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Optimization of Sugar Reduction using Steviol Glycoside for Ready-to-Drink Sweetened Tea

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ABSTRACT

Excessive sugar consumption is a major contributor to increased calorie intake and the rising prevalence of obesity, particularly through sweetened ready-to-drink (RTD) teas. This study aimed to optimize formula of reduced sugar RTD tea using steviol glycoside as sweetener, in combination with maltodextrin and xanthan gum, through a mixture design approach. Steviol glycoside next called as stevia is a zero-calorie natural sweetener with a sweetness intensity approximately 300 times of sucrose. Maltodextrin was employed as filler, while xanthan gum was added to improve mouthfeel. The optimized formulation achieved a 2% reduction in sugar content using 0.009% stevia, 0.029% xanthan gum, and 1.962% maltodextrin. A reference product was formulated based on the most popular RTD jasmine black tea in the Indonesian market, which contains 7.7% (b/v) sugar per 100 mL. Result of spectrum descriptive analysis (SDA) sensory evaluation, conducted before and after ultra-high temperature (UHT) processing, showed no significant differences in sweetness, mouthfeel, astringency and jasmine aroma attributes. Compare to reference, in 100 mL product, sugar content was reduced from 7.68 to 5.78%, while total calorie slightly decreased from 30.71 to 30.13 kcal. In addition, the cost is slightly more expensive by IDR 126 per 350 mL package.

1. INTRODUCTION

Changes in the lifestyle of modern society, which tends to choose fast food and drinks and lack of physical activity, have caused an increase in the imbalance between calorie consumption and the body's energy needs. One of the main sources of excess calories comes from consuming excess sugar, especially those contained in packaged sweetened drinks (MBDK) such as sweet tea. Consuming MBDK does not provide a feeling of fullness, but causes an addictive effect on the sweet taste. The affordability of MBDK among the public causes consumption tend to increase, which causes an increase in the prevalence of obesity (Ferretti & Mariani, 2019). This is in line with data on the prevalence of obesity in Indonesia, which according to Riskesdas increased from 11.7% (2010) to 15.4% (2013) in the population aged >18 years (Ministry of Health, 2017), and will continue to increase until 2023 (Ministry of Health, 2023).

Obesity is defined by a Body Mass Index (BMI) >30 kg/m², or 27.5 kg/m² for Asian populations (Rubino *et al*., 2025). Obesity is known to be closely related to an increased risk of non-communicable diseases (NCDs) such as diabetes mellitus, heart disease and cancer. Consuming MBDK 1–2 times per day increases the risk of type 2 diabetes by 26% compared to consuming it once per month (Malik *et al*., 2010). In Indonesia, MBDK products contain very high sucrose sugar, namely between 37–54 g per 300–500 mL packaging (Fahria, 2022), this value is close to or even exceeds the daily sugar consumption limit 50 g/day recommended by Health Regulation No. 30 of 2013. Therefore, the government through BPOM issued Regulation No. 26 of 2021 which limits the sugar content in sweetened drinks labeled as healthier choices to a maximum of 6 g per 100 mL without added sweeteners (BPOM, 2021).

Product reformulation is an important strategy in effort to reduce sugar consumption, one of which is done by adding non-calorie sweetener food additives and evaluating their physical, chemical and sensory properties to obtain products that are accepted by consumers (Chen *et al*., 2020). Steviol glycoside (a compound obtained from the leaves of *Stevia rebaudiana*), hereinafter referred to as stevia, is a zero-calorie natural sweetener food additive which has a sweetness level of up to 300 times that of sucrose (Gandhi *et al*., 2018). However, the use of stevia alone often causes a bitter and astringent taste that consumers do not like (Tejo & Sontrunnarudrungsri, 2013). Therefore, additional ingredients such as maltodextrin and xanthan gum are needed to improve sensory characteristics. Maltodextrin is a food ingredient in the form of a polysaccharide resulting from partial hydrolysis of starch (Chavan *et al*., 2015). This material is generally used as a filler in substitutes for sucrose sugar. Xanthan gum is a type of hydrocolloid that can be used as a stabilizer and thickener in beverage product applications (Samal *et al*., 2023). The linear structure of xanthan gum consists of a repeated main chain of β-glucose which has a mannose branch (1→4) linked to glucuronic acid (1→2) at the C-3 position and an acetic or pyruvic acid residue. Its structure is a heteropolysaccharide with a primary structure consisting of repeating pentasaccharide units formed by two glucose units, two mannose units, and one glucuronic acid with a molar ratio of 2.8:2.0:2.0 (García-Ochoa *et al*., 2000). Based on the results of a survey conducted in preliminary research, packaged sweet tea products that use food additives as sweeteners in Indonesia all use artificial sweeteners, namely acesulfame K, sodium cyclamate and sucralose. Research in Padang in 2011 showed that 3 out of 4 samples of packaged sweet tea drinks contained sodium cyclamate as an additional synthetic sweetener (Rasyid *et al*., 2011).

This research aims to develop a sweet tea formulation in low-sugar packaging using a combination of stevia as a food additive, a zero-calorie natural sweetener, maltodextrin, and xanthan gum. Apart from that, this research will also evaluate the effect of the Ultra High Temperature (UHT) heating process on the sensory and physicochemical characteristics of the product, calculate the sugar content, total calories of the product produced, and its effect on price. It is hoped that the results of this research will produce low-sugar sweet tea products that still have good sensory quality and can be accepted by consumers.

2. RESEARCH MATERIALS AND METHODS

2.1. Material

The ingredients used to make packaged sweet tea are raw water (reverse osmosis/RO) commercial brand Amidis, commercial black jasmine tea leaves brand Dandang blue, commercial refined crystal sugar, Vitamin C (CSPC Weisheng Pharmaceutical-China), stevia from Cargill (ViaTechTM TS7000-USA), xanthan gum from Cargill (Satiaxane™ CX 911-France), maltodextrin DE 12 Cargill products (C*DRY MD 0191A-Indonesia), and 350 mL PET (polyethyleneterephthalate) bottles for packaging.

2.2. Method

2.2.1. Preparation of Packaged Tea

The first stage begins with a market survey of packaged jasmine black tea products and tea products that use sweetening food additives, evaluating the sugar content and other ingredients used from the labels. The most popular products on the market were selected to serve as reference control products. Laboratory scale products are made based on previous research with modifications to the brewing time (15 min) and the addition of antioxidants (Vitamin C 0.01%) (Somaputra, 2023). Tea is made by steeping 1% jasmine black tea leaves with boiling water and holding the heating for 15 min. The other solids are dissolved in boiling water separately, then the products are mixed after filtering. The control product is made with 7.7% (w/v) sucrose sugar taken from the sugar content of Pucuk Harum tea, which is the most popular packaged jasmine black tea in Indonesia.

Before product manufacture and sensory testing, ethical permission is carried out by creating a research protocol accompanied by an informed concern form and an explanatory script for respondents. Ethical permission was granted by the human ethics commission at the Institute for Research and Community Service (LPPM), Bogor Agricultural Institute with number: 1608/IT3.KEPMSM-IPB/SK/2025.

2.2.2. Optimization of Ready-to-Drink Tea using RSM (Response Surface Methodology)

The optimal formula for ready-to-drink packaged tea was designed using the deoptimal mixture design method with data processing software based on Design Expert 13.0® (DX13). This mixture application has been widely used to optimize formulas, both in beverage products, food and the pharmaceutical industry (Galvan *et al*., 2021). Control products and 2% sugar reduction formula products were replaced with stevia, xanthan gum and maltodextrin. Several experiments were carried out to obtain the upper and lower limits of the varied materials. The formula designed by DX13 was made on a laboratory scale and tested for physical, chemical and sensory properties to provide a response.

The responses to be measured are the Brix value, tannin content, color and viscosity as well as the results of sensory tests using the different from control method. Analysis was carried out using DX13 software. Ideally the analysis is carried out on significant responses in the response model with conditions; not significant results are shown by the lack of fit indicator; the difference between the predicted R^2 and adjusted R^2 values is smaller than 0.2; adequate precision value greater than 4; and the variance inflation factor (VIF) value is less than 10. The formula chosen is a formula with a desirability value above 0.75. The higher the desirability value, the more optimal the formula obtained (Rukmana *et al*., 2024). At the formula optimization stage, the target and level of importance of the response are determined for the selected response. The optimal formula was verified by repeating 5 times.

2.2.3. Product Evaluation after UHT Process

The control and selected formula products were made and sterilized using the UHT treatment at temperature of 135 °C for 10 and 30 s at the Indonesian International Institute for Life Science (I3L) Pilot Plant. A temperature of 135 ℃ is the minimum temperature for the UHT process. The commercial production process for ready-to-drink tea is taken from the reference for making ready-to-drink green tea which consists of the stages of tea extraction, formulation and sterilization using a UHT system, then the product is packaged. The commercial sterilization process using the UHT process is carried out at a temperature of 138°C for 5 seconds (Permadi *et al*., 2024). The time of 10 seconds is obtained from calculating the F0 equivalence of the process from the reference with a value of 4.08, at a temperature of 135ºC, the time required is 10 seconds. Meanwhile, the 30 second time is calculated from industrial practice which carries out UHT at a temperature of 140 ℃ for 9 seconds with an F0 of 11.64. The results of this heating process are then tested sensory using the SDA (spectrum descriptive analysis) method compared with the product before the UHT process. Physicochemical analysis is also carried out for products before and after sterilization. Next, the sugar content and calories of the product are calculated from the ingredients used. Price evaluation was carried out for one 350 mL packaging by including the industry-wide price of materials and packaging other than the water used.

2.2.4. Physical, Chemical and Sensory Measurements

Total dissolved solids (TPT): TPT measurement procedures refer to AOAC 932.12 (AOAC, 2023) and Sinamo *et al*. (2022) for liquid samples carried out using a HI96800 digital refractometer (HANNA Instruments, Romania).

Tannin content was analyzed using the permanganometric method by tritrating the product with KMnO4 solution. A total of 250 mL of tea solution was transferred into a 1000 mL Erlenmeyer flask, then 750 mL of distilled water and 25.0 mL of indigo carmine indicator were added to the Erlenmeyer flask. The solution is then titrated with KMnO4 until the color changes from dark blue to golden yellow (1 mL of 0.1N KMnO4 is equivalent to 0.004157 g of tannin). The volume of KMnO4 used was recorded and carried out 3 replications and a blank experiment was carried out (Styawan *et al*., 2021).

Color was measured according to Fu *et al*. (2020) using a Chromameter CR 300/310 (Minolta Co., Osaka, Japan). The sample is inserted into a glass cup until the surface is even with the rim of the cup (Minolta, 2013). Viscosity analysis: this analysis was carried out using an Ostwald viscometer and an Ostwald piqnometer (Lestari *et al*., 2015).

Calorie value and sugar content of control products and selected formulas: Calorie value is calculated from the sugar content and calories of each ingredient used. The calorific value for maltodextrin is calculated from laboratory test results using the by different method (proximate analysis). The sugar and calorie content of sucrose is calculated based on the purity standards in SNI for crystal sugar SNI 3140-1:2020 (BSN, 2020) while the sugar content of maltodextrin is calculated from the results of mono- and di-saccharide tests using HPLC.

Sensory tests for the optimization formula with DX13 and verification were carried out using the different from control method. In this study, the test was carried out by 22 untrained panelists by comparing the control formula and the DX13 result formula by giving a score of 0 which means the same, 1 is slightly different, 2 is somewhat different, 3 is a moderate difference, 4 is quite a big difference, 5 is a big difference and 6 is a very big difference. Panelists were given approximately 20 ml of the control formula and the formula to be assessed in a transparent glass. Testing is carried out by swallowing the product.

SDA (Spectrum Description Analysis) sensory test: this test is carried out for products before and after UHT. This method requires 8-12 trained panelists (Adawiyah *et al*., 2024). In this study, the test was carried out by 13 trained panelists. The test begins with determining the control product score (R) on the sensory attributes of sweetness, astringency, mouthfell and jasmine fragrance. This method of determining values can be done directly or determining standard values for concentration and sensory scores using the Stephen Law or Fechner Law equation which is determined by providing a concentration range and the panelists are asked to provide a score and the equation is selected based on the largest slope value.

$$\textit{Stephen equation: } R = k\,C^{n} \tag{1}$$

$$\textit{Fechner equation: } R = k \,Log\, C \tag{2}$$

where R is sensory score, k is constant, C = concentration, and n = slope

In this study, the R sweetness attribute was carried out using a standard comparison where concentrations of 2%, 5%, 10% and 16% gave a standard score of 2, 5, 10 and 15, so that this standard value could be used in sweet tea products and the panelists were asked to assess the sweetness score of the control product and the values were averaged to become the R value of sweetness (Meilgaard *et al*., 2016). For the jasmine aroma attribute, due to the lack of standards, panelists were asked to rate the control product and its value was averaged. For astringent flavors, the tea concentration range in the product is from 0.2; 0.5; 1.0 and 1.5% were asked to assess the astringency score, then entered into the Stephen and Fechner equation and it was found that Stephen's equation gave a larger slope so that the standard R value of astringency was calculated from Stephen's equation. For the mouthfeel attribute, a solution of xanthan gum was made with water with a concentration of 0.002; 0.05; 0.1 and 0.15% then the panelists were asked to assess by giving a score for each solution. The data was entered into the Stephen and Fechner equation and it was found that the Stephen equation gave a larger slope so that the Stephen equation was used to create a standard solution with a certain score. Then the solution is compared with the control product and the panelists are asked to give a mouthfeel score. The SDA test was carried out 2 times with a maximum of 3 product samples at one meeting. Panelists are asked to provide a score value by making a vertical line on a horizontal straight line on a scale of 0-15 by comparing it with a control product that has a value (R). All sensory tests were carried out by adults (aged >18 years) who were in good health. All products that are not sterilized are stored at refrigerator temperature during testing with a maximum shelf life of 3 days from the day the product is prepared.

2.2.5. Data analysis

Data obtained from the stage of determining the lower-upper limit of the independent variable to the stage of verifying the optimum formula were processed using Design Expert 13.0® software. Comparative data were processed using IBM® SPSS® Statistics version 27 software for analysis of variance (ANOVA).

3. RESULTS AND DISCUSSION

3.1. Optimization of Packaged Tea Formula with RSM

Formula optimization begins with making a control product and a low sugar product formula with a 2% reduction in sugar by replacing it with stevia, xanthan gum and maltodextrin. The formula was obtained from the product development department from the triangle method sensory test compared with the control by 12 trained panelists with the results not being significantly different. Several experiments were carried out to determine the lower and upper limits of the 3 ingredients used and it was found that the lower and upper limits for stevia were 0.003 and 0.01%, for xanthan gum it was 0 and 0.05% which provided a significant sensory difference, while for maltodextrin, the use of 0 to 2% did not provide a difference, so in this case the maltodextrin material was used as a filler to replace soluble solids from reduced sugar. Obtained 16 formulas and responses as in Table 1.

Table 1. Low sugar sweet tea formula from DX13 and response

Run	Stevia (g)	XG (g)	MD (g)	SS	Vis (cP)	Brix (º)	Tanin (%)	pH	L	a	b	ΔE*	ΔC*
1	0.0059	0.0500	1.9442	2.09	2.9193	8.9	1.941	4.810	51.26	-0.35	20.04	4.58	-3.12
2	0.0030	0.0351	1.9620	1.95	2.3559	9.0	1.6783	4.770	64.42	-0.93	23.32	9.31	-1.48
3	0.0066	0.0200	1.9733	2.05	1.9091	8.9	1.6491	4.830	50.85	-0.76	15.47	12.84	-12.22
4	0.0059	0.0500	1.9442	2.5	2.8575	8.9	1.8535	4.720	67.37	-0.91	21.82	12.79	-5.05
5	0.0037	0.0000	1.9963	2.18	1.2209	8.7	1.8389	4.690	63.8	-1.41	16.98	15.23	-12.42
6	0.0066	0.0200	1.9733	1.41	1.9969	8.3	1.7221	4.710	61.35	-1.04	20.74	8.49	-5.42
7	0.0030	0.0092	1.9878	2.14	1.3267	8.7	1.7513	4.670	43.72	0.22	16.82	12.62	-7.03
8	0.0100	0.0110	1.9790	2.41	1.7499	8.6	1.7805	4.680	40.79	0.24	16.70	15.07	-6.51
9	0.0066	0.0200	1.9733	2.32	1.6551	8.2	1.7221	4.860	45.24	-0.17	16.94	11.83	-7.5
10	0.0100	0.0000	1.9900	2.14	1.1319	8.6	1.8243	4.880	68.14	-1.13	13.65	21.89	-17.96
11	0.0030	0.0455	1.9515	2.64	2.6902	8.4	2.0432	4.890	45.45	0.08	17.38	10.69	-5.73
12	0.0066	0.0200	1.9733	1.95	1.6699	8.4	1.8827	4.830	59.01	-0.62	22.33	4.53	-1.49
13	0.0090	0.0264	1.9646	1.95	2.1229	8.8	1.7709	4.860	57.94	-0.73	10.43	21.96	-21.66
14	0.0037	0.0000	1.9963	2.5	1.2772	8.8	1.7708	4.850	58.11	-0.9	18.23	9.8	-9.06
15	0.0100	0.0336	1.9564	1.73	2.5428	8.8	1.8145	4.870	57.53	-1	9.20	24.1	-23.39
16	0.0100	0.0401	1.9499	2.05	2.8322	8.6	2.0055	4.840	66.29	-0.56	17.70	4.58	-9.06

Note: XG = Xanthan Gum; MD = Maltodextrin; SS = sensory score; Vis = Viscosity; Δ*E** and Δ*C** are calculated based on color measurements with a chromameter.

Food color undoubtedly plays an important role in driving consumer liking and acceptance of various food and beverage products. The colors we see can also lead to suppression of our appetitive eating or drinking behavior when associated with inappropriate colors (or colorings that are interpreted by consumers as inappropriate colors) (Spence, 2015). The color of the resulting product can be seen in Figure 1. Color is measured with a Chromameter. The *L*, *a*, and *b* values are direct test results, ΔE^* is the calculation result of L^*, a^* and b^* control and sample, and the ΔC^* value is C^* sample – C^* control. The formula for ΔE^* is as follows:

$$\Delta E^* = \sqrt{\left(\Delta L^{*2} + \Delta a^{*2} + \Delta b^{*2}\right)} \quad (3)$$

Based on color parameters, 16 formulas have different *L*, *a*, *b*, ΔC^* and ΔE^* values. The addition of xanthan gum will increase the viscosity, also increasing the turbidity of the product. Research in apple juice showed a similar impact on increasing the viscosity and turbidity of the product (Gössinger *et al*., 2018). Increased turbidity with the addition of

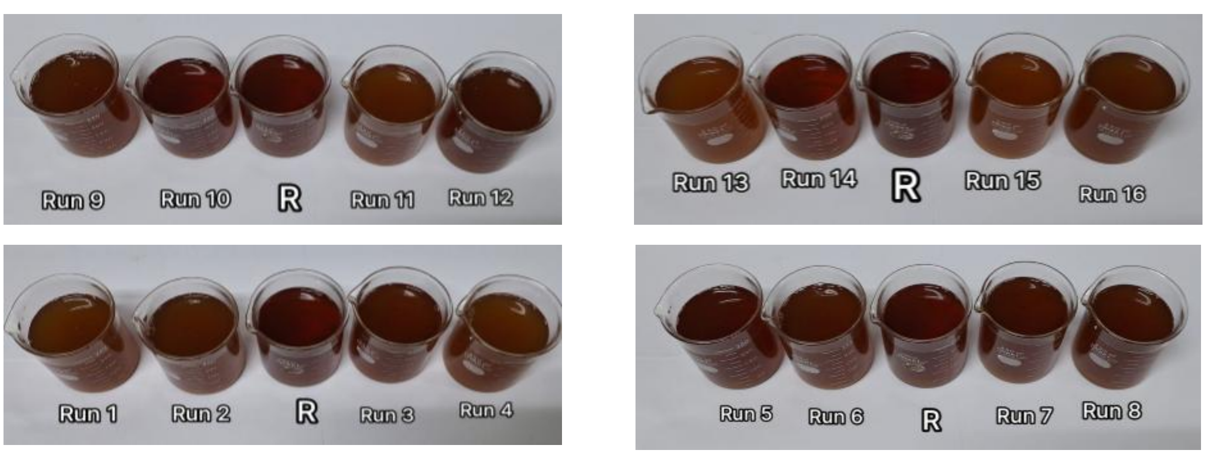


Figure 1. Tea color from 16 formulas (run) compared with control (R)

of xanthan gum was also found in vodka products (Mohan & Anand, 2024). Visually, the color of products with higher levels of xanthan gum gives a more faded and cloudy color. The analysis results in DX13 for the responses entered provide significant values for the viscosity and color parameters at the Δ*C** and Δ*E** values as in Table 2, these responses then make it possible to use them in making criteria for the formula that will be made.

Table 2. Characterization of response variability based on valid DX13 model results

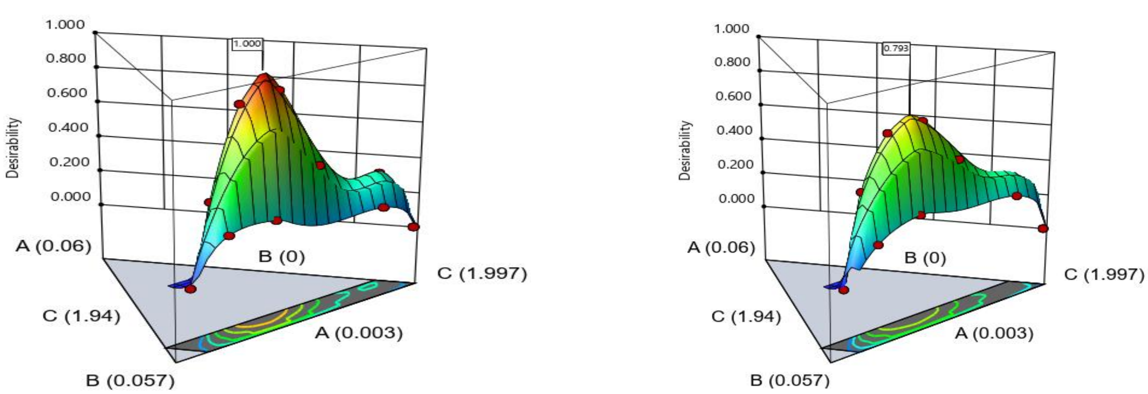
Response	**Model**	***Significant (p<0,005)***	**Lack of fit**	**R²**	**Adjusted R²**	**Adequate Precision (>4)**
Viscosity (cP)	Linier	<0.0001	0.5559	0.9605	0.9545	31.4543
Δ*E**	Linier	0.0370	0.3634	0.3979	0.3053	5.7765
Δ*C**	Special Quartic	0.0152	0.5403	0.8708	0.7231	7.7603

Next, a formula was created by entering the target viscosity from the control viscosity value of 2.275 cP and the color value Δ*C** with the target minimize. Δ*C** was chosen to be the response that represents color because it provides higher desirability. Higher desirability indicates a more optimal formula. This formula is hereinafter called F1 with a desirability value of 1,000. The sensory response should be an important response for formula optimization, so another formula was created which was then called F2 by entering 2 responses in F1 plus a sensory score response with a target of 0 (the same as the control). This formula has a desirability of 0.793. The recommended formula for DX13 as a substitute for 2 g of sugar can be seen in Table 3. Viscosity and color are given medium importance value (+++), while the sensory score is an importance value of (+++++). The 3D image of DX13 for F1 and F2 can be seen in Figure 2. This 3D image provides an overview of the most optimal point at the peak of the three curves which is seen in red with a peak desirability approaching 1 at F1 and in yellow approaching a desirability of 0.75 at F2.

Formulas F1 and F2 were then verified 5 times with the same response as the previous 16 formulas. Responses repeated 5 times are entered into the DX13 software and then evaluated whether these responses are within the expected prediction range. In Table 4, it can be seen that the responses that fall within the predicted range of F1 and F2 are responses for sensory score, viscosity, tannin content, pH and L color. This shows that this model is only valid for these responses. The color parameters a and b are not valid responses, while for Brix, this is probably because the resolution capability of the test equipment is only 1 digit, so the results are slightly shifted from predictions.

Table 3. Composition of selected formulas (F1 and F2) desirability values

Formula Composition (g/100 mL)				**Desirability**
Formula	**Stevia (A)**	**Gum Xanthan (B)**	**Maltodextrin (C)**	
F1	0.010	0.029	1.961	1.000
F2	0.009	0.029	1.962	0.793



F1 F2

Figure 2. 3D output from DX13 software for F1 and F2 with A: stevia, B: xanthan gum and C: maltodextrin

Next, to see whether F1 and F2 were significantly different from the control from the sensory side, a test was carried out using SPSS-One Way Anova and continued with Dunnet from the sensory results that were different from control. The output from SPSS provides data with a p value of >0.05 for the two formulas, with a value of 0.548 for F1 and 0.348 for F2 so that from a sensory perspective it can be concluded that the two formulas are not significantly different compared to the control at the 5% level. Next, F2 was chosen to continue with the UHT process because this formula gave a lower score on sensory results in 5 repetitions, which could mean that the product was more similar to the control in terms of sensory characteristics.

Table 4. Responses to verification results from 5 repetitions of F1 and F2

Parameter/ Response	F1					F2				
	Prediction average	SD	95% PI		Average results	Prediction average	SD	95% PI		Average results
			Low	High				Low	High	
Sensory score	1.91	0.3	1.48	2.32	2.32	1.91	0.3	1.48	2.32	1.9
Viscosity (cP)	2.275	0.133	2.106	2.444	2.199	2.275	0.133	2.106	2.444	2.199
Brix (°)	8.9	0.2	8.3	9.2	**8.12***	8.78	0.21	8.33	9.24	**8.12***
Tannin (%)	1.761	0.072	1.607	1.915	1.696	1.761	0.072	1.607	1.915	1.696
pH	4.87	0.07	3.51	5	4.77	4.87	0.07	4.72	5.03	4.79
L	63.02	7.41	46.88	79.17	57.49	58.7	7.41	41.36	76.04	58.69
a	-1.32	00.34	-2.05	-0.58	**4.61***	-0.88	00.34	-1.67	-0.08	**5.49***
b	17.24	2.83	12.19	22.3	**29.79***	9.75	2.83	3.68	15.81	**30.95***

Note: *results do not match the DX13 prediction range

3.2. Changes in Physical and Chemical Characteristics

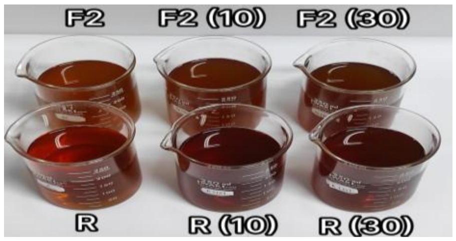
The results of the physicochemical test of the product before and after UHT are seen in Table 5. The decrease in viscosity occurred after UHT, the control product decreased more compared to F2. This likely occurs due to the hydrolysis of some sucrose into glucose and fructose which have a smaller molecular size, thereby reducing viscosity. Product F2, which has a smaller sucrose content, experienced a smaller decrease in viscosity than the control product. Sucrose hydrolysis is influenced by pH and temperature. At a lower pH and high temperature, the hydrolysis process will be higher, the same phenomenon occurs in juice products containing sucrose (Panpae *et al*., 2008). While the character of maltodextrin tends to be stable at high temperatures, acid hydrolysis of maltodextrin occurs usually at very low pH where strong acids such as Hydrochloric Acid (HCl) are added (Hartiningsih *et al*., 2020). The decrease in viscosity of the F2 product, apart from sucrose hydrolysis, can be influenced by the character of the xanthan gum solution, with a high temperature process, the viscosity of the xanthan gum solution will decrease (Naji *et al*., 2012).

Compared to the control product, the selected formula is cloudier, this causes differences in color intensity which can be seen from the *L* and *C** values. The turbidity of the selected formula product is caused by the added xanthan gum because the xanthan gum solution in water is cloudy (Liang *et al*., 2006). The product after UHT has a darker color, the longer the UHT process at the same temperature gives a darker intensity as seen in Figure 3. Color changes in the tea

Table 5. Phyical and chemical characteristics of products before and after UHT

	Before UHT		After UHT			
	R*	F2*	R(10)*	R(30)*	F2(10)*	F2(30)*
Brix (%)	7.90 ± 0.00[b]	7.85 ± 0.07[b]	7.90 ± 0.00[b]	7.90 ± 0.00[b]	7.75 ± 0.07[a]	7.90 ± 0.00[b]
pH	4.82 ± 0.00[c]	4.75 ± 0.00[b]	4.83 ± 0.01[c]	4.68 ± 0.01[a]	4.67 ± 0.01[a]	4.75 ± 0.00[b]
Tanin (%)	1.65 ± 0.00[c]	1.50 ± 0.00[cb]	1.54 ± 0.02[ab]	1.67 ± 0.00[c]	1.51 ± 0.02[a]	1.65 ± 0.04[c]
Viscosity (cP)	2.28 ± 0.00[e]	2.15 ± 0.05[d]	1.12 ± 0.01[a]	1.10 ± 0.01[a]	1.57 ± 0.02[c]	1.39 ± 0.01[b]
L	49.27 ± 0.44[c]	50.03 ± 0.12[d]	40.35 ± 0.11[b]	40.45 ± 0.26[b]	50.56 ± 0.17[d]	35.62 ± 0.07[a]
a	-0.96 ± 0.11[b]	-1.45 ± 0.01[a]	1.36 ± 0.38[c]	1.56 ± 0.10[c]	-0.66 ± 0.03[b]	3.19 ± 0.16[d]
b	17.51 ± 0.18[b]	16.85 ± 0.36[b]	17.30 ± 0.90[b]	17.49 ± 0.01[b]	14.41 ± 0.17[a]	18.00 ± 0.59[b]
C*	27.70± 0.54[b]	26.14 ± 0.76[b]	31.70 ± 1.97[c]	31.82 ± 0.28[c]	21.34 ± 0.26[a]	35.99 ± 0.27[d]

Note: Different letter in the same line show significant differences at the 5% level with Anova, *R=control product before UHT, *F2=F2 product before UHT, *R(10): Control product after 10 seconds UHT, *R(30): 30 seconds UHT control product, *F2(10): 10 seconds UHT F2 product, *F2(30: 30 seconds UHT product after heating process is usually closely related to the oxidation process of the phenolic material contained in it (Natalie d'Avila, 2013). Heating in the process of making ready-to-drink packaged tea can theoretically also reduce the antioxidant content so that the product is more easily oxidized (Kosińska & Andlauer, 2014). The addition of xanthan gum will generally increase the viscosity of the solution (Methacanon *et al*., 2021). To get a color and viscosity that is closer to control after the UHT process, further trials are needed using xanthan gum with a lower concentration which still provides a good mouthfeel effect.



R: Control
F2: Selected formula
R(10): Control with UHT 10s
R(30): Control with UHT 30s
F2(10): Selected formula UHT 10s
F2(30): Selected formula UHT 30s

Figure 3. Product color before and after UHT

3.3. Product Sensory Profile before and after UHT

The results of determining the control score value for each attribute (R) and the SDA sensory results are in Table 6. Sensory data was taken by repeating 2 times randomly from panelists whose repetition results gave a standard deviation lower than 1.5 (10%). There were 8 panelists for each attribute who met the requirements, then this data was processed using 2-way ANOVA on SPSS, followed by the Duncan test, if the product gave a significant difference at the 5% level. A spider web diagram using Microsoft Excel from the average sensory score data for each attribute was created to provide a visual representation of the sensory results.

Statistically, the results of the sensory test for sweetness and mouthfeel attributes are not significantly different between products at the 5% level, for the astringent taste and jasmine aroma attributes it gives a p value ≥ 0.05 but the subset results provide data that is not significantly different between products, especially in the selected formula (F2) as shown in Table 6. This provides information that the formula provided by RSM is valid for sensory test parameters with results that are not significantly different from the control product. Even though the product viscosity after the UHT process is different from the control, this does not make the mouthfeel significantly different because apart from viscosity, the product's mouthfeel is also influenced by other factors such as smoothness and astringency (Wolinska-Kennard *et al*., 2025).

Table 6. R score and product SDA sensory results before and after UHT

	Sweet (R=7.78)	Astringent* (R=8.42)	Mouthfeel (R=4.88)	Jasmine Aroma* (R=6.88)
Before UHT				
Control	7.09 ± 1.59	7.94 ± 1.42^{ab}	4.69 ± 0.52	7.12 ± 0.69^{b}
Selected Formula (F2)	8.14 ± 0.58	7.41 ± 1.83^{a}	5.48 ± 0.75	7.00 ± 1.17^{ab}
After UHT				
Control UHT 10s	7.78 ± 0.00	9.02 ± 0.72^{bc}	5.38 ± 0.58	5.72 ± 1.17^{a}
Control UHT 30s	6.83 ± 1.22	9.57 ± 0.66^{c}	5.30 ± 0.97	6.18 ± 0.82^{ab}
F2 UHT 10s	7.65 ± 0.66	7.94 ± 1.32^{ab}	4.92 ± 0.66	6.24 ± 1.04^{ab}
F2 UHT 30s	7.93 ± 1.40	8.28 ± 1.62^{abc}	4.48 ± 0.63	6.00 ± 1.84^{a}

Note: * in the same column, a, b, c are significant differences at the 5% level with Anova

3.4. Calculation of Sugar Content, Calories and Effect on Price

Calculations of sugar and calorie levels are based on references and test data for the ingredients used. The calculation results are shown in Table 7, the sugar content of the final product in 100 mL of product decreased from 7.68 to 5.78%, this value is already lower than the maximum limit for healthier choice products with a maximum requirement of 6%.

However, the total calorie data has not decreased too much from 30.71 to 30.13 kcal. The mono and di-saccharide (sugar) content of maltodextrin is 4.9% based on test results using HPLC, much lower than sucrose which has a purity level of 99.7% based on SNI 3140-1:2020 (BSN, 2020). However, the calorie content of maltodextrin is only slightly different compared to sucrose per 1 g, namely 3.8 kcal for maltodextrin (Hofman *et al*., 2016) and 4 kcal for sucrose. To get lower calories, the alternative are optimize the use of lower fillers or replace with low-calorie fillers.

Table 7. Calculation of sugar content and calorie content in 100 mL

Material	Sugar Levels (%)	Energy/100 g (kcal)	Control Formula			Selected Formula (F2)		
			Material (g)	Sugar (g)	Energy (kcal)	Material (g)	Sugar (g)	Energy (kcal)
Sugar	99.7[1)]	398.80[3)]	7.70	7.68	30.71	5.70	5.68	22.73
Stevia	0.0	-	0.00	-	0.00	0.01	-	-
Xanthan gum	0.0	-	0.00	-	0.00	0.03	-	-
Maltodextrin	4.9[2)]	377.28[4)]	0.00	-	0.00	1.96	0.10	7.40
Jasmine black tea	0.0	-	1.00	-	0.00	1.00	-	-
Vitamin C	0.0	-	0.01	-	0.00	0.01	-	-
Total				**7.68**	30.71		**5.78**	30.13

Note: 1) Mono and di-saccharide sugar, purity based on SNI 3140–1:2020, 2): Maltodextrin mono and di-saccharide content as a result of HPLC test, 3): Sugar calorific value/g is 4 kcal, 4): Calorie content as a result of external laboratory test using a different method (proximate analysis)

Table 8. Comparison of ingredient prices for control products and selected formulas in 350 mL

Material	Unit	Unit Price (IDR/unit)	Control Formula		Selected Formula (F2)	
			g /100 mL	Price (IDR/350 mL)	g /100 mL	Price (IDR/350 mL)
Sugar	kg	12,167.63	7,70	327.92	5.70	242.74
Stevia	kg	2,271,291.40	0,00	0.00	0.01	71.55
Xanthan gum	kg	275,799.67	0,00	0.00	0.03	27.99
Maltodextrin	kg	16,223.51	0,00	0.00	1.96	111.41
Jasmine black tea	kg	29,000.00	1,00	101.50	1.00	101.50
Vitamin C	kg	115,000.00	0,01	4.03	0.01	4.03
350 ml bottle	pcs	569.00	-	569.00	-	569.00
Bottle Cap	pcs	112.00	-	112.00	-	112.00
PVC Bottle Labels	pcs	132.00	-	132.00	-	132.00
Total price (IDR)				**1,246.44**		**1,372.22**

The influence on the price of the materials used is carried out by calculating the prices of the materials and packaging used for a volume of 350 mL of product per packaging by excluding water and production costs. This price is an industrial scale price, detailed calculations are in Table 8. The selected formula increases the price by around IDR 126 per 350 mL packaging due to the price of maltodextrin which is more expensive than sugar, plus the price of stevia and xanthan gum.

4. CONCLUSION

The selected formula as a result of RSM found that 2% sugar content could be replaced with 0.009% stevia, 0.29% xanthan gum and added maltodextrin filler up to 2% with the results of the sensory test different from control not being significantly different from the control product. Comparison of products before and after UHT, the sensory attributes of sweetness, astringency, mouthfeel and jasmine aroma using the SDA sensory test provides information that the selected formula is not significantly different from the control at the 5% level. The sugar content in 100 mL of the calculated product decreased from 7.68% to 5.78%, while the calorie content only decreased from 30.71 kcal to 30.13 kcal because the maltodextrin used still provides high calories. Based on price analysis, the new selected formula increases the price to IDR 126.00 per 350 mL packaging. Optimizing the use of xanthan gum may be necessary to obtain product color and viscosity that is closer to control. Meanwhile, the use of low-calorie fillers is needed to reduce the total calories of the product formula.

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