The Effect of Erythritol and Stevia Sweetener Types on The Sensory Characteristics of Siam Orange Peel – Mango Fruit Leather

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Abstract
The high prevalence of degenerative diseases has a positive correlation with excess sugar intake. Fruit leather is a processed product from fruit puree with the addition of sucrose sugar, so the sugar content is high. This study aims to determine the effect of the types of sweeteners erythritol and stevia on the sensory characteristics of the fruit leather of Siam Orange Peels-Mango. This study used a factorial complete randomized design (CRD) with two factors, the ratio of siam orange peel and mango fruit with 4 levels ((0%: 100%), (10%: 90%), (20%: 80%), (30%:70%)) and type of sweetener with 2 levels (erythritol and stevia). The sensory parameters tested included color, smell, taste, texture and overall. The results showed that the two factors and their interactions had a significant effect on all sensory attributes tested. Based on sensory analysis, fruit leather products 10% orange peel and 90% mango with erythritol sweetener type were the most preferred products on all sensory attributes.

Keywords: Fruit Leather, Sensory Evaluation Erythritol, Stevia, Siam Orange Peel, Mango

1. Introduction

Degenerative diseases or known as *Noncommunicable Chronic Diseases* (NCDs) are increasing from year to year. Currently, degenerative diseases have become the highest cause of death in the world. *Cardio Vascular* Disease (CVD), obesity, diabetes, and cancer are degenerative diseases which account for 60% of deaths worldwide and 70% of deaths in Europe each year. The increased risk of degenerative diseases such as diabetes and CVD correlates with obesity/overweight problems. Changes in food consumption patterns which tend to consume fast food *which* are generally high in sugar, high in calories, and low in dietary fiber are the main factors causing obesity (overweight). Excess sugar intake can be played by processed food products. The high number of calories in processed food products, one of which can come from raw sugar, which is high in calories. Excessive sugar consumption can increase the risk of obesity, diabetes, metabolic syndrome, dyslipidemia, dental caries, high blood pressure, insulin resistance, high cholesterol, cardiovascular disease, liver carcinogenesis, and other chronic diseases (Vatankhah et al., 2015), endometrial and ovarian cancer (Arthur et al., 2021).

Mango (Mangifera *indica*) is a horticulture commodity that bears seasonal fruits and originates from India. This plant spreads to the Southeast Asian region including Indonesia (Muh Arsyad, 2022). Mangoes come in a wide variety of shapes, sizes, colors and flavors. so it has the potential to be developed because of its very high level of genetic diversity (Muh Arsyad, 2022). Mango fruit contains phytochemicals , nutrients, vitamin C, dietary fiber and is rich in vitamin C

and contains beta-carotene, which are essential nutrients that can function as antioxidants (Ayu Krisna Hadi et al., 2020). Physiologically, mangoes that have been picked can carry out respiration processes and other metabolic processes. The metabolic process takes the form of overhauling the content stored in the fruit. Fadhila et al., (2022) stated that this process can accelerate wilting and decay so that mangoes can last 3 to 4 days at room temperature storage. Therefore, there is a need for food processing efforts by utilizing mangoes as the main raw material. One of them is processed into *fruit leather.*

Fruit leather is a food product made from fruit puree that is dried in an oven. The name "*leather" is used* because when the fruit puree is dried it produces a product that is shiny and has a leather-like texture (Aryani et al., 2022). *Fruit leather* drying can be done using sunlight or using an oven with a temperature of 50 - 60°C. So that it has a long shelf life, which is up to 12 months (Fadhila et al., 2022). The raw materials for *fruit leather* come from tropical or subtropical fruits such as bananas, papayas, mangoes, pineapples, apples, jackfruit, dragon fruit and so on (Ayu Krisna Hadi et al., 2020). The criteria for making *fruit leather* are determined by the sugar content, fiber and acid content. The fiber content in mangoes is still too little so it must be combined with Siamese orange peel.

Siamese oranges (Citrus *nobilis)* are a type of citrus that is widely developed in Indonesia because it has considerable potential. Around 70-80% of oranges developed in Indonesia are Siamese oranges and the remaining 20-30% are tangerines (Febrianti et al., 2019). Siamese orange peel contains compounds that are antioxidants, including phenolic acids, flavonoids, polyphenols, carotene, vitamin C, vitamin E, and lycopene which can inhibit excess free radical production so that they can work as antioxidants (Febrianti et al., 2019). Therefore, Siamese orange peel is very feasible to be developed as a processed product.

Some research regarding *fruit leather* made from fortified mango fruit, such as *fruit leather* from several types of mango (*Mangifera indica L.*) with different gum concentrations (Ayu Krisna et al., 2020), innovation in making pomelo orange fruit *leather* (*Citrus maxima*) with the addition of dragon fruit peel (Aryani et al., 2022). Nevertheless, research the effect of substitution of erythritol and stevia sweeteners on the sensory characteristics of Siam-Mango orange peel *fruit leather* has never been done.

2. Research Method

Study carried out at the Food Laboratory, Widyagama University Malang and carried out from April to July 2023. Equipment used in research these include: Oven, Stove and some kitchen equipment. The raw materials used in the manufacture of *fruit leather* are mangoes, oranges, Arabic gum and water. Research designs the method used was a factorial complete randomized design (CRD) with two factors, namely the ratio of the amount of Siamese-mango

peel to the type of sweetener (erythritol and stevia). The number of samples tested was 8 samples with two repetitions. Based on the factorial results as follows:

The treatment to be tested is a fruit comparison consisting of 4 races, namely:

JM1 = orange peel : Mango = 0 : 100

JM2 = orange peel : Mango = 10 : 90

JM3 = orange peel : Mango = 20 : 80

JM4 = orange peel : Mango = 30 : 70

The second factor tested was the variation in the concentration of the type of sweetener consisting of 4 races, namely:

G1: Erythritol 28%

G2: Stevia 5%

Table 1. Design of Siamese-mango orange peel *fruit leather formula*

Material (g)	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**
Siamese orange peel	0	10	20	30	0	10	20	30
Mango fruit	100	90	80	70	100	90	80	70
Erythritol	28	28	28	28	0	0	0	0
Stevia	0	0	0	0	5	5	5	5
Arabic gum	2	2	2	2	2	2	2	2
Citric Acid	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Research Procedure

Making Fruit Puree

Mangoes and citrus fruits are washed thoroughly and weighed according to a predetermined ratio. Fruit can be cut into smaller pieces and pureed using a blender until it becomes fruit puree.

Making Fruit Leather

Orange and mango purees were weighed at their respective concentrations (0%: 100%), (10%: 90%), (20%: 80%), (30%: 70%). The mixture was then added 0.2% citric acid, 2% Arabic gum, and 28% erythritol and 5% stevia sweeteners were homogenized by heating on *a hotplate*

at 70ºC for 2 minutes while stirring. The *fruit leather* dough can then be poured into a mold that has been previously coated with aluminum foil with a dough thickness of approximately 3-5 mm. The next stage is the drying process which is carried out using an oven at 60ºC for 20 hours. The finished product (in the form of sheets) can be cut to a certain size and stored.

Analyze is Sensory Characteristics Fruit Leather Orange-Mango Peel

Sensory analysis was carried out on 8 samples of orange-mango fruit leather according to treatment with a total of 30 panelists and using a 5-scale hedonic rating test. With a specification value of 1: really don't like, 2: don't like, 3: neutral, 4: like, 5: like very much. The sensory test parameters include texture, taste, aroma and color.

Data Analysis

The homogeneity of the measured data was analyzed using *the homogeneity test* (Lavene's *test*). If the data is homogeneous (p> 0.05), then the data processing is continued statistically with analysis of variance (Univariate *Analysis of Variance*). If the results *of the analysis of variance* show that both factors have a significant effect, then the *Duncan Multiple Range Test analysis* is continued to determine the difference in the average measurement results between treatments at the 95% confidence level (α=0.05). If the interaction of the two factors has a significant effect on the response, *Estimated Marginal Means* is performed through *the Syntax General Linear Model* to see the effect of the interaction of the two factors (*simple effect*). Data were analyzed statistically using SPSS 25 (*IBM SPSS version 25.0, SPPS Inc., Chicago*).

3. Results and Discussions

Tests on fruit leather from Siamese and mango peels were carried out on 30 panelists by assessing texture, taste, aroma, color and overall on the fruit leather.

Favorite Color of Fruit Leather

Color is a determinant of the quality of food ingredients where the color should not deviate from the color it should be (Cindramaya & Handayani, 2019). The results of sensory analysis of fruit leather color from orange peel mango puree with the addition of different sweeteners are presented in Table 2. The average value of the panelists' preference for the color of fruit leather puree mango and orange peel with the addition of erythritol sweetener ranged from 2.73-3.70 while the assessment for the type of stevia sweetener was higher with a range of 3.2-3.83.

Table 2. The effect of comparison of the concentration of mango puree and orange peel and the type of sweetener on color sensory values

Comparison of the concentration of mango puree (MP) and orange peel (OP)	Sweetener type		Average
	Erythritol	Stevia	
100%: 0%	3.70±0.15Aa	3.83±0.15Aa	3.77±0.06a
90%: 10%	2.73±0.15Ab	3.70±0.15Ba	3.22±0.48s
80%: 20%	3.40±0.15Aa	3.47±0.15Aab	3.44±0.04b
70%: 30%	3.37±0.15Aa	3.2 0 ±0.15Ab	3.29±0.08c
Average	3.30±0.35A	3.55±0.24B	

Note: In the same row, numbers followed by different capital letters indicate significant differences in the effect of the type of sugar ($p<0.05$); and in the same column followed by different lowercase letters indicate a significant difference in the effect of the concentration comparison of mango puree and orange peel ($p>0.05$) with Duncan's further test.

Based on the analysis of variance, the comparison between the concentrations of mango puree and orange peel and the type of sugar and the interaction of the two factors had a significant effect ($p <0.05$) on changes in panelist sensory scores. In general, increasing the concentration of orange peel tends to decrease the sensory value of fruit leather color. Meanwhile, the type of sweetener preferred by panelists based on color sensory was stevia. The results of this study are in line with Nianti et al. (2018) which stated that the more the addition of lemon peel the lower the brightness level or the resulting jelly candy is darker in color. The green color on the orange peel lowers the brightness level. Product color changes to darker.

Level of Like Fruit Leather Flavor

Taste is a crucial element that influences consumer acceptance of a product. Even though other aspects of the product get good ratings, if the taste of the product is not satisfactory, consumers tend to reject it (Atiqoh, et all, 2021). The results of sensory analysis of fruit leather taste from mango puree and orange peel with the addition of different sweeteners are presented in Table 3. The average value of panelists' preference for the taste of fruit leather puree mango and orange peel with the addition of erythritol sweetener ranged from 3.13-4.26 while the assessment for stevia sweetener was lower with a range of 2.53-3.83.

Table 3. The effect of comparison of the concentration of mango puree and orange peel and the type of sweetener on the sensory value of taste

Comparison of the concentration of mango puree (MP) and orange peel (OP)	Sweetener type		Average
	Erythritol	Stevia	
100%: 0%	4.23±0.18Aa	3.33±0.18Bb	3.78±0.45s
90%: 10%	4.26±0.18Aa	3.83±0.18Bab	4.05±0.22a
80%: 20%	4.06±0.18Aa	3.83±0.18Ab	3.95±0.12b
70%: 30%	3.13±0.18Ab	2.53±0.18Wb	2.83±0.30c
Average	3.92 ±0.46A	3.38±0.53B	

Note: In the same row, numbers followed by different capital letters indicate significant differences in the effect of the type of sugar ($p<0.05$); and in the same column followed by different lowercase letters indicate a significant difference in the effect of the concentration comparison of mango puree and orange peel ($p>0.05$) with Duncan's further test.

Based on the analysis of variance, the comparison between the concentrations of mango puree and orange peel and the type of sugar and the interaction of the two factors had a significant effect ($p<0.05$) on changes in panelist sensory scores. In general, increasing the concentration of orange peel tends to decrease the sensory value of fruit leather taste. While the type of sweetener preferred by panelists based on taste sensory is Erythritol. The results of this study are in line with Sarah et al (2017) which stated that panelists preferred the sweet taste elicited from the raw materials used with the addition of moderate amounts of sucrose. So that more and more additions of orange peel puree can reduce the taste value of fruit leather due to the emergence of a bitter taste caused by limonin and naringin (4,5,7-trihydroxyflavone-7-rhamnoglucoside) setyadijit et.al (2010).

Level of Like Fruit Leather Aroma

Aroma is one of the sensory parameters that need attention because it can determine the level of delicacy of a food. Aroma production in fruit will increase when the fruit approaches the climacteric period because it consists of various esters which have volatile properties (Winarno, 1992). The results of sensory analysis of fruit leather aroma from mango puree and orange peel with the addition of different sweeteners are presented in Table 4. The average value of panelists' preference for the taste of fruit leather puree mango and orange peel with the addition of erythritol sweetener ranged from 2.90–3.73 while the assessment for stevia sweetener was higher with a range of 2.66-4.10.

Table 4. The effect of comparison of the concentration of mango puree and orange peel and the type of sweetener on the sensory value of Aroma

Comparison of the concentration of mango puree (MP) and orange peel (OP)	Sweetener type		Average
	Erythritol	Stevia	
100%: 0%	3.73 ±0.13Aa	4.10 ±0.13 Aa	3.90±0.20b
90%:10%	3.60 ±0.13Aa	3.6 0 ±0.13A ab	4.60±0.00a
80%:20%	3.56 ±0.13Aa	4.06±0.13B a	3.81±0.25c
70%:30%	2.90 ±0.13Ab	2.66 ±0.13A b	2.78±0.12s
Average	3.44±0. 32 A	3.60±0.58B	

Note: In the same row , numbers followed by different capital letters indicate significant differences in the effect of the type of sugar ($p<0.05$); and in the same column followed by different lowercase letters indicate a significant difference in the effect of the concentration comparison of mango puree and orange peel ($p>0.05$) with Duncan's further test.

Based on the analysis of variance, the comparison between the concentrations of mango puree and orange peel and the type of sugar and the interaction of the two factors had a significant effect ($p<0.05$) on changes in panelist sensory scores. In general, increasing the concentration of orange peel tends to reduce the sensory value of the aroma in fruit leather. The type of sweetener preferred by panelists based on aroma sensory was stevia. The aroma of fruit leather can be caused by various concentrations of sweeteners. Faransisca (2017), stated that sweeteners are volatile flavors which cause aroma precursor compounds which will then produce a distinctive aroma in fruit. In addition, the chemical reactions that occur in the processing process make it possible to produce flavorful compounds (Ladamay, 2014).

Fruit Leather Texture Preference Level

Texture in food is a combination of various components and structural elements that are arranged into micro and macro structures (Aryani, et al. 2022). Food texture can be evaluated using sensory analysis (Sidi, et al. 2014). The results of sensory analysis of fruit leather texture from mango puree and orange peel with the addition of different sweeteners are presented in Table 5. The average value of the panelists' preference for the texture of fruit leather puree mango and orange peel with the addition of erythritol sweetener showed a higher value ranging from 3.40-4.10 while the assessment for the type of stevia sweetener was lower with a range of 3.46-3.73.

Table 5. The effect of comparison of the concentration of mango puree and orange peel and the type of sweetener on texture sensory values

Comparison of the concentration of mango puree (MP) and orange peel (OP)	Sweetener type		Average
	Erythritol	Stevia	
100%: 0%	3.96±0.10Aa	3.73±0.10Aa	3.85±0.12b
90%: 10%	4.10±0.10Aa	3.7 0±0.10Ba	4.90±0.20a
80%: 20%	3.86±0.10Aa	3.50±0.10Ba	3.68±0.18c
70%: 30%	3.40±0.10Ab	3.46±0.10Aa	2.43±0.03s
Average	3.83±0.26A	3.59±0.12B	

Note: In the same row, numbers followed by different capital letters indicate significant differences in the effect of the type of sugar ($p<0.05$); and in the same column followed by different lowercase letters indicate a significant difference in the effect of the concentration comparison of mango puree and orange peel ($p>0.05$) with Duncan's further test.

Based on the analysis of variance, the treatment compared with the concentration of mango puree orange peel and sugar type treatment as well as the interaction of the two factors had a significant effect ($p<0.05$) on changes in panelist sensory scores. In general, an increase in the concentration of orange peel tends to reduce the texture sensory value of fruit leather. While the texture that panelists preferred based on sensory was the type of *erythritol* sweetener in the treatment of the comparison of mango puree and orange peel 90 %: 10% with an average value of 4.90 (plastic). This research is in line with Astuti, (2015) which states that one of the requirements for fruit leather is to have a plastic texture so that it can be rolled up. The results of the panelists' assessment of the texture showed that the more orange peel used, the texture of the resulting fruit leather tends to be tougher.

Overall Like ability Level Fruit Leather

The overall value is the average of the hedonic test parameters including color, aroma, taste, and fruit leather texture of orange and mango peels and the type of sweetener for each treatment (Triastuti, D. 2022). The results of sensory analysis of overall fruit leather from mango puree and orange peel with the addition of different sweeteners are presented in Table 6. The average value of the panelists' preference for the texture of fruit leather puree mango and orange peel with the addition of erythritol sweetener showed a higher value ranging from 3.66-4.23 while the assessment for the type of stevia sweetener was lower with a range of 3.13-4.03.

Table 6. The effect of comparison of the concentration of mango puree and orange peel and the type of sweetener on the overall sensory value

Comparison of the concentration of mango puree (MP) and orange peel (OP)	Sweetener type		Average
	Erythritol	Stevia	
100%: 0%	3.96±0.10Aa	3.73±0.10Aa	4.07±0.03b
90%: 10%	4.10±0.10Aa	3.70±0.10Ba	4.08±0.15a
80%: 20%	3.86±0.10Aa	3.50±0.10Ba	3.62±0.49c
70%: 30%	3.40±0.10Ab	3.46±0.10Aa	3.50±0.17s
Average	3.83±0.26A	3.59±0.12B	

Note: In the same row, numbers followed by different capital letters indicate significant differences in the effect of the type of sugar ($p<0.05$); and in the same column followed by different lowercase letters indicate a significant difference in the effect of the concentration comparison of mango puree and orange peel ($p>0.05$) with Duncan's further test.

Based on the analysis of variance, the comparison between the concentrations of mango puree and orange peel and the type of sugar and the interaction of the two factors had a significant effect ($p<0.05$) on changes in panelist sensory scores. In general, increasing the concentration of orange peel tends to decrease the sensory value of fruit leather color. While the type of sweetener preferred by panelists based on overall sensory is Erythritol. Ayu, et al. (2021) stated that the difference in the panelists' judgments that expressed likes or dislikes depended on the panelists' subjective impression of fruit leather. The panelist's assessment of fruit leather is a combined assessment of the characteristics of color, aroma, taste and texture of fruit leather.

4. Conclusions

Based on the results of the study, it can be concluded that the comparison of the concentration of mango puree with orange peel and the type of sugar treatment and the interaction of the two factors had a significant effect ($p<0.05$) on changes in panelist sensory scores including color, taste, textured aroma and overall. The addition of orange peel and the type of sweetener affects the sensory value so that the more the addition of orange peel and a different type of sweetener, the lower the panelist's level of preference for fruit leather. The best treatment based on the senori preferred by the panelists was the comparison of the concentration of mango puree (MP) and orange peel (OP) which was 90%: 10% with the type of sweetener Erythritol.

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