant difference in the preference for the power of RDFM. Smear test was done by applying marmalade on white bread. RDFM with brown sugar had a lowest score on smear attribute. This is related to the texture of the marmalade which was the least preferred, which also made it difficult to applied marmalade on white bread. According to Syaifuddin et al. (2019) a low jam value indicates that the jam is too thick, or that the jam is too runny, making it difficult to

spread the jam. The smear favored by panelists is marmalade that is neither too thick nor too runny so it is easily spread on white bread. RDFM smear with various sweetener were found neutral by panelists and not significantly different except with brown sugar sweetener that was disliked. This is due to the texture and viscosity which affected the smear of RDFM. This is in accordance with the opinion of Agustina and Handayani (2016) that the smear of similar jam products is closely related to viscosity and texture.

Based on the Table 3, it can be seen that the hedonic test results of RDFM with the use of sucrose, brown sugar, honey, sorbitol, and HFS sweeteners had a significant effect on the overall preference of RDFM. The overall preference for panelists on RDFM from highest to lowest is in sucrose sweetener marmalade, sorbitol marmalade, HFS sweetener marmalade, HFS sweetener marmalade, honey sweetener marmalade and brown sugar sweetener marmalade. This showed that the sucrose sweetener marmalade both from the attributes of color, taste, texture, and smear received the best response from the panelists so that overall the RDFM with sucrose sweetener has the highest value. In the opinion of Lukito et al. (2012) that in a preference test, panelists were asked to respond privately about their likes or dislikes to a product where the test of preference is always related to the existence of a product and the acceptability of the product. RDFM with sucrose sweetener was the most preferred in its flavor and smear attributes which make it the most preferred overall. RDFM with sucrose sweetener produces the most preferred sweet taste because it was influenced by the sweetness level of the type of sweetener and sucrose is the sweetener most commonly used in food. The sweetness level of sucrose is the level of sweetness used as a standard for the level of sweetness of other sweeteners. This is in accordance with the opinion of Agustina and Handayani (2016) that sucrose is used as a standard sweetness level for other types of sweeteners. Marmalade with sorbitol sweetener is the most preferred after marmalade with sucrose sweetener. The color and texture attributes of RDFM with sorbitol sweetener are the most preferred by panelists. The red color produced in RDFM with the highest was the most preffered by panelists, thus affecting overall results. According to Winarno (2004) the color factor in food material will visually appear first compared to other food factors so as to determine the quality of food.

Conclusion

The use of different types of sweeteners affected the physical, chemical and hedonic characteristics of RDFM. The color intensity of the RDFM showed the highest brightness was found in HFS sweetener marmalade, the highest redness in sorbitol sweetener marmalade, and the highest yellowness in honey sweetener marmalade. The highest viscosity and Total Soluble Solids (TSS) were obtained in RDFM with sucrose sweeteners. The lowest water activity was obtained in marmalade with sucrose sweetener and the highest in marmalade with sorbitol sweetener. The hedonic characteristic of marmalades indicated that the most preferred color attribute of marmalade was sorbitol sweetener; the most preferred taste attribute was sucrose sweetener; the most preferred texture attribute was sorbitol sweetener; the most preferred attribute of smear was sucrose sweetener; and the most preferred overall is sucrose sweetener. The most optimal sweetener to use was sucrose resulted desirable hedonic characteristics which was the most preferred in overall.

Acknowledgment

The author would like to thank Food Technology Laboratory Assistant and Soursop Velva Research Team for their support and help to this research.

References

Agustina, W.W., Handayani, M.N. 2016. The addition influence of carrot (*Daucus carota*) towards the sensory characteristics and physicochemical the red dragon fruit jams (*Hyloreceus polyrhizus*). FORTECH 1(1): 16–28. DOI:https://doi.org/10.17509/edufortech.v1i1.3970. (In Bahasa Indonesia)

Arslaner, A., Salik, M.A., Bakirci, İ. 2020. The effects of adding Hibiscus sabdariffa L. flowers marmalade on some quality properties, mineral content and antioxidant activities of yogurt. Journal of Food Science and Technology. Springer. DOI:10.1007/s13197-020-04533-z.

Arumaningrum, D., Susilo, B., Argo, B.D. 2015. The effect of sucrose proportion and osmosis time for white dragon fruit quality (*Hylocereus undatus*). Jurnal Keteknikan Pertanian Tropis dan Biosistem 3(1): 100–105. (In Bahasa Indonesia).

Basu, S., Shivhare, U.S., Singh, T. V., Beniwal, V.S. 2011. Rheological, textural and spectral characteristics of sorbitol substituted mango jam. Journal of Food Engineering 105(3): 503–512. DOI:10.1016/j.jfoodeng.2011.03.014.

Dayakar Rao, B., Anis, M., Kalpana, K., Sunooj, K. V., Patil, J. V., Ganesh, T. 2016. Influence of milling methods and particle size on hydration properties of sorghum flour and quality of sorghum biscuits. LWT - Food Science and Technology 67 8–13. DOI:10.1016/j.lwt.2015.11.033.

Doğan, M. 2011. Rheological behaviour and physicochemical properties of kefir with honey. Journal fur Verbraucherschutz und Lebensmittelsicherheit 6(3): 327–332. DOI:10.1007/s00003-010-0643-6.

Fajarwati, D.S. 2017. The effect of sucrose and matodextrins combination on physicochemical and organolepticparameters of soybean sweetened condensed milk. Jurnal Pangan dan Agroindustri 5(3): 72–82. (In Bahasa Indonesia).

Faradillah, N., Hintono, A., Pramono, Y.B. 2017. Characteristics of low calorie milk caramel candy by different proportion of sucrose and stevia sugar (*Stevia rebaudiana*). Jurnal Aplikasi Teknologi Pangan 6(1): 39–42. DOI:10.17728/jatp.206. (In Bahasa Indonesia).

Hasanah, U., Dede, R.A., Nurtama, B. 2014. Preferences and detection threshold of sweetness and bitterness: multicultural and gender approach. Jurnal Mutu Pangan 1(1): 1–8. (In Bahasa Indonesia).

Inam, A., Hossain, M., Siddiqui, A., Easdani, M. 2013. Studies on the Development of Mixed Fruit Marmalade. Journal of Environmental Science and Natural Resources 5(2): 315–322. Bangladesh Journals Online (JOL). DOI:10.3329/jesnr.v5i2.14836.

Jaya, A., Apriyani, S. 2017. The effect of gelling agent and sucrose on the quality of calamansi marmalade. AGRITEPA: Jurnal Ilmu dan Teknologi Pertanian 4(2): 53–64. Unived Press. DOI:10.37676/agritepa.v4i2.676. (In Bahasa Indonesia).

Karseno, K., Setyawati, R. 2013. The properties of nutmeg jam: proportion of cane sugar, coconut sugar and pineapple. Jurnal Pembangunan Pedesaan 13(2): 147–155. (In Bahasa Indonesia).

Karunia, F.B. 2013. Kajian penggunaan zat adiktif makanan (pemanis dan pewarna) pada kudapan bahan pangan lokal di pasar kota semarang. Foof Science and Culinary Journal 2(2): 72–78.

Kurniawati, E.C., Husamah, Latifa, R., Zaenab, S., Permana, T.I., Fauzi, A. 2019. Making *Eucheuma cottonii* Doty jam with various palm sugar concentrations. IOP Conference Series: Earth and Environmental Science. Vol. 276. Institute of Physics Publishing. DOI:10.1088/1755-1315/276/1/012019.

Kuwada, H., Jibu, Y., Teramoto, A., Fuchigami, M. 2010. The quality of high pressure-induced and heat-induced yuzu marmalade. High Pressure Research 30(4): 547–554. DOI:10.1080/08957959.2010.534090.

Lukito, G.A., Suwarastuti, A., Hintono, A. 2012. The effect of salting method on nacl level, tenderness, and consumer's preference of quail eggs. Animal agriculture journal 1(1): 829–838. (In Bahasa Indonesia).

Melgarejo, P., Martínez, R., Hernández, F., Martínez, J.J., Legua, P. 2011. Anthocyanin content and colour development of pomegranate jam. Food and Bioproducts Processing 89(4): 477–481. DOI:10.1016/j.fbp.2010.11.004.

Miskiyah, Widaningrum, Winarti, C. 2011. Edible coating application based on sago starch and vitamin c on sweet pepper: consumer's preference and microbiological quality. Jurnal Hortikultura 21(1): 68–76. DOI:10.21082/jhort.v21n1.2011.p68-76. (In Bahasa Indonesia).

Murtius, S.W. 2016. Aktivitas amilolitik pada parutan ubi kayu (*Manihot uttilissima*) yang diperam dengan waktu yang berbeda. Teknologi Pertanian Andalas 20(1410–1920): 27–34. DOI:https://doi.org/10.25077/jtpa.20.1.27-34.2016.

Naufalin, R., Tri, Y., Anna, S. 2013. Types and concentration effect of natural preservatives on the quality of palm sugar. Jurnal Teknologi Pertanian 14(3): 165–174.

Novita, T., Tutuarima, T., Hasanuddin. 2017. Physical and chemical properties of marmalade citrus of calamondin (*Citrus microcarpa*) : study of pectin and sucrose concentrations. Jurnal Eksakta 18(02): 165–169. DOI:https://doi.org/10.24036/eksakta/vol18-iss02/73.

Parera, N.T., Bintoro, V.P., Rizqiati, H. 2018. physical properties and organoleptic of gelato made from goat's milk mixture with cinnamon (*Cinnamomum burmanii*). Jurnal Teknologi Pangan 2(1): 40–45. DOI:10.14710/jtp.2.1.%p. (In Bahasa Indonesia)

Peranginangin, R., Handayani, A.M., Fransiska, D., W. Marseno, D., Supriyadi, S. 2015. Effect of CaCl 2 and alginate concentration on characteristics of analog alginate pulpy orange. Jurnal Pascapanen dan Bioteknologi Kelautan dan Perikanan 10(2): 163. DOI:10.15578/jpbkp.v10i2.375. (In Bahasa Indonesia).

Priatni, S., Pradita, A. 2015. Stability study of betacyanin extract from red dragon fruit (*Hylocereus polyrhizus*) Peels. Procedia Chemistry 16 438–444. DOI:10.1016/j.proche.2015.12.076. (In Bahasa Indonesia).

Qonitah, S.H., Affandi, D.R., Basito. 2016. Study of the use of high fructose syrup (HFS) as sucrose subtitution on the characteristics of biscuit made from corn flour (*Zea mays*) and kidney beans flour (*Phaseolus vulgaris* L.). Jurnal Teknologi Hasil Pertanian 9(2): 9–21. (In Bahasa Indonesia)

Ramadhani, P.D., Setiani, B.E., Rizqiati, H. 2017. The quality of avocado jam (persea americana mill) with various natural sweetener flavouring. Jurnal Teknologi Pangan 1(1): 8–15. DOI:https://doi.org/10.14710/jtp.1.1.%25p. (In Bahasa Indonesia)

Rubio-Arraez, S., Ferrer, C., Capella, J.V., Ortolá, M.D., Castelló, M.L. 2016. Development of lemon marmalade formulated with new sweeteners (isomaltulose and tagatose): effect on antioxidant, rheological and optical properties. Journal of Food Process Engineering 40(2):. DOI:10.1111/jfpe.12371.

Ruiz, J.C.R., Campos, M.R.S. 2019. Development of nopal-pineapple marmalade formulated with stevia aqueous extract: effect on physicochemical properties, inhibition of α-amylase, and glycemic response. Nutricion Hospitalaria 36(5): 1081–1086. DOI:10.20960/nh.02048.

Seth, D., Mishra, H.N. 2011. Optimization of honey candy recipe using response surface methodology. American Journal of Food Technology 6(11): 985–993. DOI:10.3923/ajft.2011.985.993.

Shofiati, A., Andriani, M.A.M., Anam, C. 2014. Study of antioxidant capacity and sensory acceptance of dragon fruit peel teabag addition of lemon peel and stevia. Jurnal Teknosains Pangan 3(2): 5–13. Retrieved from www.ilmupangan.fp.uns.ac.id (In Bahasa Indonesia)

Singgih, W.D., Harijono, H. 2015. The effect of proportion glutinous rice flour and potatoes on wingko processing. Jurnal Pangan dan Agroinsudtri 3(4): 1573–1583. (In Bahasa Indonesia)

Susanto, W.H., Setyohadi, R.B. 2011. The effect of apple (*Malus sylvestris*) varieties and fermentation time by yeast saccharomy. Jurnal Teknologi Pertanian 12(3): 135–142. (In Bahasa Indonesia)

Susiloningsih, B.K.E., Nurani, F.P. 2019. Chemistry characteristics of marmalade made from dragon fruit peel and kepok banana. Jurnal Teknologi Pangan 13(2): 35–44. DOI:10.33005/jtp.v13i2.1704. (In Bahasa Indonesia)

Sutrisno, C.D.N., Susanto, W.H. 2014. The influence of type and concentration paste (coconut milk and nuts) toward brown sugar quality product. Jurnal Pangan dan Agroindustri 2(1): 97–105. Retrieved from http://jpa.ub.ac.id/index.php/jpa/article/view/26. (In Bahasa Indonesia)

Syafutri, M.I., Lidiasari, E., Indawan, H. 2010. Characteristics of *Cucumis melo* L. jelly candies with the addition of sorbitol and *Curcuma domestika* Val. extract. Jurnal Gizi dan Pangan 5(2): 78. DOI:10.25182/jgp.2010.5.2.78-86. (In Bahasa Indonesia)

Syaifuddin, U., Ridho, R., Harsanti, R.S. 2019. Pengaruh konsentrasi kulit buah naga merah (Hylocereus polyrhizus) dan gula terhadap karakteristik selai. Teknologi Pangan dan Ilmu Pertanian 1(1): 27–39.

Vaclavik, V.A., Christian, E.W. 2008. Essentials of food science. 3rd ed. New York: Springer.

Vilela, A., Matos, S., Abraão, A.S., Lemos, A.M., Nunes, F.M. 2015. Sucrose replacement by sweeteners in strawberry, raspberry, and cherry jams: effect on the textural characteristics and sensorial profile—a chemometric approach. Journal of Food Processing 2015 1–14. DOI:10.1155/2015/749740.

Wahyuni, R. 2011. Optimasi pengolahan kembang gula jelly campuran kulit dan daging buah naga super merah (*Hylocereus costaricensis*) dan prakiraan biaya produksi. Teknologi Pangan : Media Informasi dan Komunikasi Ilmiah Teknologi Pertanian 1(1): 16–38. DOI:10.35891/tp.v1i1.475. (In Bahasa Indonesia)

White, J.S. 2009. Misconceptions about high-fructose corn syrup: is it uniquely responsible for obesity, reactive dicarbonyl compounds, and advanced glycation endproducts?. The Journal of Nutrition 139(6): 1219S-1227S. DOI:10.3945/jn.108.097998.

Winarno, F. 2004. Kimia dan Gizi Pangan. Jakarta: Gramedia Pustaka Utama.

Wisesa, T.B., Widjanarko, S.B. 2014. Maximum value determination of red dragon fruit peel extraction process. Pangan dan Agroindustri 2(3): 88–97. (In Bahasa Indonesia)