Vol. 14, No. 5 (2025): 1893 - 1904 http://dx.doi.org/10.23960/jtep-l.v14i5.1893-1904

JURNAL TEKNIK PERTANIAN LAMPUNG

ISSN 2302-559X (print) / 2549-0818 (online)

Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

Product Development of High Carotenoids Chocolate Confectionery Based on Red Palm Olein Oleogel

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Article History:

Received : 17 April 2025
Revised : 14 May 2025
Accepted : 29 May 2025

Keywords:

Carotenoid,
Chocolate Confectionery,
Mixture Design,
Oleogel,
Red Palm Olein.

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ABSTRACT

Red palm oil (RPO)-based oleogel had potential as a substitute for cocoa butter substitute (CBS) in the manufacture of chocolate confectionery. This study aimed to obtain the optimum formula of chocolate confectionery with RPO-based oleogel and determine the physicochemical characteristics, sensory profile and hedonic rating, nutrition facts, and contribution to meet the vitamin A requirement. The methods used were: (1) manufacture and characterization of RPO-based oleogel, (2) optimization formulas of chocolate confectionery with RPO-based oleogel by D-optimal mixture design, and (3) characterization of chocolate confectionery with RPO-based oleogel. The result showed that RPO-based oleogel had a high carotenoid content of 545.87±3.39 mg/kg and slip melting point of 46.67–47.83°C. The optimum formula was 17.780% CBS, 13.880% RPO-based oleogel, and 3.340% stearin which had a texture of 1861.49 g_f and total carotenoids of 207.861 mg/kg. The sensory profile of chocolate confectionery with RPO-based oleogel based on the RATA method was yellow color; sweet, milk, fatty, and vanilla flavor; sweet, bitter, and fatty aftertaste; hard texture; melted, sandy, and sticky mouthfeel. The score of children panelists' liking was 4.52 (liked extremely). One serving size of this product fulfilled 12% of the daily vitamin A requirement from the total requirement of 600 RE.

1. INTRODUCTION

Vitamin A deficiency (VAD) is a health disorder in the body due to the unfulfilled need for vitamin A. VAD is one of the health problems that often occurs in children throughout the world, including Indonesia. According to WHO data, as many as 190 million toddlers worldwide suffer from VAD (WHO, 2011). VAD that occurs in children is caused by their high vitamin A needs due to increased physical growth and low food intake (Kapil & Sachdev, 2013). The Indonesian government has attempted to overcome the condition of VAD in Indonesia through high-dose vitamin A capsule supplementation and food fortification. However, this attempt cannot always be carried out because the fortification carried out still uses synthetic vitamin A imported from abroad (Marliyati *et al*., 2010). Therefore, other attempts are needed to overcome the VAD problem by developing high-vitamin A food products from natural sources.

Children often prefer sweet snacks such as chocolate confectionery products. Chocolate production generally uses cocoa butter substitute (CBS) fat as a substitute for cocoa butter because it has physical characteristics similar to cocoa butter (Hasibuan *et al*., 2020). CBS is obtained from palm kernel oil that contain saturated fatty acids and does not contain vitamin A, so it needs to be substituted with ingredient that contain vitamin A. One of them is red palm olein (RPO) which obtained from crude palm oil (CPO). RPO contains carotenoid compounds, mostly in the form of β-carotene which has provitamin A activity (Stutz *et al*., 2015). RPO is a CPO olein fraction that is produced without a bleaching process so that the oil produced is red because of the high carotenoid content (Robiansyah *et al*., 2017).

RPO contained carotenoids that imparted a natural yellow-orange color to food products, thereby enhancing their visual appeal. The carotenoid content in RPO, particularly β-carotene, served as a source of vitamin A that provided health benefits, such as help to relieve vitamin A deficiency disease, increase serum retinol and lower cholesterol, and increase antioxidant level (Tan *et al*., 2021). The use of RPO in food products contributed a distinctive aroma and flavor. However, when applied at high concentrations, RPO could impart an undesirable palm oil aftertaste (Silsia *et al.*, 2021).

RPO has a liquid form at room temperature because it contains a lot of unsaturated fatty acids, so it has limitations to be applicated in food products. Therefore, RPO needs to be modified into solid fat at room temperature so that it can expand its application in the formulation of various food products. The modification that can be carried out is the oleogelation process to produce oleogel. Oleogel was formed through the self-assembly of oleogelators into 3D network congealing the oil into a soft solid matrix. The matrix was formed as a result of crystallization from the oil and oleogelator homogenization process which is accompanied by heating and followed by cooling (Samateh *et al*., 2018). The oleogelation process can minimize the transformation of unsaturated fatty acids composition and the formation of trans fatty acids.

RPO-based oleogel has potential as a solid fat substitute in the manufacture of confectionery products. Studies regarding the use of RPO-based oleogel in the manufacture of chocolate confectionery have never been carried out. Until now, there has been no study regarding the formula for manufacture of chocolate confectionery using RPO-based oleogel, so the physicochemical characteristics and sensory profile of this product are not yet known. This study aimed to obtain the optimum formula of chocolate confectionery with RPO-based oleogel and determine the physicochemical characteristics, sensory profile and hedonic rating, nutrition facts of chocolate confectionery with RPO-based oleogel, and its contribution to meet the vitamin A requirement. The development of chocolate confectionery products with RPO-based oleogel is expected to fulfill the vitamin A requirement of children so that it can help overcome VAD in Indonesia.

2. MATERIALS AND METHODS

2.1. Tools and Materials

The tools used in this study were chocolate molds, analytical scales (Fujitsu CY 224C), hot plates and magnetic stirrers (Termolyne Cimarec-3), spectrophotometers UV-Vis (Uvmini-1240 Shimadzu), texture analyzers (Lloyd TA1), oven, furnace, Soxhlet apparatus, refrigerator, thermometer, glassware, and sensory test equipment sets. The materials used in this study were red palm olein (RPO) (Carotino Sdn Bhd, Johor, Malaysia), beeswax (www.beeswaxmurni.com, Jakarta, Indonesia), cocoa butter substitute (CBS) (PT Fortuna Pancaran Sakti, West Jakarta, Indonesia), commercial chocolate (Cho Cho Chocolate Bar, Jago Milk Chocolate, L'AGIE Chocolate Compound, and Chomp Chomp Chocolate Coin Strip), sugar, skim milk powder, soy lecithin, vanilla, and chemicals for analysis.

2.2. Methods

2.2.1. Manufacture and Characterization of RPO-based Oleogel

The manufacture of RPO-based oleogel was carried out by direct dispersion method between RPO and beeswax oleogelator. RPO and beeswax were weighed in a 9:1 ratio and mixed in a glass container (Rachmawati *et al*., 2024a). The mixture of RPO and beeswax was heated using a shaking water bath at 65°C for 20 min. The homogeneous mixture was then cooled at 5°C for 24 h until an oleogel was formed (Kamali *et al*., 2019). The RPO-based oleogel that had been obtained was then tested for slip melting point (SMP) using capillary tube (AOCS, 2009) and total carotenoids using a UV-Vis spectrophotometer (ISO, 2011).

2.2.2. Optimization Formulas of Chocolate Confectionery with RPO-based Oleogel

The method used in optimization formulas of chocolate confectionery with RPO-based oleogel was a D-optimal mixture design using Design Expert 13 (DX13) program. The optimization stage consisted of determination of the variables limits in the formulation, design of the optimization experiment, manufacture of chocolate confectionery with RPO-based oleogel and responses testing, analysis of the responses and optimization of the formulation, and verification of the best chocolate confectionery formula.

a. Determination the variables limits in the formulation

The control variables consisted of the concentrations of sugar, skim milk powder, soy lecithin, and vanilla; the independent variables consisted of the concentrations of cocoa butter substitute (CBS), RPO-based oleogel, and stearin, expressed as relative proportions (%) of the total formulation used; and the dependent variables consisted of texture value and total carotenoid content. Determination of the lower and upper limits of CBS, RPO-based oleogel, and stearin was based on the results of trial and error by looking at the texture response.

b. Design the optimization experiment

The lower and upper limit values of CBS, RPO-based oleogel, and stearin, as well as the texture and total carotenoid responses were entered into the DX13 program to obtain a formula model for manufacturing chocolate confectionery. Furthermore, chocolate confectionery was made based on this formula.

c. Manufacture of chocolate confectionery with RPO-based oleogel and responses testing

The composition of ingredients in manufacturing chocolate confectionery consisted of 35% fat based raw materials (CBS, RPO-based oleogel, and stearin), sugar, skim milk powder, soy lecithin, and vanilla. A total of 100 mL of water was put into a glass container and heated on a hotplate until it reached a temperature of 65°C. CBS, RPO-based oleogel, and stearin were put into a glass container, then placed in a container containing water that had been heated until it melts. Sugar, skim milk powder, vanilla, and soy lecithin were added to the fat mixture and stirred evenly. Heating was continued on the hotplate until the temperature reached 65°C while continuing to stir for 30 minutes. After that, the mixture was removed and put into a chocolate mold and cooled at 2–3°C for 1 hour (Hade, 2022). The chocolate confectionery that had been obtained was then tested for texture using the Lloyd TA1 Texture Analyzer with 6 mm cylindrical probe (Kulthe *et al*., 2014) and total carotenoids using a UV-Vis spectrophotometer (ISO, 2011).

d. Analysis of the responses and optimization of the formulation

The results of the response testing were entered into DX13 program for analysis to obtain a mathematical model and analysis of variance (ANOVA). Furthermore, the criteria were selected for the optimized responses, the criteria goal of texture response is target 2000 g_f and the criteria goal of total carotenoid response is maximize. The DX13 program provided several optimum chocolate confectionery formulas based on the responses used. In response analysis, several criteria must be fulfilled, including the model must be significant ($p < 0.05$), the lack of fit value must be insignificant ($p > 0.05$), the adjusted R^2 and predicted R^2 values have a difference of less than 0.2, and the adequate precision value must be more than 4 (Yudiastuti *et al*., 2024). The best formula should have a maximum desirability value (~1.0).

e. Verification of the best chocolate confectionery formula

The chocolate confectionery formula with a highest desirability value then verified for response testing and the results were compared with the predicted response value from the DX13 program. The results were considered verified if the actual response test value was still in the range of 95% Confident Interval (CI) and 95% Prediction Interval (PI).

2.2.2. Characterization of The Best Chocolate Confectionery with RPO-based Oleogel

Characterization was carried out on the best chocolate confectionery with RPO-based oleogel formulas selected. Analysis was carried out on the parameters of slip melting point (SMP) using capillary tube (AOCS, 2009), proximate analysis (AOAC, 2019), sensory analysis by rate all that apply (RATA) (Ares *et al*., 2014) and hedonic rating (Meilgaard *et al*., 2016), and nutrition facts and contribution to fulfilled the vitamin A (BPOM, 2019). RATA test was carried out by 50 panelists aged over 17 years to evaluate the sensory profile of product by provides the intensity of sensory attributes on a five scale (1 = very weak to 5 = very strong). Hedonic rating was carried out by 50 children aged 7–12 years to evaluate the liking for the overall attributes on a five scale (1 = disliked extremely to 5 = liked extremely).

3. RESULT AND DISCUSSION

3.1. Characteristics of RPO-Based Oleogel

RPO-based oleogel was produced using the direct dispersion method between RPO and beeswax. This method was chosen because beeswax was a hydrophobic oleogelator so it can be directly dissolved in oil accompanied by heating and stirring (Patel & Dewettinck, 2016). The results of the analysis of RPO, beeswax, and RPO-based oleogel on the total carotenoid and slip melting point (SMP) parameters were presented in Table 1. The carotenoid content of RPO in this study was lower than the results reported by Rachmawati *et al*. (2024b) of 657.24±15.67 mg/kg. However, the carotenoids of beeswax and RPO-based oleogel in this study were higher than those of Rachmawati *et al*. (2024b), which were 94.18±1.69 mg/kg and 483.27 mg/kg. The carotenoid content in RPO could not be maintained and decreased during the processing to produce oleogel. Carotenoids are pigments that are unstable and easily degraded during processing and storage (Gheonea *et al*., 2020). Using low temperatures for a prolonged period was recommended than the process using high temperatures for a short time so that the carotenoid content could be maintained (Maryuningsih *et al*., 2021). The addition of beeswax reduced the concentration of RPO thereby reducing the total carotenoid content in the RPO-based oleogel (Rachmawati *et al*., 2024b).

Table 1. Characteristics of RPO, beeswax, and RPO-based oleogel

Parameters	RPO	Beeswax	RPO-based Oleogel
Total Carotenoid (mg/kg)	597.02±6.56	122.88±1.72	545.87±3.39
Slip Melting Point (°C)	22.33–23.33	60.33–63.00	46.67–47.83

RPO had a melting point less than room temperature (<25°C) so it was liquid at room temperature. The melting point of beeswax in this study was not much different from that reported by Rachmawati *et al*. (2024b) of 60.71°C. These results indicated that beeswax had a solid form at room temperature. The melting point of the RPO-based oleogel produced in this study was not much different from Rachmawati *et al*. (2024b) of 47.29°C. RPO-based oleogel in this study began to melt at 46.67°C and melted completely at 47.83°C. The melting point of RPO was related to the high level of unsaturated fatty acids contained in RPO. Unsaturated fatty acids had double bonds which tended to have a cis configuration. This caused a decrease in intermolecular Van der Waals interactions, that can reduced the melting point of materials containing unsaturated fatty acids (Sumbono, 2019). RPO, beeswax, and RPO-based oleogel in this study were presented in Figure 1.

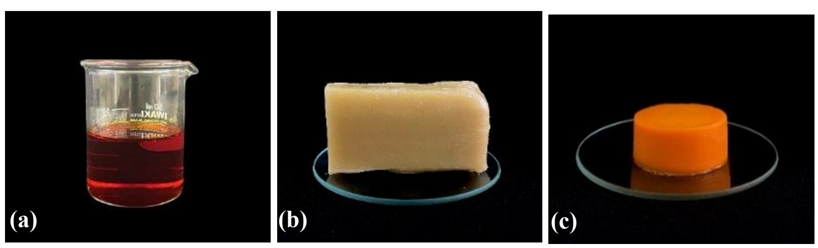


Figure 1. Appearance of : (a) RPO, (b) beeswax, and (c) RPO-based oleogel

3.1. Optimization Formulas of Chocolate Confectionery with RPO-Based Oleogel

3.2.1. Limits of Variables in Chocolate Confectionery with RPO-Based Oleogel Formulas

The variables in the chocolate confectionery formula were concentration of cocoa butter substitute (CBS), RPO-based oleogel, and stearin. The determination of the lower and upper limits of the variables was chosen based on the results of trial and error by looking at the texture response which was similar to the commercial product (2000 g_f) as reference. The lower and upper limit values of CBS, RPO-based oleogel, and stearin in chocolate confectionery with RPO-based oleogel formulas were presented in Table 2.

3.2.2. Analysis of Optimization Response of Chocolate Confectionery with RPO-Based Oleogel Formulas

The lower and upper limit values of the variables were entered into the DX13 program and the responses were in the form of texture and total carotenoids to obtain 14 formula models for making chocolate confectionery (Table 3). Figure 2 showed products resulting from the formula optimization of the chocolate confectionery with RPO-based oleogel.

Table 2. The lower and upper limits of variables in chocolate confectionery with RPO-based oleogel formulas

Variables	Lower Limit	Upper Limit
CBS (%)	17.5	31.5
RPO-based Oleogel (%)	3.5	14.0
Stearin (%)	0.0	3.5

Table 3. Formula and optimization responses of chocolate confectionery with RPO-based oleogel

Run	Variables			Responses	
	CBS (%)	RPO-based Oleogel (%)	Stearin (%)	Texture (g_f)	Total Carotenoid (mg/kg)
1	23.155	1.1845	0.000	1113.418	180.794
2	23.986	7.514	3.500	1691.239	133.284
3	30.323	4.677	0.000	5001.417	114.342
4	18.130	14.000	2.870	908.324	206.281
5	24.037	9.483	1.480	1332.671	155.865
6	20.777	10.724	3.500	1222.901	161.752
7	26.471	8.529	0.000	1790.928	148.428
8	27.945	6.174	0.881	2640.172	121.311
9	29.115	3.500	2.385	3859.551	105.046
10	21.010	13.990	0.000	941.281	194.629
11	26.544	4.956	3.500	3892.981	115.204
12	24.037	9.483	1.480	1200.449	151.217
13	18.130	14.000	2.870	927.026	204.389
14	24.037	9.483	1.480	1363.153	155.900

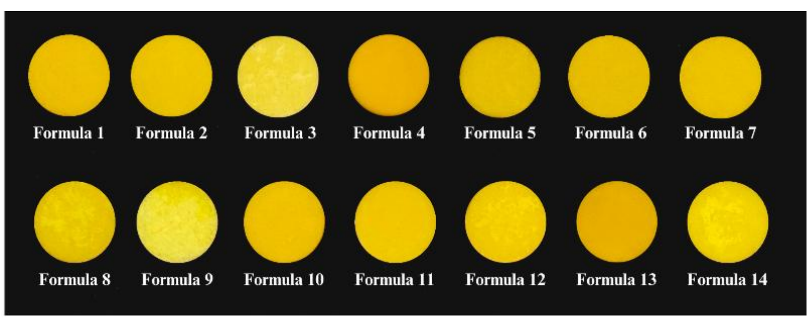


Figure 2. Chocolate confectionery with RPO-based oleogel from the formula optimization

Table 4. Analysis of variance for optimization response of chocolate confectionery with RPO-based oleogel

Responses	Model	Signification ($p<0.05$)	Lack of fit ($p>0.05$)	R^2	Adj. R^2	Pred. R^2	Adeq. Precision
Texture (g_f)	Special Quartic	<0.0001	0.066	0.996	0.989	0.881	36.942
Total Carotenoid (mg/kg)	Special Cubic	<0.0001	0.259	0.995	0.992	0.953	45.338

The results of the analysis of variance for each optimization responses were presented in Table 4. The entire model was significant ($p<0.05$) for the response and the selected model, and all responses had a lack of fit value that was not significant ($p>0.05$), which meant that the selected model had a good fit to the response data and was not significant for incompatibility model.

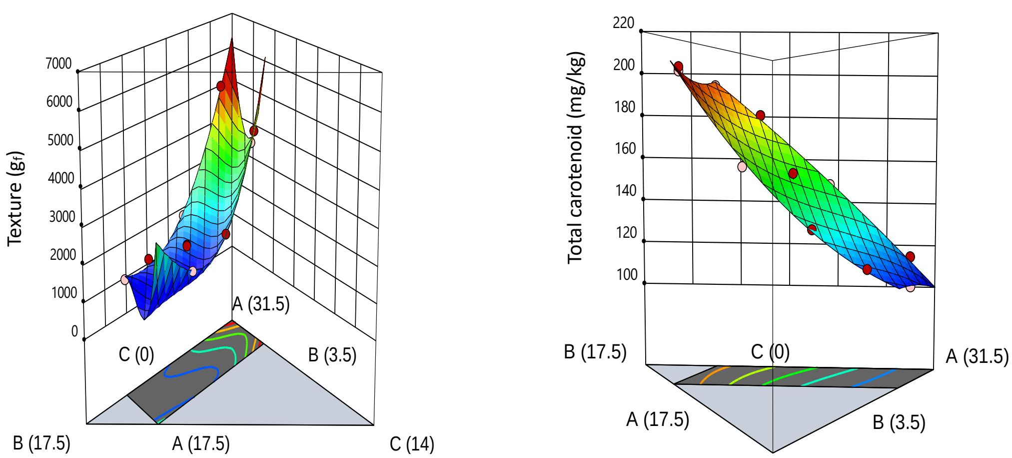
a. Texture response analysis

Texture parameters were important indicators that determined the quality of chocolate. The type of fat affected the hardness texture of chocolate products. Chocolate that used vegetable fat had the lowest hardness texture, while chocolate that used cocoa butter had the highest hardness texture (Sutrisno *et al.*, 2018). The equation used to interpret the texture response was presented in Equation 1.

$$\text{Texture} = 6261.87\ (A) + 2585.16\ (B) + 1.347E{+}05\ (C) - 13{,}110.47\ (AB) - 1.719E{+}05\ (AC) - 1.761E{+}05\ (BC) + 1.712E{+}05\ (A^2BC) + 2.270E{+}05\ (AB^2C) - 7.443E{+}05\ (ABC^2) \quad (1)$$

The Equation 1 showed that the texture response was affected by the concentration of CBS (A), RPO-based oleogel (B), stearin (C), and the interaction of the three. CBS had a greater effect on the texture of chocolate confectionery than RPO-based oleogel and stearin. The higher the CBS concentration used in the chocolate confectionery formula, the higher or harder the hardness value was obtained. The hardness texture of chocolate was influenced by its constituent fatty acids. Saturated fatty acids, such as those dominant in CBS, had straight chains without double bonds and were arranged tightly in a crystalline structure through strong Van der Waals interactions, thereby forming a solid and hard structure. In contrast, unsaturated fatty acids, such as those in RPO-based oleogel, had double bonds with a cis configuration that caused the hydrocarbon chains to bend. This bent structure hindered the compactness of the crystalline arrangement, thus resulting in a softer texture (Sumbono, 2019). The use of oleogel in chocolate processing produced a lower level of hardness compared to chocolate processed with CBS which had a higher level of hardness (Ramlah *et al.*, 2019).

The combination of components that mutually affected the texture value was shown in the 3D graph in Figure 3(a). The different colors on the graph indicate the relative texture values. The lowest texture value was 908.324 g_f, obtained with the formula containing 18.130% CBS, 14.000% oleogel, and 2.870% stearin, represented by the blue color. The highest texture value was 5001.417 g_f, obtained with the formula containing 30.323% CBS, 4.677% oleogel, and 0.000% stearin, represented by the red color.



(a) (b)

Figure 3. 3D graph of : (a) texture response, and (b) total carotenoid response

b. Total carotenoid response analysis

Total carotenoid parameters were important indicators in chocolate confectionery with RPO-based oleogel. High total carotenoids were expected to indicate high β-carotene content as provitamin A. The equation used for interpretation of the total carotenoid (TC) response was presented in Equation 2.

$$TC = 100.08\ (A) + 223.22\ (B) + 55.83\ (C) + 22.06\ (AB) + 94.07\ (AC) + 150.78\ (BC) - 504.64\ (ABC) \quad (2)$$

The Equation 2 showed that the total carotenoid response was affected by the concentration of CBS (A), RPO-based oleogel (B), stearin (C), and the interaction of the three. RPO-based oleogel had a greater effect on the total carotenoid of chocolate confectionery than CBS and stearin. The higher the RPO-based oleogel concentration used in the chocolate confectionery formula, the higher the total carotenoid produced. This was in line with the results of previous study (Rachmawati *et al.*, 2024a) which showed that increasing the concentration of RPO-based oleogel could increase the total carotenoids of the spread product. The carotenoid content in chocolate confectionery products came from the use of RPO-based oleogel. The carotenoid content in RPO-based oleogel gave a yellow color to chocolate confectionery product. Increasing the concentration of RPO-based oleogel caused an increase in the intensity of the yellow color in chocolate confectionery.

The combination of components that mutually affected the total carotenoid value was shown in the 3D graph in Figure 3(b). The different colors on the graph indicate the relative total carotenoid. The lowest total carotenoid was 105.046 mg/kg, obtained with the formula containing 29.115% CBS, 3.500% oleogel, and 0.000% stearin, represented by the blue color. The highest total carotenoid was 206.281 mg/kg, obtained with the formula containing 18.130% CBS, 14.000% oleogel, and 2.870% stearin, represented by the red color.

3.2.3. Formula Optimization and Verification of Chocolate Confectionery with RPO-Based Oleogel Formula

Optimization was carried out with the aim of obtaining the best formula of chocolate confectionery with RPO-based oleogel by optimization of the analyzed responses. The criteria for each variable were presented in Table 5. The goal criteria for CBS, RPO-based oleogel, and stearin variables were in range because the optimal formula was expected to be in the concentration interval used. The goal criteria for texture response was a target of 2000 g_f because this was the texture range for commercial chocolate. The goal criteria for total carotenoid response were to maximize because it was expected that chocolate confectionery with RPO-based oleogel had a high carotenoid content.

Table 5. Criteria for determining the optimum formula for chocolate confectionery with RPO-based oleogel

Variables	Goal	Lower Limit	Upper limit	Importance
CBS (%)	In range	17.5	31.0	3 (+++)
RPO-based Oleogel (%)	In range	3.5	14.0	3 (+++)
Stearin (%)	In range	0.0	3.5	3 (+++)
Texture (g_f)	Target → 2000	908.324	5001.417	3 (+++)
Total Carotenoid (mg/kg)	Maximize	105.046	206.281	3 (+++)

Table 6. Optimal formulas for chocolate confectionery with RPO-based oleogel from optimization

Formula	CBS (%)	RPO-based Oleogel (%)	Stearin (%)	Desirability
1	**17.780**	**13.880**	**3.340**	**1.000**
2	18.616	12.884	3.500	0.932
3	26.614	8.386	0.000	0.652
4	24.563	6.937	3.500	0.471
5	20.850	14.000	0.150	0.358

The optimization results provided five optimal formulas presented in Table 6. The selected formula is Formula 1, that was CBS 17.78%, oleogel 13.88%, and stearin 3.34% that had the highest desirability value. The desirability value indicated the degree of precision of the optimization solution. The selected formula was then verified to determine the ability of the model to predict optimal values.

The verification results of the optimal formula were presented in Table 7. The response of texture and total carotenoid were in the range of 95% Confident Interval (CI) and 95% Prediction Interval (PI) values. This showed that the optimal formula had response that matched the predictions by the DX13 program. Chocolate confectionery with RPO-based oleogel had a yellow color that came from RPO which contained carotenoids and a solid form but had a low level of hardness. The nutrient value of chocolate confectionery with RPO-based oleogel is presented in the next section.

Table 7. Verification of the optimal formula of chocolate confectionery with RPO-based oleogel

Responses	Prediction	Verification	95% CI low	95% CI high	95% PI low	95% PI high
Texture (g_f)	2000.00	1861.49	1490.66	2509.35	1467.18	2532.83
Total Carotenoid (mg/kg)	206.486	207.861	199.473	213.5	198.752	214.221

3.2. Characteristics of The Best Chocolate Confectionery with RPO-Based Oleogel

3.3.1. Physical and Chemical Characteristics of Chocolate Confectionery with RPO-Based Oleogel

The physical characteristic of chocolate confectionery with RPO-based oleogel was slip melting point (SMP). Chocolate confectionery with RPO-based oleogel had an SMP value of 35–37.33°C. This temperature showed that the chocolate confectionery product with RPO-based oleogel was solid at room temperature, but melted easily in the mouth (body temperature), which is a desirable characteristic of chocolate. According to Saputro *et al.* (2022), the melting point of chocolate is influenced by fat content. The RPO-based oleogel contributed to strengthening the fat crystal network within the chocolate matrix, thereby improving thermal stability and maintaining a firm texture (Kurniaditya *et al.*, 2024).

The chemical characteristics of chocolate confectionery products with RPO-based oleogel included moisture, ash, protein, fat, and carbohydrate content. The chemical composition of chocolate confectionery with RPO-based oleogel was presented in Table 8. The chemical composition was essential to ensure product consistency, shelf stability, and provide information for nutrition labeling. Moisture content affects texture, microbial stability, and shelf life. Fat content influences melting behavior and flavor release. Protein and ash content contribute to nutritional value. Carbohydrates determine energy contribution and sweetness profile. The use of RPO-based oleogel mainly affected the increase in the fat fraction of chocolate confectionery with RPO-based oleogel, while other components (moisture, ash, protein, and carbohydrates) remained relatively unchanged (Kurniaditya *et al.*, 2024).

Table 8. Chemical composition of chocolate confectionery with RPO-based oleogel

Parameters	Result
Moisture content (%wb)	1.59±0.04
Ash content (%wb)	2.52±0.06
Protein content (%wb)	9.28±0.23
Fat content (%wb)	33.47±0.13
Carbohydrate content (%wb)	53.15±0.47

Table 9. Sensory profile of chocolate confectionery with RPO-based oleoge

Attributes	Intensity	Attributes	Intensity
Yellow color	4.29	Bitter aftertaste	1.48
Sweet flavor	3.92	Fatty aftertaste	3.18
Milk flavor	3.88	Hard texture	2.00
Fatty flavor	3.52	Melted mouthfeel	3.64
Vanilla flavor	3.52	Sandy mouthfeel	4.32
Sweet aftertaste	3.62	Sticky mouthfeel	2.38

Noted: 1 = very weak, 2 = weak, 3 = moderate, 4 = strong, and 5 = very strong

3.3.2. Sensory Profile and Hedonic Rating of Chocolate Confectionery with RPO-Based Oleogel

Sensory attributes of chocolate confectionery with RPO-based oleogel were obtained through focus group discussions (FGD) carried out by 12 graduate students of Master of Food Science, IPB University. Through the FGD, sensory attributes of chocolate confectionery with RPO-based oleogel were yellow color, sweet flavor, milk flavor, fatty flavor, vanilla flavor, sweet aftertaste, bitter aftertaste, fatty aftertaste, hard texture, melted mouthfeel, sandy mouthfeel, and sticky mouthfeel. Sensory attributes obtained from the FGD results were used in the RATA test questionnaire. Sensory profile of chocolate confectionery with RPO-based oleogel by RATA method was presented in Table 9 and Figure 4.

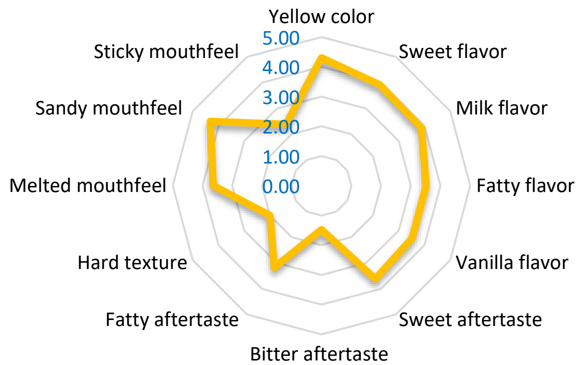


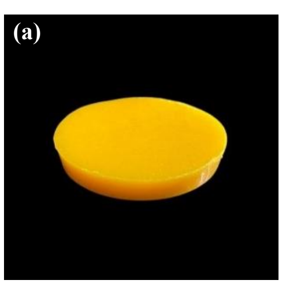
Figure 4. Spider web of chocolate confectionery with RPO-based oleogel

The level of panelist's liking for chocolate confectionery with RPO-based oleogel was carried out through a hedonic rating test on overall attributes. The level of children panelist's liking for chocolate confectionery products with RPO-based oleogel was liked extremely (4.52). Children liked sweet snacks, so they had a high level of liking for chocolate confectionery with RPO-based oleogel. Children were not able to detect specific attributes such as aftertaste and mouth-feel in the product and only detected the attributes of sweet and milk flavor which had a strong intensity (Table 9).

3.3.3. Nutrition Facts and Contribution of Chocolate Confectionery with RPO-Based Oleogel

Nutritional facts on food labels were a medium that could be used to provide information on nutritional content and the capacity of product to meet daily nutritional needs. Nutrition facts listed the nutritional content of food and other components, such as serving size, number of servings, and percentage of daily values for the general public in Indonesia (Illavina & Kusumaningati, 2022). The results of chemical analysis on chocolate confectionery with RPO-based oleogel were used in calculating nutrition value. The calculation of nutritional value refers to BPOM Regulation Number 22 of 2019 concerning Nutritional Fact on Processed Food Labels. Chocolate confectionery based on RPO oleogel and the nutritional facts from the optimal formula are presented in Figure 5.

(a)



(b) **NUTRITION FACTS**

Serving size 10 g
1 Serving per package

AMOUNT PER SERVING		
Total Calories	**55 kcal**	
Calories from Fat	30 kcal	
		%DV*
Total Fat	**3 g**	8%
Protein	**1 g**	3%
Total Carbohydrate	**5 g**	4%
Sodium	**20 mg**	1%
Total Carotenoid	2 mg	

**Persen Daily Value are based on 2150 calories diet. Your DV might be higher or lower depending on your calories need.*

Figure 5. (a) Chocolate confectionery with RPO-based oleogel from optimal formula, and (b) Nutrition facts of chocolate confectionery with RPO-based oleogel

The carotenoid content in chocolate confectionery with RPO-based oleogel derived from RPO was considered to be able to meet the daily vitamin A needs of each person. RPO contained 56.02% β-carotene of the total carotenoids contained in it (Ng & Choo, 2016). Chocolate confectionery with RPO-based oleogel had a total carotenoid of 207.861 mg/kg, so it contained β-carotene of 116.402 mg/kg. β-carotene had to be converted into retinol equivalents (RE) units in order to determine the vitamin A content. The bioavailability of β-carotene in oil ranged from 5–65% with an average of 37% (Shi *et al.*, 2023). If it was assumed that the bioavailability of β-carotene was 37%, then the amount of β-carotene in chocolate confectionery with RPO-based oleogel that could be absorbed by the body is 43.069 µg/g. 1 RE vitamin A was equivalent to 6 µg of β-carotene (BPOM, 2016). Therefore, chocolate confectionery with RPO-based oleogel contained 7.178 RE/g, so that one serving of the product of 10 g contained 71.78 RE. Consumption of one serving of the chocolate confectionery with RPO-based oleogel could meet 12% of the daily vitamin A requirement from the total requirement of 600 RE.

4. CONCLUSIONS

Optimization formula of chocolate confectionery with RPO-based oleogel using D-optimal mixture design by Design Expert 13 program produced the optimal formula, which was CBS 17.780%, oleogel 13.880%, and stearin 3.340% that has the highest desirability value (1.000). Chocolate confectionery with RPO-based oleogel from the optimal formula had a texture value of 1861.49 g_f and total carotenoid content of 207.861 mg/kg. The sensory profile of chocolate confectionery with RPO-based oleogel was yellow color, sweet flavor, milk flavor, fatty flavor, vanilla flavor, sweet aftertaste, bitter aftertaste, fatty aftertaste, hard texture, melted mouthfeel, sandy mouthfeel, and sticky mouthfeel. The level of children panelists' liking for chocolate confectionery products with RPO-based oleogel was liked extremely (4.52). Chocolate confectionery with RPO-based oleogel had an SMP value of 35–37.33°C, moisture content of 1.59±0.04%, ash content of 2.52±0.06%, protein content of 9.28±0.23%, fat content of 33.47±0.13%, and carbohydrate content of 53.15±0.47%. One serving of chocolate confectionery with RPO-based oleogel of 10 g provided energy requirements of 55 kcal and fulfilled 12% of the daily vitamin A requirement from the total requirement of 600 RE. The product development of chocolate confectionery with RPO-based oleogel in this study was still carried out on a laboratory scale, therefore a production scale-up process is needed to increase production capacity and improve the process to reduce the undesired sandy mouthfeel intensity.

ACKNOWLEDGEMENT

Acknowledgements to the Directorate General of Higher Education, Research, and Technology, Ministry of Education, Culture, Research, and Technology, Republic of Indonesia who has funded this research in accordance with the 2024 Research Program Implementation Contract Number: 027/E5/PG.02.00.PL/2024 dated 11st June 2024.

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