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Comparison of Butter and Oleogel As Fat Replacement from Red Palm Oil With Cocoa Butter Gelator and Their Influence on The Physical and Chemical Characteristics of Gelato

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ABSTRACT: Red palm oil (RPO) has a high β-carotene content and can be used as a fat replacement in dairy products. However, the direct application of RPO in gelato will affect the product's physical properties. Besides that, the distinctive characteristics of RPO can also affect the sensory properties of food, reducing the product's palatability. Therefore, in this study, an oleogelation process was carried out on RPO into oleogel, which was applied to gelato. This study aimed to determine the comparison between butter and RPO oleogel with cocoa butter gelator at specific concentrations (5%, 10%, 15%) and its effect on the physical and chemical characteristics of gelato, and the percentage of the best treatment compared to control gelato. The results showed that gelato treatment affected the physical and chemical characteristics (proximate). The best gelato formulation was CBO 1 (2.1% oleogel + 2.9% unsalted butter). Then, the best oleogel percentage was CB5% (5% cocoa butter and 95% RPO gelator concentration) with an oil loss value of 18.18%±0.16. The gelato overrun value was 17.62±0.53 %; melting time was 21 minutes 42 seconds; hardness was 397.09±4.81 N, and chewiness was 58.96±0.48 N; it had a bright yellow color; viscosity before and after aging was 3435.22±14.09 cP and 4228.89±7.88 N; fat content was 4.90±0.12%; and β-carotene content was 20.67±0.19 ppm, which can be claimed as high β-carotene gelato.

Keywords: butter, cocoa butter, gelato, oleogel, red palm oil

INTRODUCTION

Red palm oil (RPO) is a derivative product of crude palm oil obtained through a series of processes such as gum separation, neutralization, and no bleaching. Skipping the bleaching process strives to maintain the high carotenoid content so that the color would be intense red at a concentration of 500−700 ppm and tocopherols as much as 500−1000 ppm (Jun *et al*., 2018). RPO is a source of β-carotene which is easily absorbed by the body and then converted into retinol as the active form of vitamin A (precursor/provitamin A) which is good for eye health and includes natural antioxidants for the body (Rice & Burns, 2010). The addition of RPO to food is generally used for vitamin A fortification. Based on the nutritional potential of RPO, which is functionally very good for health, RPO is suitable for application in food products and development such as shortening, fat powder, spread products, emulsions in the form of drinks

Nowadays, most people have understood the need to crave a dessert that is delicious and fresh, such as ice cream, but still has health benefits. The consumption rate of ice cream in Indonesia is 0.6 L/capita/year and has been increasing in recent years. Although the per capita consumption is low compared to other ASEAN countries, Indonesia has the largest ice cream consumption in Southeast Asia at 158 million L/year. According to Euromonitor, it is projected that Indonesia's ice cream market growth will increase to 240 million L or around 8.75% (Marketeers, 2015). Ice cream has several classifications and many types of ice cream that have spread in the community, but in recent years in Indonesia, a type called gelato has developed.

Gelato is a type of Italian ice cream that is a type of frozen dairy food dessert and is now widely developed in Indonesia. Gelato and ice cream have the same ingredient composition but with different percentages of ingredients that can affect the content as well. Gelato is milk-based and usually uses egg yolks. In addition, gelato is lower in fat (4-8%) and overrun (25-60%) but high in sugar (16-25%, including sucrose and corn syrup) when compared to ice cream, giving it a denser, thicker, chewy, and creamy texture (Goff & Hartel, 2013). The warmer temperature of gelato (10-15 °C) than ice cream makes gelato suitable for the tropical climate in Indonesia so that it can be favored by various groups of people ranging from children to adults. The quality of gelato is an essential factor in maintaining consumer confidence in gelato products in the market (Arbuckle, 1996). Butter and red palm oil are fatty ingredients often used in gelato making. However, using butter may raise health-related concerns due to its high saturated fat content. Meanwhile, red palm oil, which is extracted from red palm fruits, has become an attractive alternative due to its beta-carotene content and other antioxidant compounds that give the product its natural red color.

The direct application of RPO into food products has its limitations and challenges due to the pungent and disturbing taste and aroma of RPO. The distinctive characteristics of RPO can affect the sensory properties of food, thus reducing the product's palatability, so in this study there is a process of processing RPO into oleogel. RPO will be modified with the oleogelation process technique by changing its form from liquid to solid fat (Chaves *et al*., 2018). Oleogel that has gone through the oleogelation process is formed with the help of a cocoa butter gelator, which functions to structure the oil into a semi-solid by trapping RPO to reduce the pungent aroma of RPO and improve product palatability. Currently, there are many studies on the application of oleogel utilization in food products.

Oleogel is one approach used to reduce saturated fat in food products. Oleogel is a gel system consisting of liquid oil and fat gelator. Cocoa butter gelators, derived from cocoa oil, have been used in various food products to improve the structural stability and texture of fats. To our knowledge, few researches have been conducted on using a combination of butter and red palm oil oleogel with cocoa butter gelator in gelato making. Therefore, this study aimed to investigate the effect of the ratio of butter and red palm oil oleogel with cocoa butter gelator on the physical and chemical characteristics of gelato.

The results of this study are expected to provide new insights into the effect of the combination of butter and red palm oil oleogel with cocoa butter gelator on the physical and chemical characteristics of gelato. The findings from this study can serve as a basis for manufacturers to develop healthier gelato with good organoleptic quality, as well as provide alternative options for health-conscious consumers in choosing frozen products.

MATERIALS AND METHOD

Materials

The research materials used are ultra-high temperature low-fat high calcium milk (4% total fat, 35% calcium), low-fat skimmed milk powder (0% fat, 15% protein), granulated sugar, emulsifier mono-diglycerides of fatty acid (MAG-DAG/E471), stabilizer using glucomannan, pure red palm oil were obtained from Metro Bandar Lampung local farmer, butter unsalted, and cocoa butter. The chemicals used are pro analysis grade which included; catalyst (Merck, Germany), concentrated H_2SO_4 98% (Mallinckrodt, USA), boric acid 4% (Merck), bromocresol green-methyl red indicator (BCG-MR) (Merck, Germany), NaOH (Merck, Germany), $Na_2S_2O_3$ (Merck, Germany), petroleum ether (Merck, Germany), n-hexane (Merck, Germany), HCl 37% (Merck, Germany), pure beta-carotene (standard, Sigma), ethanol 96% (Merck, Germany), chloroform (Merck, Germany), potassium hydroxide (Merck, Germany), starch (Merck, Germany), phenolphthalein indicator (Merck, Germany), glacial acetic acid (Merck, Germany), potassium iodide (Merck, Germany), KIO_3 (Merck, Germany), and iodine-bromide reagent (IBr) (Merck, Germany), also technical chemicals in the form of aquadest.

Characterization of Red Palm Oil

The red palm oil to be used must be analyzed first by testing the content of β-carotene, iodine number, free fatty acids, and peroxide value. The purpose of this process is to determine the content of β-carotene, the suitability of the type of red palm oil fraction for the manufacture of oleogel and gelato formulations, and the quality or degree of damage to red palm oil.

Based on the reference from Nagendran *et al*. (2000), the application of RPO fractions in ice cream products is divided into 5, namely red palm oil, red palm olein, red palm stearin, red palm super olein, and red palm mid-fraction. The description of suitability is found in the red palm olein fraction, very suitable to be applied to the red palm super olein fraction, and not suitable for the RPO (unrefined), red palm stearin, and red palm mid-fraction fractions due to the physical properties produced when applied to ice cream or gelato products.

Olein is a liquid fraction that is very stable to oxidation, mixes well, and makes the dough homogeneous when added with emulsifiers such as ice cream/gelato because it is included in the oil-in-water emulsion system. Meanwhile, stearin is the solid fraction for making margarine and shortening.

Analysis of β-carotene Content

Testing of beta-carotene content was carried out using the spectrophotometric method, which refers to the research of Yuan *et al*. (2008) and reference Gardjito and Wardana (2003) with modifications. The determination of beta carotene in the emulsion was started by preparing a standard curve using 0.0025 g of pure beta carotene dissolved in ethanol:hexane (2:3) mL in a volumetric flask. Then, multilevel dilutions were made at several points, such as the volume of the beta carotene solution taken (0; 0.25; 0.5; 0.75; 1; and 1.25) and the beta carotene content in ppm (0, 5, 10, 15, 20, and 25). After that, it was continued to see the absorbance measurement on the spectrophotometer for three repetitions of the experiment, and the absorbance results were entered into the standard $y = ax + b$ equation to calculate the beta-carotene content of the sample.

Testing on samples is almost similar to making a standard curve. First, the gelato sample (± 1 mL) was weighed to see in grams in a test tube, then extracted with a mixture of 2 mL of ethanol and 3 mL of n-hexane. After that, vortex to mix thoroughly for 1 minute. Extraction was repeated for the second and third. The amount of dilution is adjusted to the level of beta-carotene contained in the sample. Then, the absorbance was measured with a UV-Vis spectrophotometer at 450 nm. The concentration of β-carotene was obtained by referring to the standard curve of β-carotene.

In general, beta carotene absorbs light in the UV region but is more robust in the visible region between 400 and 500 nm with a peak of 470 nm. However, the measurement of β-carotene in gelato samples was conducted at a wavelength of 450 nm because it can provide the maximum absorption of β-carotene.

The equation calculated the β-carotene analysis:

$$\beta\text{-carotene content (ppm)} = \frac{X\ value\ from\ standard\ curve\ equation\ result\ \left(\frac{mg}{mL}\right) \times sample\ volume\ (mL) \times dilution\ factor}{initial\ sample\ weight\ (g)}$$

Iodine Number Test Analysis

The analysis of the iodine number test refers to the research of Nielsen (2011) and Sudarmadji *et al*. (1977). Begin by weighing 0.25 g of red palm oil in a closed Erlenmeyer. After that, 10 mL of chloroform and 25 mL of IBr were added and incubated in a dark place for 1 hour. Then 10 mL of 15% potassium iodide and 100 mL of distilled water were added. Next, titrate with 0.1 N $Na_2S_2O_3$ (which has been standardized) until pale yellow. The last stage was adding 2 mL of 1% starch solution and the titration was carried out again until the blue-black color disappeared. In a blank solution, it is made from 25 mL of scorched reagent plus 10 mL of 15% potassium iodide and diluted with 100 mL of distilled water that has been boiled and titrated with sodium-thiosulphate solution.

The equation calculated the iodine number:

$$\text{Iodine number (g } I_2\text{/100 g)} = \frac{volume\ in\ mL\ titration\ (blank - sample) \times N\ Na2S2O3 \times 12.69}{sample\ weight\ (g)}$$

Free Fatty Acid Test Analysis

The analysis of the free fatty acid (FFA) test refers to the method used by BSN (2019) in the Indonesian National Standard 7709 and Maimun *et al*. (2017) with modifications. The test was conducted using the alkalimetric titration method. The test begins with weighing ± 5 g of red palm oil in an erlenmeyer. Then it was dissolved in 50 mL of ethanol 95%, then heated for 10 minutes in a water heater and covered with a counter cooler, and shaken until homogeneous. Then let it stand for a few minutes, then add 3 drops of phenolphthalein indicator and continue to shake again slowly. The last step was titrated with a standardized 0.1 N potassium hydroxide solution until the color changed to pink. When carrying out the titration, there is a pause to see the color change and record the titrant needed for each level of color change until it turns pink.

The FFA test was calculated by equation:

$$\text{FFA (\%)} = \frac{25.6\ (constants\ as\ palmitic) \times normality\ of\ the\ titrant\ solution\ (N) \times volume\ of\ titrant\ used\ (mL)}{sample\ weight\ (g)}$$

Peroxide Value Test Analysis

The analysis of the peroxide value (PV) test refers to the method used by BSN (2019) in the Indonesian National Standard 7709 and AOCS (2003) Cd 8-53 with modifications. It started with weighing ± 5 g of red palm oil in a 250 mL erlenmeyer. Then add 30 mL of acetic acid:chloroform (3:2 v/v) and shake until homogeneous. Then 0.5 mL of saturated potassium iodide was added and shaken again for 1 minute. If the solution is homogeneous, it can be continued with storage in a dark place for 2 minutes. After that, 30 mL of distilled water and 2 mL of 1% starch were added which changed the color of the solution to blackish blue. The final step is to carry out the titration process using 0.1 N $Na_2S_2O_3$ titrant gradually while stirring constantly so that the color changes from blue to yellow. In the same way, a blank titration was also made.

The PV test was calculated by equation:

$$\text{PV (meq}O_2\text{/kg)} = \frac{mL\ volume\ of\ titrant\ used\ (in\ the\ sample - blank) \times normality\ of\ the\ titrant\ solution\ (N) \times 1000}{sample\ weight\ (g)}$$

Preparation of Red Palm Oil Oleogel

The method used from previous research (Godoi *et al*., 2019) with modifications. The first step in the preparation of oleogel was preheated red palm oil to 90 °C on a hotplate magnetic stirrer. After that, cocoa butter as a gelator was mixed according to various concentrations (5%, 10%, and 15%) and stirred at 200 rpm for 15 minutes. The temperature during the mixed process was controlled to be constant at 90 °C. Then, the oleogel was left in the open space until the temperature dropped to room temperature (± 25 °C). The oleogel was continued to be stored at 4 °C for 24 hours so that the formation of crystals and networks on the oleogel.

Analysis of Oil Binding Capacity and Oil Loss in Oleogel

Analysis testing refers to the method of Meng *et al*. (2018) with modifications and assisted by a centrifuge. In the first step, an empty 15 mL centrifuge tube was weighed. Followed by weighing 10 grams of RPO oleogel sample. Then, the sample was centrifuged at 25 °C with a speed of 4000 rpm for 30 minutes. Then, the centrifuge tube is inverted for 3 minutes, and two different layers will form between the oil and oleogel, then the oil separated from the oleogel is discarded. The centrifuge tube is weighed, and the tube weight is recorded. Re-analysis was performed in triplicate. The percentage of oil binding capacity and oil loss oleogel tests were calculated by the equation:

$$\text{Oil Loss (\%)} = \frac{(m1-m)-(m2-m)}{(m1-m)} \times 100\%$$

Oil Binding Capacity (%) = 100 - %Oil Loss

m: empty tube weight (g)

m1: the weight of the tube containing the sample before centrifugation (g)

m2: the weight of the tube containing the sample after centrifugation (g)

Gelato Formulations

The formulation for making gelato used in this study refers to Goff & Hartel (2013) and Kemenady *et al*. (2019) with modifications as shown in Table 1.

According to references, gelato has a fat content in the range of 4-8%. In this study, gelato preparation used a percentage of fat content of 5%, which was sourced from oleogel and unsalted butter. The choice to use a fat content of 5% is also based on the results of trial and error conducted in the laboratory and the minimum fat content provisions in SNI 3713:2020 regarding ice cream. The targets in this study who consumed gelato were children over 3 years old (all ages from children to adults), but we assume the classification is in general age groups. The RPO used came from Lampung because it includes the super olein fraction. The basis for determining the formulation used was the β-carotene content in pure RPO of 1126.21 ppm, so 1 gram of RPO contains 1.13 mg of β-carotene.

According to Nagendran *et al*. (2000), it was stated that 1 RE is equivalent to 1 µg retinol or 6 µg beta carotene, or 12 µg provitamin A carotenoid. Based on BPOM provisions (2016) regarding nutritional label reference for food products, the recommended average nutritional adequacy rate of vitamin A for the general age group or the general public in Indonesia is 600 RE, which is equivalent to 7200 µg total carotene or is equivalent to 3600 µg (3.6 mg β-carotene per day) according to the Decree of the Minister of Health of the Republic of Indonesia No. 28 of 2019. In addition, to claim a food product that is high/rich in β-carotene, it must meet at least not less than 30% nutritional label reference per 100 grams of product in solid form or equivalent to 1.08 mg of β-carotene per 100 grams. The minimum amount of red palm oil added to the dough is 1.04% (1.13 mg/1.08 mg x 100%).

The making of gelato refers to Clarke (2004) and Goff & Hartel (2013) with modifications. Making gelato has the same principles as making ice cream. The manufacturing process includes material preparation, pasteurization, homogenization, aging, agitation, and cooling. The process was initiated by weighing all the ingredients according to a predetermined formula. Then, low-fat UHT milk is heated to 40 °C over low heat, and sugar and skimmed milk powder are added until it is evenly mixed while stirring gently. When the heating temperature has reached 60 °C, an emulsifier and stabilizer are added. The process of stirring slowly over low heat is continued until the temperature reaches 70 °C. After that, add unsalted butter and oleogel. Furthermore, the pasteurization process was carried out for 30 seconds at 80−85 °C. After all processes were completed, the gelato mixture was left to cool down to lower its temperature (±55 °C) and followed by a homogenization process with the help of a mixer at low speed (value 1−2) for ±15 minutes. The gelato dough mixture was continued with the aging process at refrigerator temperature ±4 °C for 24 hours (overnight) in closed condition. Then proceed with the

Table 1. Gelato formulation

Sample	Material Composition (%)						
	Sugar	**Skim Milk Powder**	**Emulsifier (MAG-DAG)**	**Stabilizer (Glucomannan)**	**Oleogel**	**Unsalted Butter**	**UHT Low-Fat Milk**
K	12	18	0.3	0.3	0	5	64.4
CBO 1	12	18	0.3	0.3	2.1	2.9	64.4
CBO 2	12	18	0.3	0.3	2.2	2.8	64.4
CBO 3	12	18	0.3	0.3	2.3	2.7	64.4

K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter) agitation process (quick freezing method) or stirring the gelato dough mixture with the help of a gelato machine or ice cream maker for 25−30 minutes (the determination of time depends on the base made). Finally, gelato is stored in a freezer at a temperature range of -14 ℃ to -18 ℃ in a closed place.

Physical properties of gelato analysis

Overrun

Overrun testing refers to Marshall & Arbuckle (1996) with shot glasses. The test was carried out by measuring the weight of the gelato dough before turning the gelato dough in the ice cream maker (before aging) and after churning it in the ice cream maker.

Overrun was calculated by using the following formula:

$$\text{Overrun (\%)} = \frac{dough\ weight\ (g) - ice\ cream\ weight\ (g)}{ice\ cream\ weight\ (g)} \times 100\%$$

Melting Time

According to Lestari et al. (2019), the melting time analysis was carried out on gelato that had been stored in the freezer (-18ºC) in a frozen state (1 day of storage). The initial step of the test was to weigh 10 g of gelato on a sieve, which also contained a glass as a storage container. Then, the gelato is left at room temperature (±25ºC) until it thaws completely, and it is ensured that all the liquid can drip through the filter. Calculation of melting time using the help of a stopwatch, and melting time is calculated since the gelato is removed from the freezer and is declared complete when all the gelato in the filter has fallen to the bottom.

Color

Color analysis testing on gelato was carried out using a chromameter following the method of Oh *et al*. (2017) and Rodliyani (2019). Color analysis was carried out 24 hours after the gelato samples were made. This color test uses the Hunter system with four parameters, namely L* (light/dark), a* (red/green), b* (yellow/blue), and ΔE (total color difference). ΔE describes the total color difference between the sample and the control so that it can be seen how big the difference is. The formula used is as follows:

$$\Delta E = \sqrt{(L - Lk)^2 + (a - ak)^2 + (b - bk)^2}$$

If an ΔE value of less than 1.5 is obtained, it means that the total color difference is small, if an ΔE value is between 1.5-3, it means that the samples have different color controls, and if the ΔE value is more than 3, the color between the samples and the control is very different.

Texture Analysis (Hardness and Chewiness)

Texture analysis testing using two tools. First, with the help of the Universal Testing Machine (UTM) Zwick/Z0.5, which is connected to the eXpert software to measure the hardness of gelato with a pre-load of 0.01 N, a pre-load speed of 300 mm/min, and a test speed of 10 mm/min. Furthermore, the second tool uses a Texture Analyzer (LLYOD materials testing TA1) connected to Nexygen Plus 3.0 software to measure chewiness. The process is done by compressing using a probe as deep as 50% of the sample height with a pre-load/stress of 1 N, a test speed of 0.5 mm/s, a wait time of 0.5 seconds, and a pre-load/stress speed of 300 mm/min.

Chemical properties of gelato analysis

Analysis of Water Content and Total Solids

Testing the water content was carried out in an oven at 105°C and using a sample of 2 g. Analysis of water content and total solids was carried out using the Gravimetric method (AOAC, 2005). The formula used is as follows:

$$\text{Water content (\%)} = \frac{X1 - X2}{W} \times 100\%$$

X1 = Initial weight of weighing bottle + sample (g);

X2 = Weight of weighing bottle + constant sample after baked (g);

W = Sample weight (g)

Total solids (%) = 100% - water content (%)

Fat Content Analysis

The fat content analysis test used is the Soxhlet method, which refers to AOAC (2000). In general, the Soxhlet method is used for dry samples, but the sample used is gelato (wet sample). Therefore, prior to testing the fat content with Soxhlet, pre-treatment in the form of hydrolysis and drying must be given. The following formula can calculate fat content:

$$\text{Fat content (\%)} = \frac{W - Wo}{S} \times 100\%$$

W - Wo = fat residue weight (g);

W = constant weight of container + fat residue (g);

Wo = the constant weight of the empty container (g);

S = sample weight (g)

Protein Content Analysis

Protein content analysis was carried out using the micro-Kjeldahl method, which refers to AOAC (2000). The conversion factor used is 6.38 because the raw material for making gelato is dairy products (Andarwulan *et al*., 2011). Analysis of total protein content using the micro-Kjeldahl method was divided into three stages, namely destruction, distillation, and titration. The percentage of protein in the sample can be calculated using the following formula:

$$\%N = \frac{HCl\ titration\ volume\ (mL\ sample - blank) \times Normality\ HCl \times 14.008}{sample\ weight} \times 100\%$$

Table 2. Characteristics of red palm oil

	Nutiva	Salmira	RPO Lampung
β-carotene concentration (ppm)	1839.11 ± 67.44	1754.30	1126.21 ± 47.48
Iodin number (g I_2/100 g)	56.92 ± 2.41	-	60.82 ± 1.74
Free fatty acid (%)	10.37 ± 0.17	-	3.47 ± 0.07
Peroxide value (meq O_2/kg)	14.30 ± 0.95	-	3.81 ± 0.00

Table 3. Characteristics of RPO oleogel

Variation of Oleogel Concentration	Oil Loss (%)	β-carotene concentration (ppm)
CB5%	18.18 ± 0.16^{a}	998.12 ± 7.71^{c}
CB10%	19.69 ± 0.87^{ab}	937.34 ± 3.28^{b}
CB15%	21.70 ± 2.27^{b}	870.59 ± 2.57^{a}

Code: CB5% (oleogel with gelator concentration of 5% cocoa butter and 95% RPO), CB10% (oleogel with gelator concentration of 10% cocoa butter and 90% RPO), CB15% (oleogel with gelator concentration of 15% cocoa butter and 85% RPO).

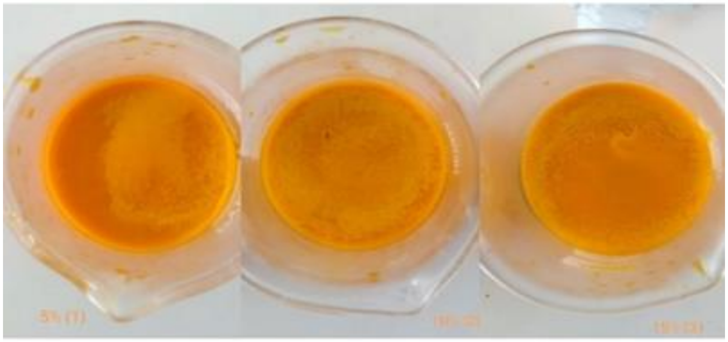

Figure 1. Appearance of oleogel variations

Figure 2. Gelato samples for testing

Protein content (%wb) = %N x conversion factor

Ash Content Analysis

Ash content analysis test refers to AOAC (2000). Beginning with the oven, the crucible at 105 ℃ overnight. After that, the crucible is put into a desiccator to lower the temperature. Then the crucible is weighed and filled with 2 g of gelato sample, and pre-burning on the stove. Then, the crucible is put into the muffle furnace for the ashing process for ± 4 hours at 600 ℃ until the black color disappears and the remaining grayish-white ash is obtained. Then, the crucible is left overnight in the muffle furnace until it cools completely. Then, the crucible containing ash is weighed. The equation calculated the percentage of ash content:

$$\text{Ash content (wb\%)} = \frac{constant\ weight\ crucible + ash\ (g) - weight\ of\ empty\ crucible\ (g)}{g\ sample}\ x\ 100\%$$

Analysis of Carbohydrate Content

Analysis of the calculation of carbohydrates used is by different methods. The by-different method is a rough determination of carbohydrates in food samples and involves moisture content, ash content, protein content, and fat content.

The equation calculated the analysis of carbohydrate content:

$$\text{Carbohydrate content (\%)} = 100\% - \left(\begin{array}{c}\%water\ content\ +\ \%ash\ content\ + \\ \%protein\ content\ +\ \%fat\ content\end{array}\right)$$

Experimental Design and Data Analysis

The experimental design used in this study was a factorial randomized block design for physical testing and a completely randomized factorial design for chemical testing. All physical and chemical analysis experiments (testing overrun test section, melting time, viscosity, color, water content and total solids, beta-carotene content, ash content, protein content, carbohydrate content, and fat content) were conducted in three replicates (three batches) with triplicate analysis in each measured, except for the texture test, two replicates were conducted in each measured. The statistical analysis was performed using the One-way ANOVA method and Duncan's Post Hoc test at the 5% probability to determine the significant differences (p<0.05) or more specific information about treatment comparisons.

RESULT AND DISCUSSION

Characteristics of RPO and RPO Oleogel

It can be seen in Table 2 that several factors, such as variety, maturity level, and the heating process in the processing unit, can influence differences in RPO β-carotene concentrations. The test results for β-carotene levels were compared to β-carotene levels in gelato to determine the effect of processing on β-carotene retention. According to Marliyati *et al*. (2010), beta-carotene in RPO is higher because carotene is an oil-soluble pigment, so it is concentrated in the olein fraction. Furthermore, on the iodine number, RPO Nutiva includes the olein fraction and RPO Lampung includes the super olein fraction. According to Pande *et al*. (2012), super olein has an iodine value of 60 or more, which physically has clarity, stability, and a lower tendency to turn cloudy compared to normal olein. Based on SNI 7709:2019 regarding the quality standard of palm cooking oil, the free fatty acid value calculated as palmitic acid is a maximum of 0.3% and the maximum peroxide value is 10 meq O_2/kg (BSN, 2019). The value of free fatty acids from RPO Lampung and Nutiva exceeded the maximum limit. The value of free fatty acids in the oil, even in small amounts, can result in an unpleasant taste and rancid odor in the oil, so that is what causes the use of RPO in food products to give an aftertaste. As for the results of the peroxide number, only RPO Lampung is still in the range of values. The low peroxide value in RPO Lampung can be caused by the rate of formation of new peroxides, which is smaller than the rate of their degradation into other compounds, considering that peroxide levels quickly degrade and react with other substances. Unsaturated fatty acids can bind oxygen to their double bonds to form peroxides and then form aldehydes, so this is what causes the smell and taste, as well as the rancidity of the oil. The greater the value of the peroxide number, the more peroxide in the sample (Safitri & Roosdiana, 2020).

The research parameters for oleogel are oil loss and β-carotene levels, presented in Table 3. An oleogel system that is formed is stated to be more stable if it has a low oil loss value, this indicates the ability to bind more and better oil because of its strong structure (Meng *et al*., 2018). The oil loss test for each variation in the percentage of cocoa butter gelator shows that the greater the percentage of cocoa butter gelator added, the greater the oil loss value, so the oleogel with cocoa fat gelator made shows a reasonably good oil binding ability only at CB5% when applied to products such as ice cream or gelato. According to research conducted by Ristanti *et al*. (2018), the addition of more than 5% cocoa butter will produce a soft oleogel texture that tends to be viscous because cocoa butter when mixed with oil will experience incompatibility (incompatibility) so that the crystal structure of the fat formed in the oleogel becomes unstable and neither gelated nor perfectly distributed. In this case, it can be evaluated that the use of cocoa butter gelator is <5%. The appearance of the oleogel variations is shown in Figure 1. In addition, the results obtained regarding the levels of β-carotene from each oleogel, the higher the concentration of cocoa butter gelator and the lower the percentage of RPO addition resulted in lower levels of β-carotene.

Physical and Chemical Characteristics of Gelato

The process of making gelato, the composition of the dough, and the ingredients used to make gelato can determine the quality of the end result in physical and chemical parameters. The appearance of gelato samples for testing is shown in Figure 2.

Physical Characteristics of Gelato

Overrun Test of Gelato

The results of the gelato overrun test are presented in Table 4.

Table 4. Overrun test result of gelato

Sample	Overrun (%)
K	18.26 ± 0.30[b]
CBO 1	17.62 ± 0.53[a]
CBO 2	19.85 ± 0.64[c]
CBO 3	21.57 ± 0.24[d]

Note: different letters indicate significantly different values on Duncan's Post Hoc test (5% level)

K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter)

According to the results, the comparison of RPO oleogel and unsalted butter application in gelato samples had a significant effect on gelato overrun. The greater the percentage of RPO oleogel (the increasing percentage of cocoa butter gelator concentration and the decreasing percentage of RPO) and the smaller the percentage of unsalted butter added, the more the overrun value increases as well.

The greater the percentage of RPO oleogel (the increasing percentage of cocoa butter gelator concentration and the decreasing percentage of RPO) and the smaller the percentage of unsalted butter added, the more the overrun value increases as well.

Overrun testing was conducted as a parameter for the increase in the volume of gelato dough caused by air ingress during the homogenization, mixing, and churning processes. According to Clarke's (2004) reference, overrun is associated with increased gelato volume due to air trapped by fat globules that can form emulsions. The low amount of fat globules in gelato influences the gelato's air bubbles so that the coverage is less and the impact on overrun is low. According to Marshall *et al*. (2003), the volume of ice cream or gelato can increase due to the agitation process at the freezing stage, which makes air enter the dough. In fact, the higher the overrun value, the lower the quality of the ice cream. However, gelato with too low overrun will have a heavy, sticky, and gummy texture and undesirable melting characteristics.

Gelato dough tends to be thicker than ice cream. The dough is related to viscosity, so the viscosity of the dough influences the overrun value. Dough that is thick and has a high viscosity will produce gelato with low overrun. According to Oksilia *et al*. (2012), thick dough increases the mobility of water molecules because the space between particles in the dough is getting narrower so that less air enters the dough during the agitation process. Therefore, the resulting overrun value becomes lower, and this is already complied with obtained.

Melting Time of Gelato

The results of the gelato melting time test are presented in Table 5.

Table 5. Melting time results of gelato

Sample	Melting time (minutes:seconds)
K	20:35 ± 0.19[c]
CBO 1	21:42 ± 0.10[d]
CBO 2	20:15 ± 0.03[b]
CBO 3	19:24 ± 0.08[a]

Note: different notation indicates significantly different values on Duncan's Post Hoc test (5% level) K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter)

According to the result, the greater the percentage of RPO oleogel (increasing percentage of cocoa butter gelator concentration and decreasing percentage of RPO) and the smaller the percentage of unsalted butter addition, the faster the gelato melts. Melting time is required for ice cream/gelato to melt entirely at room temperature and is influenced by several factors, such as overrun value, viscosity, and ingredients (Goff & Hartel, 2013). The higher the viscosity, the smaller the overrun of ice cream will be, causing the melting time of ice cream/gelato to be longer (Oksilia *et al*., 2012). Good ice cream or gelato is expected to have a long melting time or melting resistance at room temperature, but melts quickly at body temperature (in the oral cavity).

Melting time is also influenced by the size of the ice crystals, where the smaller the size of the ice crystals, the longer the melting time of the ice cream/gelato (Muse & Hartel, 2004). According to Goff & Hartel (2013), gelato has the property of not melting quickly when at room temperature due to its high sugar content and low-fat content. In addition, the serving temperature of gelato is warmer (10−15 °C warmer) than ice cream, so this is what makes gelato have a longer melting time than ice cream. Every 10 g of ice cream or gelato tested had a good melting time of 15–20 minutes, so the gelato samples in this study exceeded the excellent melting time standard.

Texture of Gelato

The results of the texture test on gelato are presented in Table 6.

Table 6. Texture test result of gelato

Sample	Texture	
	Hardness (N)	Chewiness (N)
K	388.84 ± 12.48^{c}	61.37 ± 0.30^{d}
CBO 1	397.09 ± 4.81^{c}	58.96 ± 0.48^{c}
CBO 2	321.98 ± 31.50^{b}	47.97 ± 0.13^{b}
CBO 3	283.10 ± 28.31^{a}	37.08 ± 0.39^{a}

Note: different notation indicates significantly different values on Duncan's Post Hoc test (5% level)

K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter)

According to the results, the comparison of RPO oleogel and unsalted butter application in gelato samples influenced the hardness and chewiness of gelato. The greater the percentage of RPO oleogel (the increasing percentage of cocoa butter gelator concentration and the decreasing percentage of RPO) and the smaller the percentage of unsalted butter addition, the more the hardness and chewiness values decreased significantly. Regarding statistical testing, the hardness value of the control with CBO 1 was not significantly different, while CBO 2 and CBO 3 were significantly different from the control (0.73-0.83 times of the control). Meanwhile, the chewiness values of all samples were significantly different from the control (0.60-0.96 times the control).

In making gelato, the ingredients used, such as sugar, milk protein, milk fat, vegetable fat, stabilizer, emulsifier, and total solids, significantly affect the formation of gelato texture in terms of hardness and chewiness. Hardness and chewiness values that can describe the texture of a food product are strongly influenced by several things, such as air and moisture in the product which can determine the viscosity of the product (Trinh & Steve, 2012). Texture value is often associated with overrun, where the overrun value of gelato which tends to be lower than ice cream, causes gelato to have a denser texture and softer consistency because it contains less air (Whetzel, 2012).

Gelato Color Test

The results of the color test on gelato are presented in Table 7.

Comparison of the application of RPO oleogel and unsalted butter in gelato gives a significantly different color effect on the L* parameter which shows brightness and b* which shows yellowness, and does not give a significantly different effect on the a* parameter which shows green color because it is negative. The color of a food product plays an essential role in food acceptance. Visually, the color factor appears first to determine the impression of an ingredient being considered attractive and delicious. In addition to being a factor that determines quality, color can also be used as an indicator of whether or not the mixing method or processing method is characterized by the resulting color that is uniform (homogeneous) and evenly distributed.

The b* parameter is different from the other parameters, the control and treatment samples have different colors (1.88-2.23 times the control) where the control is white/beige while all treatment samples are yellow. The final color of a product is determined by the highest percentage of ingredients in the gelato-making composition, in this case, milk, and the addition of RPO

Table 7. Color test results of gelato

Sample	Color Parameters			
	L*	a*	b*	ΔE
K	78.84 ± 1.83^{b}	-10.65 ± 0.95^{a}	18.37 ± 1.47^{a}	-
CBO 1	74.71 ± 3.38^{a}	-9.56 ± 1.68^{b}	40.93 ± 1.69^{d}	22.96
CBO 2	75.31 ± 1.80^{a}	-9.28 ± 0.87^{b}	38.05 ± 1.91^{c}	20.04
CBO 3	76.67 ± 2.59^{ab}	-9.95 ± 0.30^{ab}	34.64 ± 1.29^{b}	16.43

Note: the same notation indicates the same or not significantly different values, while different notation indicates significantly different values on Duncan's Post Hoc test (5% level)
K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter)

Table 8. Viscosity test results of gelato dough

Sample	Viscosity (cP)	
	Before Aging	After Aging
K	2662.67 ± 13.31^{c}	3871.67 ± 6.86^{c}
CBO 1	3435.22 ± 14.09^{d}	4228.89 ± 7.88^{d}
CBO 2	2076.11 ± 12.69^{b}	3330.33 ± 7.42^{b}
CBO 3	1170.00 ± 20.62^{a}	2376.00 ± 7.18^{a}

Note: different notation indicates significantly different values on Duncan's Post Hoc test (5% level)

K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter)

in the oleogel preparation causes the gelato color to become yellowish. Based on the study's results, the greater the percentage of RPO oleogel (increasing percentage of cocoa butter gelator concentration and decreasing percentage of RPO) and the smaller the percentage of unsalted butter addition, the more the yellowness index decreased significantly. The ΔE parameter as a whole has a total color difference that is very different because the ΔE value exceeds the value of 3.

Viscosity of Gelato Dough

The viscosity results of gelato dough before and after aging are presented in Table 8.

A comparison of the application of red palm oil oleogel and unsalted butter in gelato has a significantly different effect on the viscosity of gelato dough before and after aging. The difference in viscosity values before and after aging in gelato dough, which increased significantly, shows that aging time can affect viscosity. The results obtained from the viscosity value the more significant the percentage of red palm oil oleogel (the increasing percentage of cocoa butter gelator concentration and the decreasing percentage of red palm oil), and the smaller the percentage of unsalted butter addition, the lower the viscosity value.

The aging time required in making ice cream or gelato is in the range of 4-24 hours. According to Arbuckle (1996), the aging time is usually 24 hours to produce ice cream/gelato with good results. During the aging process, several changes occur such as fat crystallization, fat destabilization, and hydration of proteins and stabilizers. Gelato dough tends to be thicker than ice cream, so the thick dough can limit the mobility of water molecules because the space between particles in the dough is narrower, so less air enters the dough during the agitation process. Viscosity is inversely proportional and has a relationship with overrun, where the higher the viscosity, the lower the gelato overrun so that the gelato melting time will be longer and can also affect the product storage time (Oksilia *et al*., 2012) so this research is in accordance with the literature. According to Goff & Hartel (2013), it is also stated that the overrun value is inversely proportional to the viscosity of the gelato before and after freezing, where the higher the viscosity of the gelato, the lower the percent development. A thick dough makes the cavity where the air is captured during aeration smaller.

Proximate Analysis of Gelato

Proximate analysis included protein content, fat content, water content, ash content, and carbohydrate content, the results of which are presented in Table 9.

According to the results, the comparison of unsalted butter and RPO oleogel application has a significant effect on ash content, protein content, and fat content in gelato. At the same time, it does not affect water content and carbohydrate content.

In the water content results, the greater the percentage of red palm oil oleogel (increasing percentage of cocoa butter gelator concentration and decreasing percentage of RPO) and the smaller the percentage of unsalted butter addition, the lower the water content. This is in accordance with the reference of Padaga & Sawitri (2005), the composition of water in the dough and the final product of ice cream/gelato generally ranges from 56−64%.

In the ash content results, the greater the percentage of red palm oil oleogel (increasing percentage of cocoa butter gelator concentration and decreasing percentage of red palm oil) and the smaller the percentage of unsalted butter addition, the lower the ash content. The ash content of an ingredient can reflect the quality of a food ingredient related to the presence of specific metal contaminants.

Table 9. Proximate gelato analysis test results

Sample	Component (%) wb				
	Water	Ash	Protein	Fat	Carbohydrate by difference
K	56.49 ± 01.31^{a}	1.93 ± 0.02^{a}	6.76 ± 0.07^{a}	4.85 ± 0.01^{a}	29.98 ± 1.32^{b}
CBO 1	56.03 ± 0.96^{a}	2.04 ± 0.03^{c}	7.85 ± 0.03^{b}	4.90 ± 0.12^{a}	29.17 ± 0.93^{ab}
CBO 2	56.00 ± 0.92^{a}	1.97 ± 0.03^{b}	7.94 ± 0.04^{c}	5.07 ± 0.18^{b}	29.01 ± 0.90^{a}
CBO 3	55.97 ± 0.46^{a}	1.92 ± 0.01^{a}	8.05 ± 0.03^{d}	5.08 ± 0.26^{b}	28.98 ± 0.51^{a}

Note: the same notation indicates the same or not significantly different values, while different notation indicates significantly different values on Duncan's Post Hoc test (5% level)

K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter)

In the results of protein content, the greater the percentage of RPO oleogel (increasing percentage of cocoa butter gelator concentration and decreasing percentage of RPO) and the smaller the percentage of unsalted butter addition, the higher the protein content. The most significant protein sources in this gelato research are UHT low-fat milk and skim milk powder. Protein serves to stabilize the fat emulsion after the homogenization process, adds flavor, helps with foaming, and increases and stabilizes the water binding capacity, which affects the viscosity of the gelato and produces a soft and dense gelato texture. The protein content of gelato has already complied with the Indonesian National Standard (SNI) 3713-2020 regarding ice cream, with a minimum protein content of 2.7%.

In the manufacture of ice cream and gelato, fat plays a role in the foaming process related to its ability to trap air. Low-fat content in gelato products will affect the denser texture due to low development and resistance or melting power (Goff & Hartel, 2013). The source of fat used in this gelato-making research is RPO in oleogel preparation with cocoa butter gelator and the addition of unsalted butter. According to Chandra *et al*. (2017), using RPO as a substitute for milk fat (wholly or partially) is thought to have a better nutritional effect.

In the fat content results, the greater the percentage of RPO oleogel (increasing percentage of cocoa butter gelator concentration and decreasing percentage of RPO) and the smaller the percentage of unsalted butter addition, the higher the fat content. The standard ratio of gelato fat content, according to Goff & Hartel (2013) is 4−8%. Then, when compared to the Indonesian National Standard (SNI) 3713-2020 regarding ice cream, the minimum fat content is 5%. This indicates that the resultant product from this study is appropriate and meets the requirements.

Carbohydrate content testing with the by-difference method is done through calculation analysis based on moisture, ash, fat, and protein content contained in gelato so that these four components influence carbohydrate content.

Total Solids Content of Gelato

The results of the gelato total solids analysis are presented in Table 10.

Table 10. Total Solids Content of Gelato

Sample	Total Solids (%)
K	43.51 ± 1.31^{a}
CBO 1	43.97 ± 0.96^{a}
CBO 2	44.00 ± 0.92^{a}
CBO 3	44.03 ± 0.46^{a}

Note: the same notation indicates the same or no different value significant on Duncan's Post Hoc test (5% level)

K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter)

Each gelato sample used the same ingredients and formulation percentage. This makes the comparison of the application of unsalted butter and red palm oil oleogel in gelato does not cause changes or make a significant difference to the total solids of gelato. According to Muse & Hartel (2004), the total solids content in ice cream/gelato is all the constituent components of ice cream/gelato except water content, which includes total solids are, carbohydrates, fats, proteins, vitamins, and minerals. In addition, the value of total solids produced already complied with the Indonesian National Standard 3713:2020 regarding ice cream with a minimum of 31%.

Beta-carotene Content of Gelato

The beta-carotene content of the gelato is presented in Table 11.

Table 11. Beta-carotene content of gelato

Sample	Beta-carotene content (ppm)
K	- (not detected)
CBO 1	20.67 ± 0.19[d]
CBO 2	19.33 ± 0.47[c]
CBO 3	16.68 ± 0.95[b]

Note: different notation indicates significantly different values on Duncan's Post Hoc test (5% level)

K: control (without oleogel + 5% unsalted butter); CBO 1: (2.1% oleogel with 5% cocoa butter gelator + 2.9% unsalted butter); CBO 2: (2.2% oleogel with 10% cocoa butter gelator + 2.8% unsalted butter); CBO 3: (2.3% oleogel with 15% cocoa butter gelator + 2.7% unsalted butter)

Comparison of RPO β-carotene content with those already in gelato form is classified as good carotene retention during processing (pasteurization, homogenization, aging, agitation, and cooling). Physically, the presence of carotene in gelato is indicated by the color of the gelato, which leads to yellow to orange. The carotenoid pigments in gelato cause fat to take on color, as carotene is fat-soluble. In this study, the assumption of 1 serving of gelato is 100 g. Of the three treatment samples, CBO1 has the highest β-carotene content of 20.67 ppm which is equivalent to 20.67 µg/g, so that in 100 g there are 2067 µg in one serving of gelato or equivalent to 2.0670 mg β-carotene. If it is related to the BPOM regulation (2016), which is in accordance with the Decree of the Indonesian Minister of Health No. 28 of 2019, one day to fulfill the recommended daily intake of vitamin A for the general public is 3.6 mg of β-carotene. Consumption of one serving of gelato can fulfill the daily intake of vitamin A coupled with the consumption of other sources of vitamin A such as fruits and vegetables. In addition, gelato in this study can be claimed as a food product that is high/rich in β-carotene because it meets more than 30% ALG, namely 46.33-57.42% per 100 g of product in solid form.

The β-carotene content found in gelato is related to the oil loss found in each variation of oleogel added. CB5% added to CBO 1 has a low oil loss compared to CB10% and CB15% added to CBO 2 and CBO 3 so that the oleogel in CBO 1 can trap/bind oil well and protect so that the retention of β-carotene in the product is high compared to CBO 2 and CBO 3. If the resulting oil loss value is high, the oil released from the oleogel is so much that the influence of temperature cannot protect it and causes damage to β-carotene. This is in accordance with the statement of Azarine (2019), which states that low β-carotene levels can also be caused by damage during the processing process, where beta-carotene can be degraded at high temperatures and oxidation.

CONCLUSION

Comparison of the application of unsalted butter and red palm oil oleogel with cocoa butter gelator resulted in significant differences ($p<0.05$) in physical parameters (overrun, melting time, texture which includes hardness and chewiness, viscosity before and after aging, and color in L* and b* parameters). Meanwhile, the chemical characteristics had significant differences ($p<0.05$) in ash content, protein content, fat content, and β-carotene content.

The best gelato formulation percentage was CBO 1 with a percentage ratio of using 2.1% oleogel (5% cocoa butter gelator) and 2.9% unsalted butter, because the results regarding physical and chemical characteristics were almost close to the control, and there were values from the test results that exceeded higher.

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