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Formula Optimization of Black Mulberry and Canistel Mixed Juice Using Mixture D-Optimal from Design Expert Software

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ABSTRACT

Black mulberry (Morus nigra L.) and canistel (Pouteria campechiana) are classified as fruit commodities that are still not optimal in their utilization. Based on their sensory and nutritional characteristics, they have potential to be processed into products for a longer shelf life and more valuable. The purpose of this study was to determine the optimal formula for a mixed fruit juice product made from black mulberry and canistel in terms of chemical, physical and sensory characteristics. The optimization formula was analyzed by Design Expert software ver.11 and through the Mixture D-Optimal method. The independent variables in this study are black mulberry puree, canistel puree, and sucrose. The dependent variables were 0.05% sodium benzoate and a mixture of CMC and sodium alginate 0.25% with a ratio of CMC: sodium alginate 1:1. The chemical parameters analyzed consisted of anthocyanin, beta carotene, vitamin C, and antioxidant activity. The physical parameters consisted of viscosity and sensory parameters consisted of flavor, sweet taste, and sour taste. The results obtained that the optimal formulation was based on the highest desirability value from the results of the analysis using the Design Expert program and the value was 0.807. The optimal formula for mixed fruit juices was black mulberry puree 53.356%, canistel puree 35.252%, and sucrose 11.092%.

Keywords: *Black Mulberry; Canistel; Design Expert; Juice; Optimization*

INTRODUCTION

Fruits as agricultural products and source of nutrition will easily be damaged by physical, chemical, parasitic, or microbiological factors. The way to extend the shelf life of fruits is to process them into various kinds of processed products, including fruit juice. Mixing different fruits as a fruit juice is one way to increase the nutritional quality of fruit juice that can improve sensory characteristics, and increase the vitamin and mineral content depending on the type and quality of fruit that we used.

Black mulberry fruit (*Morus nigra L.*) is an attractive fruit with a purplish red to a black color and has a fresh taste that tends to be sour and slightly sweet. In addition, mulberry has high antioxidant content thus has potential as a functional food ingredient. Black mulberry fruit contains high anthocyanins and vitamin C which can act as antioxidant . The vitamin C content of black mulberry fruit is 28.37 mg/100 gram (Cahyadi et al., 2017). In addition, black mulberry fruit is rich in anthocyanin compounds 147.68 mg/100 gram (Azmi and Yunianta., 2015).

Canistel is rarely found in the modern and traditional market so this commodity may be unfamiliar to some people especially for urban community. When it is ripe, the canistel fruit will have a yellow to orange color, soft texture, strong flavor, and a sweet taste. The orange color of the canistel is an indicator of the presence of carotenoids in the fruit. Canistel contains various types of carotenoids and the total carotenoid is 226 µg/g (Costa et al., 2014). Beta carotene is a source of provitamin A that plays a role in maintaining eye health. One type of carotenoid that is largely contained in canistel is beta carotene, which is 156 g/g so that canistel has the potential as a functional food ingredient (Puspita et al., 2019).

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Black mulberry and canistel mixed fruit juice is made as an effort to take advantage of the potential of local fruits that are still not optimally utilized. In addition, it is also carried out to produce a food product that complements each other in terms of nutritional characteristics.

Black mulberry is rich in vitamin C and anthocyanin compounds, but have small content of beta carotene. The lack of beta carotene is expected to be complemented by mixing with canistel fruit which is rich of beta carotene content. With the content of vitamin C, anthocyanins and beta carotene, this mixed fruit juice have the potential as a functional beverage product that can play a role in protection or prevention, treatment of disease, and improving the performance of body functions.

Mixture experiments consist of mathematical and statistical techniques that are useful for modeling and problem analysis of a response that is influenced by several variables. One of the purposes of using this experimental design is to optimize the desired response. Design Expert is a software that can be used for mixture experiments and process optimization in the main response caused by several variables and the goal is to optimize the response. Design Expert provides several design options with their respective functions, one of which is Mixture Design which functions to find the optimal formulation.

This research uses the Design Expert program with the D-Optimal Mixture method which is used to help optimize the product or process. The Design Expert program with the D-Optimal Mixture method has advantages compared to other data processing programs, namely the accuracy of this program is quite high, more flexible, and also provides statistical features that make it easy to operate (Tiaraswara, 2016).

METHODS

Material

The raw materials used in this study were black mulberry from black mulberry plantation at Kampung Sindangsari Ciwidey Kabupaten Bandung and canistel fruit from canistel plantation at Cipatat Kabupaten Bandung Barat. Chemical materials for chemical analysis come from Pasundan University Research Laboratory and Toko Subur Kimia Jaya Bandung. The chemical materials for mixed fruit juice are sucrose, sodium benzoate, CMC, and sodium. The chemicals used for the analysis of anthocyanin content were methanol, potassium chloride buffer pH 1.0, and sodium acetate buffer pH 4.5. The materials used for the analysis of beta carotene content were acetone, petroleum ether, and sodium sulfate. The materials that will be used for the analysis of antioxidant activity are methanol and DPPH (2,2-Diphenyl-1-Picryhydrazyl). The materials used for the analysis of total sugar content were concentrated sulfuric acid (H_2SO_4), 30% NaOH, phenolphthalein, HCl, Luff Schoorl solution, KI, starch, and $Na_2S_2O_3$. The materials used for the analysis of vitamin C content include 0.1 N iodine solution and 1% starch

Tools

The tools used in this research are digital analytical balance, knife, blender, spoon, glass, filter, pan, gas stove, water bath, measuring flask, Erlenmeyer, aluminum foil, pipette, spectrophotometer, burette, and viscometer

Research Design

The research design was composed of two variables, which consist of the independent and dependent variables. The independent variables in this study were black mulberry puree, canistel puree, and sucrose while the dependent variables were 0.05% sodium benzoate and a mixture of CMC and sodium alginate 0.25% with a ratio of CMC: sodium alginate that was 1:1. Then some formulations are offered by the Design Expert. The products based on the Design Expert formula then need to be analyzed for chemicals, physics, and sensory responses.

Black mulberry and canistel puree as independent variables respectively made from 1:1 and 1:5 ratios with water. Black mulberry has higher water content than canistel, and the best water ratio for canistel fruit juice is 1:5 (Saputri, 2019). The addition of sugar is intended to add taste, usually added as much as 5 to 15 percent (depending on the type of fruit used). In order to obtain significant results for each formula, the fruit component for fruit juice is made with a range of 20 percent as the independent variable (Wulandari, 2016).

Table 1. Independent variable

No.	Variable	Low	High
1	Black Mulberry Puree	32	55
2	Canistel Puree	32	55
3	Sucrose	10	15

Table 2. Dependent variable

No.	Variable	Amount (%)
1	Sodium Benzoate	0.05
2	CMC	0.125
3	Sodium Alginate	0.125

Table 3. Mixed fruit juice formulas to be analyzed based on design expert

F	%Black Mulberry Puree	%Canistel Puree	%Sucrose
F1	55%	33.90%	10.80%
F2	50.96%	37.48%	11.27%
F3	43.93%	42.83%	12.94%
F4	37.58%	52.12%	10%
F5	39.74%	44.96%	15%
F6	32.83%	55%	11.87%
F7	47.99%	41.71%	10%
F8	52.70%	32%	15%
F9	46.48%	38.22%	15%
F10	35.90%	48.80%	15%
F11	42.03%	47.67%	10%

Test Parameters

The chemical parameters for mixed fruit juice as the response variable are the analysis of anthocyanin content (AOAC, 2016). beta carotene content (AOAC, 2016), vitamin C content (AOAC, 2016), antioxidant activity (Filbert et al, 2014). The physical parameters are the measurement of viscosity (AOAC, 2016). The sensory parameters are the hedonic test (preference) with the attribute flavor, sour taste, and sweet taste (AOAC, 2016).

Data Analysis

Design Expert presents the results of the ANOVA analysis of variance. A response variable was stated to be significantly different at the 5% significance level if the p-value of the F-Test ("Prob>F") of the analysis are smaller than or equal to 0.05, while if the p-value of F Test analysis is greater than 0.05 then the response variable is declared not significantly different. Furthermore, these response variables are used as model predictions to determine the optimal formula.

Design Expert ver. 11.0 will process all response variables based on the criteria set and provide solutions to several optimal formulas chosen. The optimization target value that can be achieved known as the desirability value, which is indicated by a value from 0-1. If the desirability value closer to 1, the more it is easy for a formula to reach the optimal formula point based on the response variable.

RESULT AND DISCUSSIONS

Anthocyanin

Anthocyanin content for each formula then will be calculated statistically by design expert software. The result is shown in Table 4. Based on the analysis of variance (ANOVA) results, the p-value of F-Test in the quadratic model is <0.0001 (smaller than 0.05) which shows that anthocyanin content on each formulation from 11 formulations used as the initial model of analysis are significantly different.

Based on the data obtained, the value of R^2 is 0.9930 which indicates that the independent variable in this case A (Black Mulberry Puree), B (Canistel Puree), and C (Sucrose) has a 99.30% effect on anthocyanins content. The rest are influenced by other factors outside the independent variables.

Figure 1 shows a diagram of the distribution of anthocyanin content. The scattered dots indicate the position of each formula from 11 formulations based on the anthocyanin content response with a quadratic model. The formula with the highest anthocyanin content is placed in the red graphic area followed by orange, yellow, green, and light to dark blue which indicates the lower response of anthocyanin.

Therefore the high anthocyanin content was in line with the higher percentage of black mulberry puree. Interactions between components of fruit juice raw materials such as the presence of dilution using water, and the addition of canistel fruit and sucrose can reduce the stability of anthocyanins which are less stable at neutral and alkaline pH conditions. In addition, interactions with high temperatures, light, and oxygen during fruit juice processing can cause a decrease in the balance of anthocyanin compounds so that they can cause degradation (Babaloo and Jamei, 2018).

Table 4. Summary of statistical analysis results of anthocyanin response

Analyzed components	Result
Mean	132.56
Standard Deviation	3.54
Ordo Model	Quadratic
Sequential p-value	0.0499
p “prob > F”	<0.0001 (significant)
R-Square (R^2)	0.9930
Adjusted R^2	0.9860
Predicted R^2	0.9427
Mathematical Model Equations	$Y = 198.44\ A + 92.75\ B + 93.86\ C – 66.27\ AB – 26.59\ AC – 0.4596\ BC$

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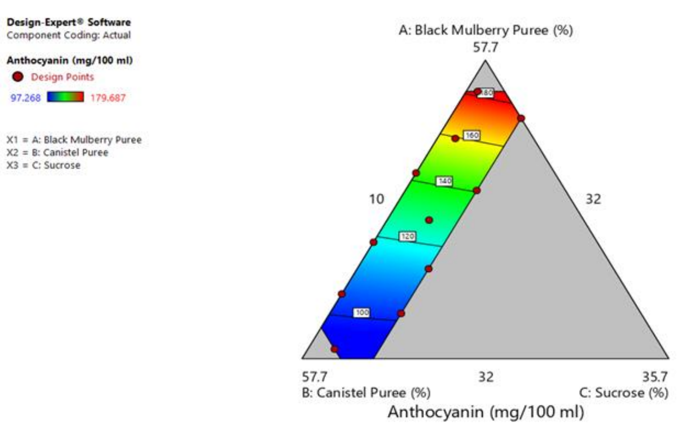

F	Anthocyanin (mg/100g)
F1	179,687
F2	160,667
F3	125,047
F4	101,939
F5	114,619
F6	97,268
F7	147,570
F8	174,098
F9	141,480
F10	99,437
F11	116,371

Figure 1. Anthocyanin Response Contour Plot Graph

Beta Carotene

The ANOVA results are presented the p-value of F-Test in the cubic model is 0.5895 (greater than 0.05). If the p-value greater than 0.05 indicates beta carotene content on each formulation from the 11 formulations used as the initial model of the analysis are not significantly different.

The value of R-square (R^2) is obtained as presented in Table 5, the R-square value of the response to beta carotene content is 0.9235. This value indicates that the independent variables in this case A (Black Mulberry Puree), B (Canistel Puree), and C (Sucrose) have an effect of 92.35% on the beta carotene as the dependent variable. The rest are effected by other factors in outside the independent variable.

Figure 2 shows a diagram of the distribution of beta-carotene content. The scattered dots indicate the position of each formula from 11 formulations based on the beta-carotene response with a cubic model. The formula with the highest beta carotene content is placed in the red graphic area followed by orange, yellow, green, and light to dark blue which indicates the lower response of beta carotene. The yellow color of the canistel fruit is an indicator of the presence of carotenoid content which is a good source of provitamin A for eye health and can also act as an antioxidant (Puspita et al., 2019). The graph on the response of beta carotene with the cubic order model shows that there is a mutual interaction between the variables of black mulberry puree, canistel puree, and sucrose.

Table 5. Summary of statistical analysis results of beta carotene response

Analyzed components	Result
Mean	7.90
Standard Deviation	4.36
Ordo Model	Cubic
Sequential p-value	0.4836
p “prob > F”	0.5895 (not significant)
R-Square (R^2)	0.9235
Adjusted R^2	0.2355
Predicted R^2	-645.5278
Mathematical Model Equations	Y = -7.09 A – 2.93 B + 13267.14 C + 38.10 AB – 22705.33 AC – 22070.69 BC + 19437.59 ABC – 61.57 AB (A-B) + 10349.12 AC (A-C) + 9148.39 BC (B-C)

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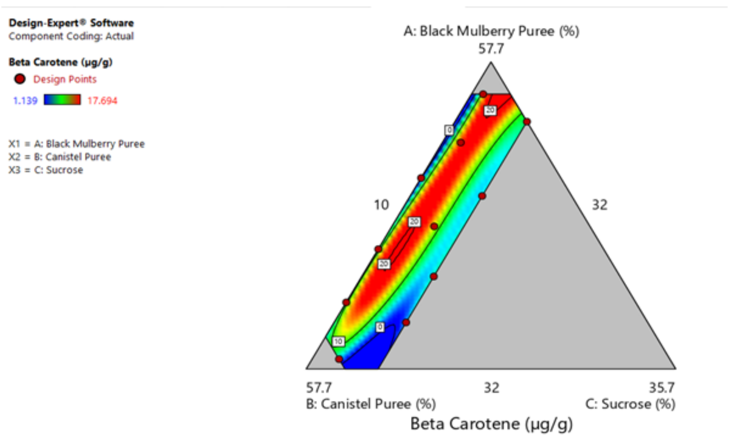

F	Beta Carotene (µg/g)
F1	11,483
F2	17,704
F3	12,969
F4	9,536
F5	8,886
F6	4,426
F7	1,151
F8	8,800
F9	3,517
F10	2,926
F11	5,676

Figure 2. Beta Carotene Response Contour Plot Graph

Carotenoid pigments derived from natural ingredients are usually constrained by their stability. One of the weaknesses of carotene which is less stable is caused by the influence of heating (temperature) during the manufacturing process. According to Anggreini et al (2018), the stability of carotenoids can also be influenced by sugar concentrations where higher sugar concentrations can degrade carotenoids.

Vitamin C

Based on the results of the analysis of variance (ANOVA) presented in Table 6, the p-value of the F-Test in the special cubic model is 0.0026 (less than 0.05). The p-value of the F-Test smaller than 0.05 indicates that vitamin C content on each formulation from the 11 formulations used as the initial model of analysis are significantly different.

The value of R-square (R^2) 0.9790 indicates that the variables A (Black Mulberry Puree), B (Puree Canistel), and C (Sucrose) have an effect of 97.90% on vitamin C as the dependent variable and the rest (2.10%) are influenced by other factors. The response of vitamin C with the special cubic order model shows the red area of the graph in line with the high percentage of black mulberry puree (Figure 3). During the processing, the fruit which is a source of vitamin C will be degraded due to the heating process. In addition, the interaction with oxygen and sunlight also causes vitamin C to be easily oxidized (Eyduran, 2015).

The addition of sucrose and the presence of sugar in black mulberry and canistel allows for a reduction decrease in vitamin C during the processing. Vitamin C is a reducing compound, acid ascorbate is in equilibrium with dehydroascorbic acid. Under acidic conditions, the lactone ring of dehydroascorbic acid decomposes to form diketogulonate compounds so that vitamin C is protected in the presence of sugar (Cheung and Bhavbhuti, 2015).

Table 6. Summary of statistical analysis results of vitamin c response

Analyzed components	Result
Mean	12.92
Standard Deviation	0.9106
Ordo Model	Special Cubic
Sequential p-value	0.0205
p “prob > F”	0.0026 (significant)
R-Square (R^2)	0.9790
Adjusted R^2	0.9476
Predicted R^2	0.8377
Mathematical Model Equations	Y = 25.04 A + 16.51 B + 343.24 C – 37.03 AB – 435.30 AC – 487.36 BC + 273.30 ABC

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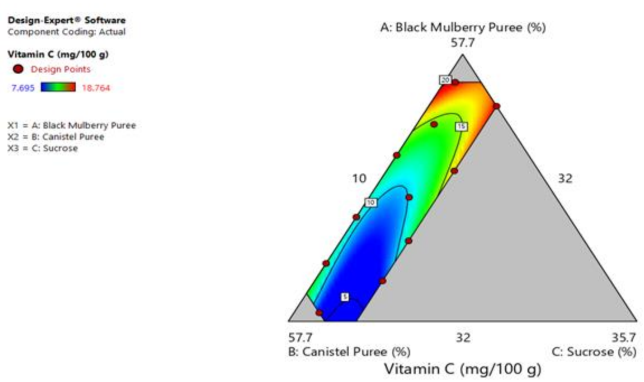

F	Vitamin C (mg/100g)
F1	18,747
F2	14,328
F3	9,910
F4	12,153
F5	12,153
F6	7,695
F7	14,277
F8	18,764
F9	16,466
F10	7,710
F11	9,913

Figure 3. Vitamin C Response Contour Plot Graph

Antioxidant Activity (IC50)

Analysis of the antioxidant activity as a variable response in 11 black mulberry and canistel mixed fruit juice formulas are presented in Table 7. Based on the results of ANOVA the p-value of F-test in the linear model is <0.0001 (smaller than 0.05) shows that antioxidant activity on each formulation from the 11 formulations that were used as the initial model of analysis are significantly different.

Contour Plot graphs of antioxidant activity response (Figure 4) with a linear order model showing the red graph area tends to lead to the puree canistel variable. The higher IC50 value, the weaker the antioxidant activity. The IC50 value is the concentration of the sample solution capable of reducing DPPH activity by 50% or a number indicating the concentration of the extract (ppm) which is able to inhibit the oxidation process by 50%. The smaller value IC50 value means the higher the antioxidant activity.

Black mulberry fruit contains vitamin C and flavonoid compounds with high phenolic concentrations. Black mulberry fruit is rich in anthocyanins, a flavonoid derivative compound that is dominant in black mulberry fruit. Several studies on anthocyanins have reported that these compounds have free radical inhibitory activity (Budiman et al., 2018).

Canistel contains a variety of phenolic compounds that have potential as antioxidants including gallic acid, gallocatechin, catechin, epicatechin, dihydromyricetin, catechin-3-O-gallate, and myricitrin. In addition, canistel contains a variety of carotenoid compounds that can also act as antioxidants (Costa et al., 2014).

Table 7. Summary of statistical analysis results of antioksidan activity (ic50) response

Analyzed components	Result
Mean	1747.71
Standard Deviation	57.27
Ordo Model	Linear
Sequential p-value	<0.0001
p “prob > F”	<0.0001 (significant)
R-Square (R^2)	0.9700
Adjusted R^2	0.9625
Predicted R^2	0.9393
Mathematical Model Equations	Y = 1198.75 A + 2236.92 B + 2234.05 C

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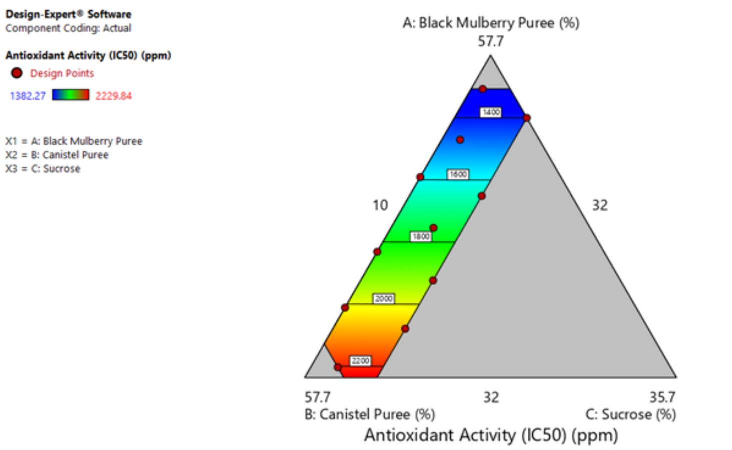

F	Antioxidant Activity IC50 (ppm)
F1	1382,271
F2	1471,997
F3	1713,156
F4	2055,841
F5	1878,709
F6	2229,845
F7	1524,581
F8	1441,858
F9	1596,986
F10	2138,344
F11	1791,180

Figure 4. Antioxdant Activity Response Contour Plot Graph

Viscosity

Analysis of the viscosity as response variable on 11 black mulberry and canistel mixed fruit juice formulas are presented in Table 8. Based on the results of the analysis of variance (ANOVA) the p-value of F-test in the linear model is 0.0026 (less than 0.05). The p-value smaller than 0.05 indicates that viscosity on each formulation from the 11 formulations used as the initial model for the analysis are significantly different.

Based on the graph of the viscosity response with a linear order model, it shows the red area on the graph tends to lead to variable C (canistel puree). The larger the dissolved solids component in the material, the more increase viscosity. The added sucrose sugar has the following properties: hydrophilic due to the presence of a hydroxyl group in the molecular structure. The hydroxyl group will bind to water molecules through bonds hydrogen, as a result of these conditions the water contained in the food will reduce. Therefore, the increase in viscosity is influenced by sucrose content. The sucrose concentration contains a high degree of brix thereby increasing the viscosity. This is due to the presence of solids that can trap water to form a gel. Therefore, in addition to the effect of the addition of sucrose, the addition of a canistel with a high enough sugar content can also increase product viscosity (Cheung and Bhavbhuti, 2015).

Table 8. Summary of statistical analysis results of viscosity response

Analyzed components	Result
Mean	36.19
Standard Deviation	4.75
Ordo Model	Linear
Sequential p-value	0.0026
p “prob > F”	0.0026 (significant)
R-Square (R^2)	0.7745
Adjusted R^2	0.7181
Predicted R^2	0.5990
Mathematical Model Equations	Y = 21.88 A + 50.02 B + 43.93 C

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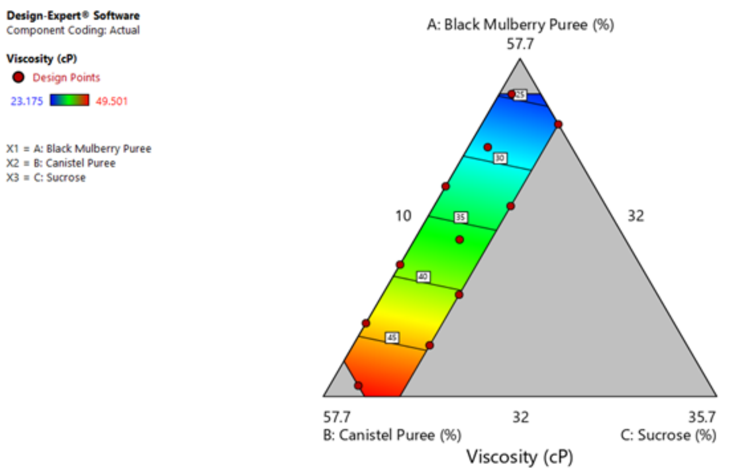

F	Viscosity(Cp)
F1	23,175
F2	23,919
F3	31,879
F4	41,239
F5	33,547
F6	49,501
F7	36,955
F8	29,182
F9	36,823
F10	48,379
F11	43,564

Figure 5. Viscosity Response Contour Plot Graph

Flavor

The special quartic order model is determined based on the lowest sequential p-value, which is 0.0590. Based on the results of the analysis of variance (ANOVA) presented in Table 9, the p-value of f-test in the special quartic model was 0.0561 (greater than 0.05). The p-value which is greater than 0.05 indicates that flavor on each formulation from the 11 formulations used as the initial model of the analysis are not significantly different.

The value of R-square (R^2) on the flavor response is 0.9857. This value indicates that the independent variables, namely A (Puree Black Mulberry), B (Puree Canistel), and C (Sucrose) have an effect of 98.57% on the dependent variable, namely the flavor response, and the rest is influenced by other factors outside the independent variables.

The adjusted R^2 and predicted R^2 values are 0.9284 and -3.7457, respectively (Table 9). The negative sign in predicted R^2 indicates that the overall special quartic is more accurate in predicting the flavor response than the model. The negative value in predicted R^2 occured because the results of the actual flavor response data obtained show insignificant results for each component treatment.

Table 9. Summary of statistical analysis results of flavour response

Analyzed components	**Result**
Mean	4.07
Standard Deviation	0.0833
Ordo Model	Special Quartic
Sequential p-value	0.0590
p “prob > F”	0.0561 (not significant)
R-Square (R^2)	0.9857
Adjusted R^2	0.9284
Predicted R^2	-3.7457
Mathematical Model Equations	$Y = 5.49\ A + 5.13\ B + 97.15\ C – 6.56\ AB –123.96\ AC – 119.36\ BC + 230.41\ A^2BC + 180.92\ AB^2C – 704.56\ ABC^2$

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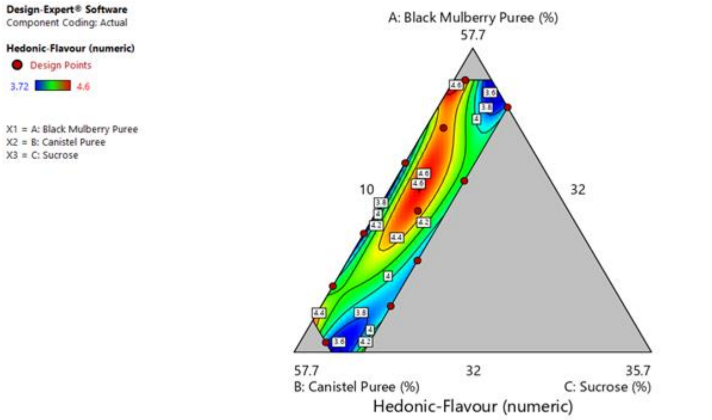

F	Flavour
F1	4,60
F2	4,40
F3	4,55
F4	4,08
F5	3,83
F6	3,83
F7	3,83
F8	3,90
F9	4,12
F10	3,92
F11	3,72

Figure 6. Flavour Response Contour Plot Graph

Based on the graph and the mathematical model of the flavor response using the special quartic order model, it can be observed that the area on the graph is not linearly or evenly distributed, which indicates that there is a mutual interaction between the changing variables. The acid content contained in mulberry juice causes an acidic flavor that can give a fresh impression when consumed. In the canistel, there are several compounds such as alcohol, phenols, alkanes, aldehydes, aromatic compounds, secondary alcohols, aromatic aminos, and halogens that will come out and cause a distinctive flavor when the fruit is ripe (Sunila et al., 2016). The strong flavour contained in the canistel flesh is the main attraction for most people, but not everyone likes and is used to the smell because this fruit is still relatively rare or consumed (Puspita et al., 2019).

Sweet Taste

The quadratic order model was determined based on the lowest sequential p-value of 0.4106. Based on the results of the analysis of variance (ANOVA) presented in Table 10, the p-value of f-test in the linear model was 0.4702 (greater than 0.05). The p-value which is greater than 0.05 indicates that sweet taste on each formulation from the 11 formulations used as the initial model of the analysis are not significantly different.

Table 10. Summary of statistical analysis results of sweet taste response

Analyzed components	Result
Mean	4.59
Standard Deviation	0.4439
Ordo Model	Quadratic
Sequential p-value	0.4106
p “prob > F”	0.4702 (not significant)
R-Square (R^2)	0.5176
Adjusted R^2	0.0351
Predicted R^2	-1.2157
Mathematical Model Equations	Y = 4.33 A + 4.28 B – 40.71 C – 0.8207 AB + 57.93 AC + 60.00 BC

The value of R-square (R^2) on the sweet taste response is 0.5176. This value shows that the independent variables, namely A (Puree Mulberry Hitam), B (Puree Canistel), and C (Sucrose) have an influence of 51.76% on the dependent variable, namely the response to sweetness and the rest is influenced by other factors outside the independent variables.

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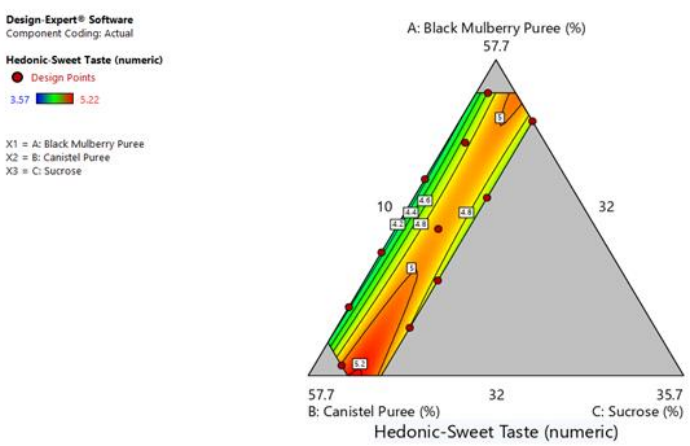
Taste is a sensation detected by the sense of taste of the composition and mixing of food ingredients. This attribute is one of the important considerations for consumers in choosing or rejecting a product. The graph shows the red area of the graph tends to lead to the variable C (sucrose)

Taste is formed from the combination of the composition of the ingredients used in a food product. Sucrose has an important role because it can increase the acceptance of food, namely by masking unpleasant tastes, balancing sour, bitter, and salty tastes, or through the formation of caramelization. Canistel when ripe has soft flesh, a strong flavor, and a sweet taste, and has a high carbohydrate content (Puspita et al., 2019). Black mulberry has a taste that tends to be sour and fresh from the organic acids and is not too dominant in the sweet taste.



F	Sweet Taste
F1	4,60
F2	5,22
F3	4,60
F4	4,12
F5	4,62
F6	5,00
F7	3,57
F8	4,45
F9	4,93
F10	4,85
F11	4,48

Figure 7. Sweet Taste Response Contour Plot Graph

Sour Taste

The results of the analysis on the response of the sour taste attribute through the hedonic test on 11 black mulberry and canistel mixed fruit juice formulas are presented in Table 11. The order model assigned to the sour taste response is cubic (Table 11). The cubic order model is determined based on the lowest sequential p-value of 0.1936. Based on the results of the analysis of variance (ANOVA) presented in Table 11, the p-value of f-test in the cubic model is 0.2656 (greater than 0.05). The p-value which is greater than 0.05 indicates that sour taste on each formulation from the 11 formulations used as the initial model of the analysis are not significantly different.

Table 11. Summary of statistical analysis results of sour taste response

Analyzed components	**Result**
Mean	4.67
Standard Deviation	0.0928
Ordo Model	Cubic
Sequential p-value	0.1936
p “prob > F”	0.2656 (not significant)
R-Square (R^2)	0.9866
Adjusted R^2	0.8657
Predicted R^2	-112.5452
Mathematical Model Equations	Y = 4.17 A + 3.53 B + 1479.79 C + 2.81 AB – 2457.80 AC – 2455.81 BC + 2048.74 ABC – 6.29 AB (A-B) + 1032.84 AC (A-C) + 1022.75 BC (B-C)

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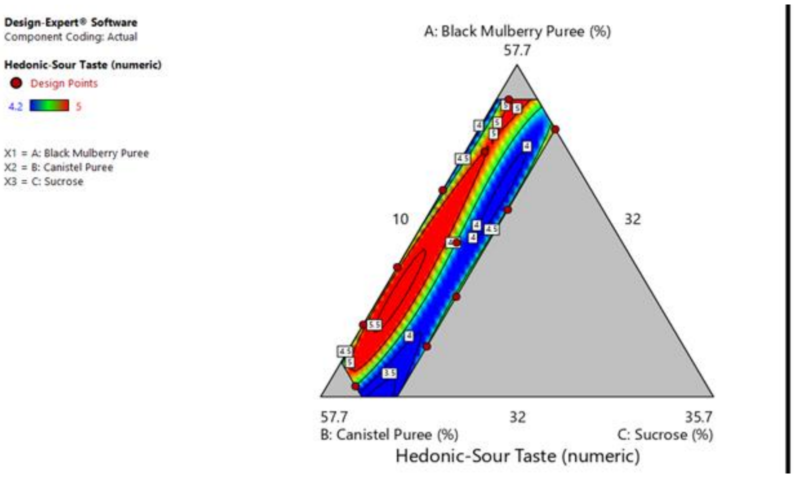

F	Sour Taste
F1	4,97
F2	5,00
F3	4,47
F4	4,73
F5	4,62
F6	4,48
F7	4,20
F8	4,97
F9	4,60
F10	4,52
F11	4,82

Figure 8. Sour Taste Response Contour Plot Graph

The value of R-square (R^2) on the sour taste response is 0.9866. This value indicates that the independent variables, namely A (Puree Black Mulberry), B (Puree Canistel), and C (Sucrose) have an effect of 98.66% on the dependent variable, namely sour taste response and the rest is influenced by other factors outside the independent variable.

The sour taste in mixed juice tends to be influenced by the components of the mulberry fruit which contains the highest organic acids and vitamin C among other ingredients. Based on the graph and mathematical model of the sour taste response with the cubic order model, it shows that the sour taste response is influenced by the interaction between ingredients.

The taste is formed from the combination of the ingredients used in a food product and consumers tend to like food with a fresh taste, namely between sour and sweet tastes more pronounced in the sense of taste (tongue) so that the fresh impression that arises will be more pronounced.

Selected Formula

Table 12. Formula solutions and selected formulas result from design expert optimization

Solution	Proportion (%) Black Mulberry Puree	Canistel Puree	Sucrose	Desirability
1	53.356	35.252	11.092	0.807*
2	47.224	37.476	15.000	0.551
3	51.779	32.921	15.000	0.515
4	42.350	42.350	15.000	0.485
5	36.452	52.972	10.276	0.364
6	41.728	47.908	10.064	0.355
7	38.246	51.454	10.000	0.332
8	40.975	48.725	10.000	0.321
9	46.776	42.924	10.000	0.203

The selected formulation is the optimal solution or formulation predicted by the Design Expert of the D-Optimal Method based on the results of the analysis of the chemical responses analyzed including anthocyanin, beta caroten, vitamin C, and antioxidant activity. The physical response was viscosity and sensory responses were flavour, sweet taste, and sour taste.

The accuracy of the formulation and the value of each response can be seen in the desirability. Desirability is the degree of accuracy of the results of the optimal solution or formulation. The closer the value to one, the higher the value of formulation accuracy, so it can be concluded that based on the desirability value that has reached 1.00, the response value has high accuracy.

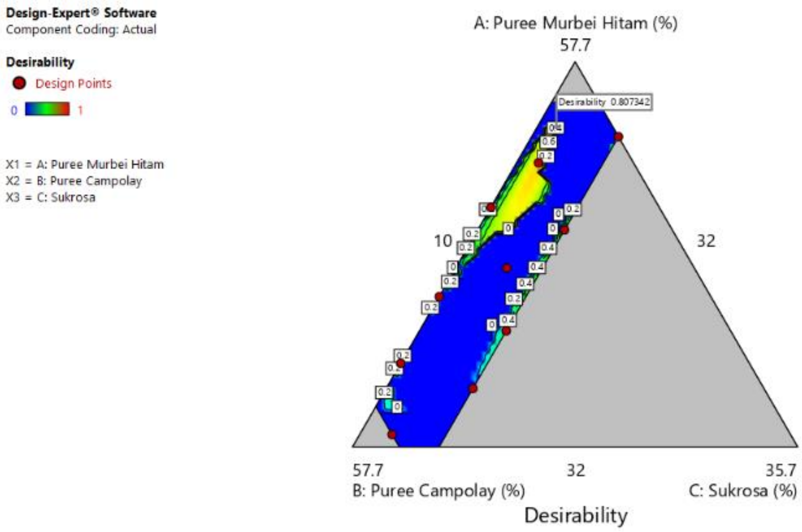

Figure 9. Contour Plot Graph of Optimal Formula Desirability Value

The desirability value of the selected formula can be achieved with a value of 0.807, which means that the formula will produce a product that has the most optimal characteristics and is by our wishes 80.7%. A desirability value close to one can be achieved due to the accuracy of the selection of test variables that can give a real influence, the determination of the relative proportion range of each test variable, and the target value of the response variable optimization. The higher the complexity of the test variable and the optimization target value, the more difficult it is to achieve a desirability value that is close to one (Wulandari, 2016).

The results obtained that the optimal formulation was based on the highest desirability value from the results of the analysis using the Design Expert program and the value was 0.807. The optimal formula for mixed fruit juices of black mulberry and canistel was black mulberry puree 53.356%, canistel puree 35.252%, and sucrose 11.092%.

CONCLUSION

The optimal formulation recommended by the Design Expert ver. 11 Mixture D-Optimal methods was obtained with a desirability value of 0.807. The optimal formula for mixed fruit juices of black mulberry and canistel is black mulberry puree 53.356%, canistel puree 35.252%, and sucrose 11.092%.

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