jffn Journal of Functional Food and Nutraceutical

CANDLENUT MILK AND CREAM APPLICATION FOR NON-DAIRY ICE CREAM WITH HIGHER POLYUNSATURATED FATTY ACID

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ABSTRACT

Lower ability to digest lactose limits the consumption of dairy products for children and teenagers. Candlenut is a known source of polyunsaturated fatty acid that can be processed into candlenut milk and cream as an alternative ingredient in the production of non-dairy food products, such as candlenut ice cream. However, the application of candlenut to the food products requires some optimizations. This research aimed to explore the optimized formula and overcome the limitations in nutritional requirement, sensory acceptance, and saponin content. Compared to dairy products, the utilization of candlenut will result in undesirable texture due to its unsaturated fatty acid content. The addition of stabilizer was able to improve the texture and was comparable to the dairy ice cream. The formulation was optimized by Design Expert software, resulted in selected formula using 49.7% candlenut cream, 29.8% of candlenut milk, 19.9% of sugar, and 0.55% stabilizer which had score 7.07±1.3 ("like moderately") of the overall acceptance by hedonic test. The iodine value of the candlenut ice cream was higher (21.56 ± 0.60) compared to dairy ice cream (4.89 ± 0.13). The selected formula of candlenut ice cream also passed the Indonesian National Standard (SNI) in fat, sugar, protein content, total soluble solid and total plate count spoilage aspects. The saponin content (49.34 ± 0.23) was also in the range of daily intake limit.

Keywords: candlenut; ice cream; unsaturated fatty acid

ABSTRAK

Laktosa intoleran membatasi asupan produk laktosa pada anak-anak dan remaja. Kemiri diketahui sebagai sumber asam lemak tak jenuh ganda yang berpotensi untuk diolah menjadi susu dan krim kemiri sebagai bahan baku alternatif untuk memproduksi produk pangan bebas laktosa seperti es krim kemiri. Namun, pengolahan kemiri menjadi produk pangan memerlukan penyesuaian. Penelitian ini bertujuan untuk mengeksplorasi formula optimal dan mengatasi keterbatasan akan kebutuhan nutrisi, penerimaan sensorik, dan kandungan saponin. Jika dibandingkan dengan produk berbahan dasar laktosa, pemanfaatan kemiri akan menghasilkan tekstur yang tidak diinginkan karena kandungan asam lemak tak jenuhnya. Penambahan stabilizer dapat membantu memperbaiki tekstur yang sebanding dengan es krim laktosa. Formulasi dioptimasi dengan software Design Expert, menghasilkan formula terpilih dari 49,7% krim kemiri, 29,8% susu kemiri, 19,9% gula, dan 0,55% stabilizer dengan skor penerimaan keseluruhan 7,07±1,3 "Suka" pada tes kesukaan. Nilai iodin es krim kemiri lebih tinggi (21,56±0,60) dibandingkan dengan es krim laktosa (4,89±0,13). Formula es krim kemiri yang terpilih sesuai dengan Standar Nasional Indonesia (SNI) dalam aspek lemak, gula, kadar protein, total padatan terlarut, dan angka lempeng total. Kandungan saponin (49,34±0,23) juga berada dalam batasan asupan harian.

Kata kunci: asam lemak tak jenuh; es krim; kemiri

Article Information

Article Type: Research Article
Journal Type: Open Access
Volume: 3 Issue 1

Manuscript ID
V3n1808-1

Received Date
26 July 2021

Accepted Date
29 August 2021

Published Date
31 August 2021

DOI: 10.33555/jffn.v3i1.77

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Citation:
Wijaya, H., Fortunata, S. A., Rahmawati, D. 2021. Candlenut milk and cream application for non-dairy ice cream with higher polyunsaturated fatty acid. J. Functional Food & Nutraceutical, 3(1), pp.39-50

INTRODUCTION

Around 70% of children and teenagers around the world were shown to suffer from lactose indigestion or intolerance due to the depleting amount of lactase enzymes. The decrease of lactase activity is directly proportional to age, as the decrease of lactase activity starts at an early age of 2-3 years old (Sitepu et al., 2020; Hegar and Widodo, 2015). This population usually suffers adverse effects upon dairy product consumption and calls for alternative ingredients to enjoy food products that are commonly made from milk.

Candlenut is known as a spice with high fat content and has a potential to be processed into a plant-based milk and cream. Candlenut has also been studied for its high proportion of polyunsaturated fatty acid (PUFA), namely linolenic acid, linoleic acid, and oleic acid, which are known to have many beneficial effects in health. The risk of cardiovascular diseases could be decreased by the substitution of dietary saturated fats with polyunsaturated fat. The greater the reduction in saturated fat will reduce greater risk of cardiovascular diseases (Hooper et al., 2020). In addition to its fat content and profile, high availability of candlenut in Indonesia may also support its utilisation as non-dairy ingredients for animal milk and cream replacement in Indonesia. Predominantly grown in East Nusa Tenggara, South Sulawesi, Aceh and North Sumatera, candlenut production reaches 100.6 tons from 214.1 thousand hectare of candlenut plantation area in 2014 (Badan Pusat Statistik, 2020).

Despite the health benefits and potential production, candlenut oil is also shown to have weak stability in high temperature processing and give off flavor (rancid) to the end product. The phytochemical content also gives a distinct musty and bitter taste that may become challenging in its application to food with subtle flavor (Rasid et al., 2019). The low temperature processing in ice cream production and storage provide conditions to avoid the rancid flavor formation. Wide range of flavoring applications are also very common in ice cream and might help to overcome the unpleasant characteristics brought by candlenut phytochemical content. The application of additives such as stabilizer may also be applied for texture improvement of the resulting ice cream. While low temperature processing and additive application may support candlenut as a promising alternative ingredient in the production of non-dairy ice cream, it is important to also study the resulting ice cream quality especially for its compliance to the commercial standard such as, Indonesian National Standard (SNI) of dairy ice cream.

MATERIALS AND METHOD

Materials and equipment

The candlenut kernels were purchased from a local market in South Tangerang. For candlenut ice cream production, food grade mineral water, sugar, salt, CMC, and xanthan gum were used. Reagents used for analysis were potassium iodide (KI), hydrochloric acid (HCl), sodium hydroxide (NaOH), potassium dichromate ($K_2Cr_2O_7$), chloroform, sodium thiosulfate ($Na_2S_2O_3$), Bromocresol Green Methyl Red indicator soluble starch, Wijs solution, plate count agar and saline solution (NaCl 0.85%). All reagents were analytical grade and obtained from Merck (Germany).

Equipment used in candlenut processing include food processor (Mitzui, Korea), cheesecloth, water bath with hotplate (Benstead Thermolyne CIMAREC, USA) rotary evaporator (IKA, China) and ice cream maker (Cuisinart, USA), viscometer (Brookfield, USA), refractometer (ATAGO, Japan) Biosafety cabinet (ESCO, USA), hotplate (CIMAREC, USA), autoclave (HIRAYAMA, Japan), incubator (Memmert 100-800, Germany) and micropipette (Eppendorf, Germany).

Candlenut milk and cream production

Washed candlenut kernels were soaked in room temperature water (25ºC) for 1 hour, and drained afterward. The candlenut kernels were blended into the food processor with ration 125 g per 1000 ml mineral water for 3 minutes until homogenized to produce candlenut puree. The candlenut puree was filtered with cheesecloth to remove the solid particle, yielding the liquid part of the candlenut milk. To improve the stability of the candlenut milk, 6 grams of soy lecithin was added per liter and blended for 2 minutes. All the process was done at room temperature. The resulting candlenut milk was further pasteurized in a hot water bath at 60 °C for 30 minutes. The pasteurized candlenut milk was evaporated at 60 °C, 150 rpm using vacuum evaporator to reach fat content above 35% (Australian New Zealand Food Standards Code, 2016), to produce candlenut heavy cream.

Candlenut ice cream formulation

Two ice cream controls were made according to ice cream machine guidelines (CuisinArt Recipe Booklet) for simple ice cream of 250 grams of heavy cream, 150 grams of whole milk, 100 grams of granulated sugar, and a pinch of salt. The first control was using cow milk and cream while the second control was using candlenut milk and cream. Design expert is used for the formulation of candlenut ice cream using candlenut milk and cream and also stabilizer (CMC and xanthan gum). The ice cream mixtures were mixed randomly using spatula for 3 minutes and pre-cool at 2-5 °C for 120 min prior to cold mixing in the ice cream machine for 60 minute and then stored at -20°C for 24 hour. Formula variation was designed using lower and upper limits of four ingredients shown in Table 1 and randomization using Design Expert software (v 9.0). Each formula was observed in response to viscosity of the pre-cooled mixture, the meltdown rate of the ice cream, and cost of ingredients. Formula is selected based on its proximity to the first control. And the impact of stabilizer addition is observed in comparison to the second control. The minimum level and maximum level of sugar quantity were 95.8 grams and 100.0 grams. The xanthan gum was considered 2.0 grams as the minimum level and 4.0 grams as the maximum level.

Table 1. Lower and upper limit of ice cream ingredients

Ingredients	Minimum level (gr)	Maximum level (gr)
Candlenut Cream	248.5	252.2
Candlenut Milk	148.5	150.0
Sugar (SNI 01-3713-1995)	95.8	100.0
Xanthan Gum (Naresh and Shailaja, 2006)	2.0	4.0

Physical properties analysis

Viscosity analysis

For the ice cream mixture viscosity analysis, 200 ml of samples were transferred into a beaker glass. The spindle of the viscometer was adjusted inside the beaker until the sample surface reached the designated level which was marked in the spindle rod. The viscometer was turned on and the speed adjusted to 50 rpm. Viscosity of the sample was displayed on the screen of the viscometer.

Overrun analysis (Marshall et al. 2003)

Candlenut ice cream mixture was measured in the beaker glass before inserting it into the ice cream maker. After the candlenut ice cream was frozen in ice cream maker for 30 minutes, the ice cream was measured again in beaker glass before it was stored in the chest freezer. The overrun of candlenut ice cream was calculated with the following formula:

$$\%\ overrun = \frac{volume\ of\ ice\ cream - volume\ of\ mixture\ used}{volume\ of\ mixture\ used}\ x\ 100\%$$

Meltdown rate analysis (Alamprese et al., 2002)

To analyze the meltdown rate of candlenut ice cream, 50 grams of candlenut ice cream was weighed using digital balance. Candlenut ice cream sample that was stored in the chest freezer with the temperature of -20°C was thawed until it reached -15°C on the surface. The thawed samples were put in the sieve and let it melt at room temperature (25°C). The melted candlenut ice cream was held in the beaker glass and weighed every 5 minutes using a digital balance for about 60 minutes (1 hour). The meltdown rate was calculated:

$$\%\ meltdown = \frac{weight\ of\ melted\ sample}{weight\ of\ sample}\ x\ 100\%$$

Total soluble solid analysis (AOAC, 2005)

From meltdown rate analysis, the melted ice cream was collected and used to analyze the total soluble solid. The total soluble solid analysis was using a pocket refractometer at room temperature (25ºC). Refractometer was calibrated using pure water and cleaned before usage. Two drops of sample were applied in the glass of the refractometer and the "start" button was pressed. The result of total soluble solid analysis was displayed on the screen of the refractometer (in ºBrix).

Chemical properties analysis

Moisture content analysis (SNI 01-2891-1992)

One gram of the sample was weighed and dried in the oven at 105°C for 8 hours. The weight was measured periodically and the analysis stopped when constant weight was achieved. The moisture content was then calculated using this formula:

$$\%\ moisture\ content = \frac{weight\ of\ sample\ (fresh - dried)}{weight\ of\ fresh\ sample}\ x\ 100\%$$

Total ash content analysis (sni 01-2891-1992)

Porcelain crucible was dried in the oven at 105°C for 2 hours. After 2 hours of drying, the dried porcelain crucible was transferred into a desiccator for 30 minutes. The sample as much as 1 g was weighed and added into the dried porcelain crucible. The crucible was then put into a 600°C furnace. The sample was heated with a furnace for 12 hours or until the white ashes were produced and no smoke was emitted. The crucible then moved into a desiccator for another 30 minutes. The ash was weighed and calculated with the following formula:

$$\%\ ash\ content = \frac{weight\ of\ ash}{weight\ of\ sample}\ x\ 100\%$$

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$$\%\ ash\ content = \frac{weight\ of\ ash}{weight\ of\ sample}\ x\ 100\%$$

Protein content analysis (SNI 01-2891-1992)

In the protein content analysis, 0.25 grams of sample was weighed and mixed in a 100 ml Kjeldahl flask. 0.25 grams of selenium and 3 ml of concentrated H_2SO_4 was added to the flask. The prepared sample in the flask was boiled for 60 minutes until it became clear. Twenty ml NaOH 40% and 50 ml of aquadest were added to the flask once the sample was cooled down and distilled. The distilled sample was added with 10 ml of H_3BO_3 2% in Erlenmeyer flask and mixed with 2 drops of Bromocresol Green Methyl Red indicator. The distillation was stopped when the sample condensed to 10 ml and indicated with green bluish color. The product was titrated with 0.1 N HCl until the color of the sample became pink. A blank sample was also made the same way as the procedure above. The result was calculated using the formula:

$$\%\ N = \frac{(S - B) x\ N\ HCl\ x\ 14}{w\ x\ 1000}\ x\ 100\%$$

Where:

S = Volume for sample (ml)

B = Volume for blank (ml)

N = HCl Normality

14 = Relative mass of nitrogen atom

w = Sample weight (g)

Crude fat content analysis (SNI 01-2891-1992)

In the analysis of crude fat content, 2 grams of sample were weighed and spread over on top cotton and filter paper. The sample was rolled into a thimble shape and drubbed in an oven at 80°C for about an hour. The dried sample was put in a Soxhlet apparatus that has been connected with fat flasks containing boiling stones that already dried with known weight. The sample then extracted over 6 hours using 150 ml hexane. The hexane was distilled and the fat extract was dried in the oven at 100°C for an hour. The extract was cooled down and weighed. The fat content was calculated by using the following formula:

$$\%\ fat\ content = \frac{weight\ of\ extracted\ fat - weight\ of\ empty\ flask}{weight\ of\ sample}\ x\ 100\%$$

Carbohydrate analysis (SNI 01-2891-1992)

Carbohydrates in the sample were calculated by the weight differences of sample and other constituents. The constituents of the sample were water, ash, protein, fat and fibre. Carbohydrate content was calculated with the following formula:

$$\%\ carbohydrate = 100\% - (\%water + \%ash + \%protein + \%fat + \%fibre)$$

Iodine value (Council of Europe, 2004)

The Iodine value of an ice cream was measured by titration. Two grams of ice cream sample was weighed in the Erlenmeyer flask. Chloroform as much as 15 ml was added into the flask and shaken vigorously. The flask was added with 10 ml of Wijs solution and mixed until homogeneous. The mixture was stored in dark condition for 30 minutes. After 30 minutes, the mixture was added with 10 ml of 10% Potassium Iodide solution and shaken vigorously. The flask then was added with 100 ml Aquadest and homogenized. The sample were titrated with 0.1 N Sodium Thiosulphate until the yellow color was almost faded. After that, 5 ml of 1% starch were added to the mixture and shaken vigorously. The sample were titrated again until the blue color disappeared. The iodine value was calculated by using the following formula:

$$Iodine\ Value = \frac{(Black\ Titration\ Volume - Test\ Titration\ Volume)\ x\ 1.269}{Weight\ of\ sample}$$

Unsaturated fatty acid (Omega-3, Omega-6 and Omega-9) analysis (Pontoh, 2016)

The unsaturated fatty acid content (omega-3, omega-6 and omega-9) of formulated candlenut ice cream was analyzed using a gas chromatography using 30 m x 0.25 mm column (ID 0.25 µm), oven temperature gradient of 170 - 225 °C (1 °C/min), injection temperature 250 °C. The omega-3, -6, and -9 fatty acids quantitative determination were detected using FID with a helium gas carrier.

Quantitative analysis of saponin compound (SNI 01-3555-1998)

Two grams of sample were weighed and transferred into an Erlenmeyer flask. The sample was added with 25 ml KOH alcohol 0.5 M. The mixture was heated for 1 hour. After that, the sample was added with 1 ml phenolphthalein 0.5 M and mixed vigorously. The sample was titrated with HCl 0.5 N until the solution became colorless. The Blank sample was prepared without sample addition and titrated as the procedure above. The saponin content were calculated using the following formula:

$$Saponin\ Content = \frac{56.1\ x\ HCl\ normality\ x\ (black\ titration\ volume - test\ titration\ volume)}{weight\ of\ sample}$$

Microbial analysis

Total plate count analysis was conducted by using Plate Count Agar (PCA) as a media. The saline solution was made by mixing 4.25 gram of sodium chloride (NaCl) with 500 ml of distilled water. For media preparation, 18 grams of PCA powder was weighed and mixed with 800 ml distilled water in hot temperature until boiled. Both of the saline solution and media were sterilized in autoclave at 121°C for 30 minutes.

For the sample preparation, 1 ml of candlenut ice cream sample was taken and diluted in 9 ml saline solution (1:10). Series of dilutions were made into ratio 1:100, 1:1000, 1:10000, and 1:100000 from the 1:10 dilution sample. One ml of each sample from different dilutions was transferred into petri dishes and added by 20 ml of PCA agar. The samples were incubated at 37^{o}C for 48 hours inside an incubator.

Sensory analysis

The hedonic 9-point scale was used for affective testing with texture, taste, bitterness, and overall acceptance as the sensory attributes that should be evaluated. The samples were 3 different candlenut ice cream formulas which were optimized by Design Expert (v 9.0). Thirty untrained panelists were asked to score the products using numeric scores ranging from 1 until 9 (1 represented “dislike very much” and 9 represented “like extremely”). The samples were coded with 3-digit random code. The sample was prepared by weighing 20 grams of sample from each formula and served in a coded ice cream cup. The results were analyzed statistically using Friedman’s Test, and continued with Wilcoxon’s Test if there was a significant difference.

RESULTS AND DISCUSSION

The candlenut milk that underwent fat content analysis resulted in ±1000 grams of candlenut milk containing ± 78.75 grams of fat or 7.875% fat. Based on Australian New Zealand Food Standards Code (2016), the fat content of heavy cream should be 35%. To produce a candlenut cream which contained 35% fat, the candlenut milk was evaporated by a vacuum rotary evaporator until it reached the desirable fat content. Candlenut milk and cream only are not able to build ice cream texture as shown by significantly lower viscosity of candlenut ice cream without stabilizer (1,393.33±71.47 cP) in comparison to dairy ice cream (4,358.33±151.18 cP). The resulting ice cream also differs in the creaminess and crystal formation. The application of stabilizer is deemed necessary in the texture improvement of the resulting candlenut ice cream. (Goff & Hartel, 2013). As shown in Table 2, the application of CMC and xanthan gum were able to increase the pre-cooled mixture to a similar level of dairy ice cream. Nevertheless both stabilizers gave different impacts to the ice cream meltdown rate. CMC application increases meltdown rate up to 89.69 % and very hard texture of the candlenut ice cream. Xanthan gum increases meltdown rate only up to 57.40% in candlenut ice cream which is relatively similar to dairy ice cream of 49.59%. Therefore xanthan gum was chosen as the stabilizer of candlenut ice cream and used in the following ice cream formulation.

Table 2. Viscosity and meltdown rate comparison between stabilizer addition and dairy ice cream

Ice Cream Sample	Stabilizer		Viscosity (cP)	Meltdown Rate (%)
	Type	Quantity (%)		
Candlenut Ice Cream	n/a	n/a	1,393±71.40	n/a
Candlenut Ice Cream	CMC	0.06	4,345±35.36	89.69±1.50 %
Candlenut Ice Cream	Xanthan Gum	0.50	4,300±14.14	49.59±0.77 %
Dairy Ice Cream	n/a	n/a	4,358±151.18	57.40±0.31 %

Ice cream formulation using design expert

Based on the minimum and maximum limit of each ingredient from Table 1, twenty formulas were generated and the viscosity of the ice cream mixture was evaluated in response to the viscosity of pre-cooled mixtures, the meltdown rate of ice cream, and the calculated cost of ingredients (Table 3). The matrix of formula to responses value resulted in the equation as shown in Table 4 that was used for further optimization to target 4,358 cP viscosity and 57.4% meltdown rate. The optimization offered five alternative formulas which had the same responses (viscosity and meltdown rate) as the targeted ice cream (control positive ice cream), as shown in Table 5. Three optimized formulas (formula 1 - 3) with highest desirability (>0.85) were chosen and analyzed

further for its overall acceptance and perceived sensory attributes (Table 6). The panelists were not able to distinguish bitterness attributes between formula 1 and formula 3, as well as color between formula 1 and 2. However, other sensory attributes differences seemed to be significantly different. The candlenut ice cream formula 1, 2 and 3 were accepted over the range 5-7 points (neither like or dislike-like moderately), with formula 2 receiving the highest score for overall and taste acceptance. .

Table 3. Alternative formula provided by Design Expert and its responses

Formula #	Ingredients (%)				Responses		
	Candlenut Cream	Candlenut Milk	Sugar	Stabilizer	Viscosity (cP)	Meltdown Rate (%)	Economical Value (IDR)
1	49.70	29.90	20.00	0.40	2830	61.34	11808.36
2	50.04	30.00	19.16	0.80	5780	54.28	12198.83
3	50.04	30.00	19.16	0.80	5800	54.43	12198.83
4	49.70	29.85	19.65	0.80	5820	52.02	12163.59
5	50.44	30.00	19.16	0.40	2720	60.77	11890.63
6	49.90	29.70	20.00	0.40	2790	61.17	11836.19
7	50.17	29.70	19.73	0.40	2800	61.33	11867.10
8	50.07	30.00	19.53	0.40	2640	59.86	11848.27
9	50.34	29.70	19.16	0.80	5900	55.49	12240.57
10	50.34	29.70	19.16	0.80	5780	53.92	12240.57
11	49.70	30.00	19.70	0.60	4780	56.21	11982.90
12	50.02	29.70	19.48	0.80	5810	51.88	12203.93
13	50.44	29.70	19.46	0.40	2600	60.07	11898.02
14	49.70	29.70	20.00	0.60	4800	56.17	11990.29
15	49.70	29.85	19.65	0.80	5820	52.17	12163.59
16	49.90	29.80	19.79	0.50	3130	57.03	11918.39
17	49.70	30.00	19.70	0.60	4760	56.33	11982.90
18	50.24	30.00	19.16	0.60	4720	56.86	12044.73
19	50.44	30.00	19.16	0.40	2760	60.11	11890.63
20	50.16	29.84	19.37	0.63	4980	53.84	12068.94

Physicochemical and microbial analysis of selected formula

The selected formula 2 of candlenut ice cream (Figure 1) was analyzed for its physicochemical characters and microbial count to observe its compatibility with national standard (Table 7). The addition of stabilizer will increase the total soluble solid in ice cream as the stabilizer has the ability to bind water with another compound, such as sucrose (Saati and Sundari, 2009). Therefore, the addition of xanthan gum as stabilizer increased the total soluble solid of ice cream.

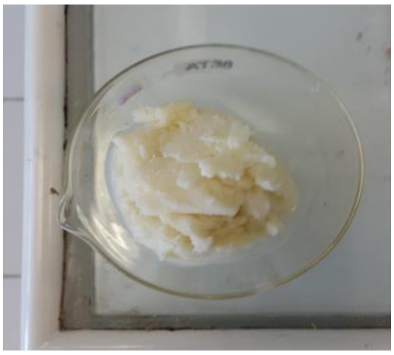

Figure 1. Selected Formula of Candlenut Ice Cream

The overrun measurement of the ice cream was done by calculating the percentage difference of volume of ice cream before and after the freezing process. In the freezing process, there was a mixing process, the air whipped towards the ice cream mixture. By the air movement into the ice cream mixture, the volume of the mixture was expanded from 0 into maximum 100%. In some areas of overrun, it provided a pleasing texture, structure and body to the ice cream. Based on the texture and quality of the ice cream, ice cream with lower quality (economic ice cream) has higher overrun, while high quality ice cream (premium ice cream) will have lower overrun (Hartolo, 2011). The overrun of the control positive ice cream was between 37.53% and 38.05%, and the overrun of the selected formula of candlenut ice cream

Table 4. Equation of Design Expert responses

	Viscosity	Meltdown Rate	Economical Value
Cream	+15,921.29135	+110.71732	+35.000
Milk	+70,082.40957	+451.51694	+8.075
Sugar	+19,935.7397	+144.99509	+13.000
Stabilizer	-1.73656×10^5	+523.26934	+190.000
Cream+ Milk	-298.45259	-1.95963	
Cream+ Sugar	-43.05408	-0.37484	
Cream+ Stabilizer	+360.01920	-1.03134	
Milk+ Sugar	-281.43017	-1.79811	
Milk+ Stabilizer	+113.01462	-2.32099	
Sugar+ Stabilizer	+374.96192	-1.47446	

Table 5. Optimized formula provided by Design Expert

Optimized Formula #	Ingredients (%)				Responses			Desirability
	Candlenut Cream	Candlenut Milk	Sugar	Stabilizer	Viscosity (cP)	Meltdown Rate (%)	Economical Value (Rp)	
1	49.700	29.914	19.836	0.552	4250.00	56.6101	11942.1	0.883948582
2	49.700	29.808	19.942	0.550	4250.00	56.6126	11944.2	0.881706645
3	49.854	29.992	19.602	0.552	4250.00	56.6099	11957.8	0.868173204
4	50.318	29.700	19.428	0.554	4234.25	56.6124	12020.2	0.796302702
5	50.438	29.840	19.160	0.562	4239.73	56.6099	12037.1	0.776290035

Ice cream quality can be determined as bad when the meltdown rate of it was high. Higher meltdown rate means the ice cream can melt easily. The ice cream quality can be determined as undesirable also when the meltdown rate of it was too low, because the texture of the ice cream will be too tough to consume (Hendriani, 2005). The meltdown rate of the selected formula of candlenut ice cream was 57.38±0.52% which was comparable with the control positive ice cream 57.40±0.31%.

Based on the proximate analysis results from Table 7, protein and fat content met the requirement from the National Standard Indonesia (SNI) value. For the total ash, moisture, and carbohydrate, there are no minimum requirements of SNI in the ice cream.

Table 6. Hedonic test result of optimized formula of candlenut ice cream

Sensory Attribute	Formula 1	Formula 2	Formula 3
Texture	6.43±1.30 [a]	7.20±1.19 [b]	6.60±1.10 [c]
Taste	6.40±0.97 [d]	6.60±1.00 [e]	5.93±1.28 [f]
Bitterness	6.50±1.07 [g]	7.00±1.20 [h]	5.83±1.32 [g]
Color	6.70±0.95 [i]	7.10±0.99 [i]	6.43±1.38 [j]
Overall Acceptance	5.63±0.96 [k]	7.07±1.31 [l]	6.70±1.24 [m]

*the hedonic test used 9 point scale for each sensory attribute; 1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4= dislike slightly, 5=neither like or dislike, 6=like slightly, 7=like moderately, 8=like very much, 9=like extremely

Table 7. Physicochemical and microbial analysis of candlenut ice cream

Character	Selected Formula of Candlenut Ice Cream	Dairy Ice Cream	SNI 01-3713-1995
Total Soluble Solid (°Brix)	22.63±0.30	21.45±0.18	Minimum 3.4
Overrun (%)	29.54±0,19	37.79±0.26	n/a
Meltdown Rate (%)	57.38±0.52	57.40±0.31	n/a
Viscosity (cP)	4,273.33±20.21	4,358.33±151.18	n/a
Protein Content (%)	3.48±0.02	n/a	Minimum 2.7
Fat (%)	11.66±0.03	n/a	Minimum 5
Total Ash (%)	0.65±0.02	n/a	n/a
Moisture (%)	63.23±0.04	n/a	n/a
Carbohydrate (%)	21.07±0.12	n/a	n/a
Iodine Value (cg/g)	21.56±0.60	4.89±0.13	n/a
Saponin (mg/g)	49.34±0.23	n/a	Limit 10-200
Total Plate Count (CFU/ml)	4.90 x 10^4	n/a	Maximum 2 x 10^5

The iodine value is a number which represents the amount of iodine in grams consumed by 100 grams of a chemical substance. Normally iodine value is used to determine the degree of unsaturation in fatty acid. In the iodine value analysis, the iodine will react with a double bond chain of unsaturated fatty acid. The higher the iodine value is, the greater the number of double bonds. Therefore, the high iodine values result in more unsaturated fatty acids. (Daun et al., 2011). The iodine value of candlenut ice cream was much higher than the dairy ice cream, which indicated the number of unsaturated fatty acids were also high.

Table 8. Categorization of frozen dessert based on overrun measurement (Marshall et al., 2003)

Product	Overrun (%)
Super premium ice cream	20-40
Premium ice cream	60-75
Ice cream, packaged	75-95
Ice cream, bulk	90-100
Sherbet	30-40
Ice	25-30
Soft ice cream	30-50
Milk shake	10-15

The results of saponin analysis (Table 7) showed the saponin content in the candlenut ice cream was around 49.34 mg/100g of saponin, and in one serving of ice cream (60 g) would contain 29.6 mg of saponin. According to Hosettmann and Marston (2005), the average limit of saponin daily intake for Asian people is 214 mg per person daily. And referring to Arnelia (2002), the recommended daily intake of saponin in food samples was 10-200 mg/100g daily. Thus, the saponin content in the candlenut ice cream was considered safe to be consumed.

The maximum number of total plate count from the SNI is 2.00 x 10^5 CFU/ml. From the results on Table 7, the total plate count of the candlenut ice cream was 4.90 x 10^4 ±0.02 CFU/ml which is below the maximum standard of SNI.

The selected formula of candlenut ice cream was analyzed for the unsaturated fatty acid content, namely omega-3, omega-6, and omega-9. The unsaturated fatty acid content was compared to the unsaturated fatty acid content in the dairy ice cream. The results showed in Table 9**.** All of the omega-3, omega-6, and omega-9, often called triple omega fatty acids, content in the candlenut ice cream showed higher amounts compared to the dairy ice cream. A study done by Elbossaty (2018) found some health benefits of the triple omega fatty acids to the body. The omega-3 is able to reduce cardiovascular disease by keeping blood vessels healthy and reducing the cholesterol and triglycerides level in the body. Rheumatoid arthritis and cancer prevention also can be triggered by omega-3. The omega-6 helps to reduce the development of diabetes type 2 and a good treatment to allergy and sclerosis. The omega-9 is able to reduce bad cholesterol (LDL) and increase good cholesterol (HDL) in blood vessels, increase immune system, protect nerves, and prevent heart disease. The recommended daily intake of the triple omega fatty acids was < 3gram/daily for omega-3, 12 – 17 gram/daily for the omega-6, and no adequate intake recommendation for the non-essential fatty acids like omega-9 (Robertson, 2020). The omega fatty acids content for one cup serving of ice cream (60 g) were 1,707.66 mg for omega-3, 2,743.29 mg for omega-6, and 1,815.93 mg for omega-9. The candlenut ice cream was able to fulfill the recommended daily intake for the omega-3, however for fulfilling the omega-6, additional intake from other food resources might be needed.

Table 9. Unsaturated fatty acid composition in the candlenut and dairy ice cream

Unsaturated Fatty Acid Composition	Selected Formula of Candlenut Ice Cream (mg/100g)	Dairy Ice Cream (mg/100g) (Lukmanto, 2012)
Omega – 3	2,846.10±7.14	13.03
Omega – 6	4,572.15±0.35	21.07
Omega – 9	3,026.55±6.72	1510.91

CONCLUSION

The application of candlenut kernel in ice cream as an alternative ingredient for non-dairy products can be promising. Xanthan gum as a stabilizer can improve the ice cream texture. The candlenut ice cream was also considered as safe to be consumed as the amount of saponin was still in the range of daily intake limit. The amount of polyunsaturated fatty acid in the candlenut ice cream was higher compared to the dairy ice cream. The selected formula of candlenut ice cream (49.85% candlenut cream, 30.00% candlenut milk, 19.60% sugar and 0.55% stabilizer) also had an overall acceptance score of 7.07±1.3 (“like moderately”). The effect of long-term storage by shelf life analysis to the food products can be explored furthermore. Addition of flavours and vitamin fortification are also recommended for further development.

ACKNOWLEDGEMENT

Author would like to thank Maria D.P.T. Gunawan Puteri, M.Sc., Ph.D. for the guidance, including all technical advice and support during the research.

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