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Formulation of Peanut and Red Palm Oil Spread as a Source of Beta-Carotene for Pregnant Women

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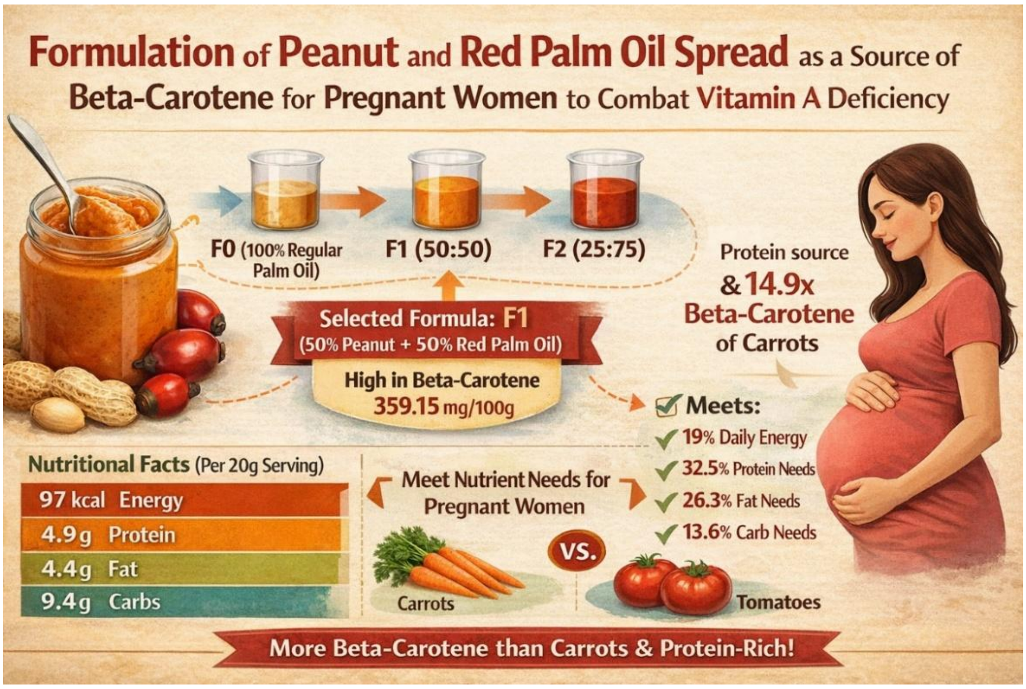
ABSTRACT

Vitamin A deficiency in pregnant women can cause problems in fetal development. The use of red palm oil, which is high in beta-carotene, can be used as a way to overcome vitamin A deficiency. This study aims to formulate peanut and red palm oil-based spread as a healthy food source of beta-carotene. This study used a completely randomized design (CRD) with three treatment levels of regular palm oil and red palm oil, namely F0 (100:0), F1 (50:50), and F2 (25:75) with 2 replications and duplo. Based on the analysis of physical characteristics, organoleptic properties, and nutritional content, the selected formula was F1). The organoleptic test used college students and pregnant women as panelists. One serving (20 g) contains 97 kcal of energy; 4.9 g of protein; 4.4 g of fat; and 9.4 g of carbohydrates, which meets 19.0% of the energy, 32.5% of the protein; 26.3% of the fat; and 13.6% of the carbohydrate requirements for pregnant women. The beta-carotene content of the selected F1 formulation is 359.15 mg/100 g, which is equivalent to 14.9 times that of carrots and 78.9 times that of tomatoes. The selected peanut butter formula meets the nutritional claim of being a protein source and contains beta carotene higher than carrots.

Key Messages:

- More than 19 million pregnant women suffer from vitamin A deficiency due to recurrent infections, increased vitamin A requirements during pregnancy, and inadequate access to and consumption of vitamin A-rich foods
- Red palm oil is known for its very high carotenoid content, which is 15 times higher than carrots and 300 times higher than tomatoes
- Peanut and red palm oil based spread has 14.9 times more beta-carotene than carrots and 78.9 times more than tomatoes

GRAPHICAL ABSTRACT



INTRODUCTION

According to the World Health Organization (WHO), approximately 190 million preschool children and more than 19 million pregnant women suffer from vitamin A deficiency due to recurrent infections, increased nutritional requirements during pregnancy, and inadequate access to and consumption of vitamin A–rich foods (1). In pregnant women, this condition may lead to organ malformations, preterm birth, and an increased risk of infectious diseases in neonates due to low vitamin A stores (2). Since the human body cannot synthesize vitamin A, it must be obtained from dietary sources containing vitamin A or provitamin A carotenoids, particularly beta-carotene, alpha-carotene, and beta-cryptoxanthin (3).

One potential yet underutilized source is red palm oil, which contains exceptionally high levels of carotenoids specially beta carotene, which is up to 15 times higher than carrots and 300 times higher than tomatoes (4). After processing, the remaining total carotenoid content ranges from 500 to 786 ppm, of which approximately 41% is beta-carotene (5), equivalent to 200–300 mg/kg (6). However, carotenoids in red palm oil are susceptible to degradation at high temperatures (7), making it more suitable for applications that do not involve intensive heating (8), such as peanut-based spreads. Peanut butter is a product that contains essential vitamins and minerals needed by the body, including folate, vitamin E, niacin, thiamine (vitamin B1), vitamin B6, riboflavin (vitamin B2), copper, phosphorus, magnesium, iron, potassium, zinc, and calcium (8). The fat content in peanut butter can also aid in the absorption of fat-soluble beta-carotene (9).

Therefore, this study aimed to formulate a peanut- and red palm oil–based spread as a potential functional food source of beta-carotene for pregnant women with vitamin A deficiency.

METHODS

This study employed an experimental design using a Completely Randomized Design (CRD) with three treatments, two replications and duplo. The study was conducted from November 2024 to October 2025. The production process and physical characteristic analyses of the peanut spread were carried out at the Food Experiment Laboratory. Organoleptic testing was conducted at the Sensory Evaluation Laboratory and Ciampea Community Health Center. Proximate and beta-carotene analyses were performed at the Nutrient Analysis Laboratory, Department of Community Nutrition, Faculty of Human Ecology (FEMA), IPB University.

The instruments used in this study were a UV-Vis spectrophotometer for beta-carotene, a DAIHAN digital rotary viscometer (WVS-2M) for viscosity, and an AMTAST AMT511 colorimeter for color. Beta-carotene

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content was analyzed using the UV-Vis spectrophotometry method. First, beta-carotene stock solutions were prepared at concentrations of 0.1 ppm, 0.2 ppm, 0.3 ppm, 0.4 ppm, and 0.5 ppm, and their absorbance was measured using a UV-Vis spectrophotometer at $\lambda = 451.50$ nm to create a calibration curve. The macerated samples of the peanut spread were extracted using a rotary evaporator. The sample extracts were then diluted with ethanol, and their absorbance was measured using a UV-Vis spectrophotometer at $\lambda = 451.50$ nm. Subsequently, a calibration curve was constructed using the resulting concentration values.

Ethical approval was obtained on September 1, 2025, with letter number 1924/IT3.KEPMSM-IPB/SK/2025. The inclusion criteria for research subjects are pregnant women aged ≥18 years with a singleton pregnancy in the second or third trimester (gestational age >14 weeks) who visit the relevant community health center in the study area and have no allergies to nuts (especially peanuts). Subjects meeting the inclusion and exclusion criteria were identified through structured interviews (including a review of the subject's allergy history) and a review of medical records or the KIA booklet. Age and trimester of pregnancy were determined based on the date of the last menstrual period (LMP) or the results of the most recent ultrasound.

The study began with formulation design and optimization through preliminary trials to develop the peanut spread product. The selected formulation was determined based on organoleptic testing, physical characteristics (color and viscosity), and nutritional analyses, including moisture, ash, protein, fat, carbohydrate, and beta-carotene content. The contribution of nutrient intake per serving size from the selected formulation was then calculated based on the Nutritional Label Reference (NLR) for pregnant women.

The experimental design consisted of three treatment levels of regular palm oil and red palm oil ratios: F0 (100:0), F1 (50:50), and F2 (25:75), each with two replications. Data were tabulated using Microsoft Excel 2019 and analyzed using SPSS version 27. Organoleptic data were analyzed descriptively, while organoleptic, physical, and nutritional data were further analyzed using Analysis of Variance (ANOVA) to determine significant differences among treatments. When significant effects were observed ($p < 0.05$), Duncan's multiple range test was applied to identify differences between treatments.

RESULTS

The peanut spread was processed through several stages, including shell removal, roasting, removal of the seed coat, and grinding of peanuts with other ingredients using a food processor for 10 minutes. The ratios of regular palm oil to red palm oil were F0 (100:0), F1 (50:50), and F2 (25:75).

Organoleptic testing is a sensory evaluation method that uses human senses to assess product quality, including appearance (color), aroma, taste, texture, and other relevant attributes (10). The tests conducted included hedonic and hedonic quality tests. A total of 39 panelists participated, consisting of 30 students from IPB University and 9 pregnant women from the Ciampea Community Health Center.

The hedonic test evaluated color, spreadability, aroma, taste, texture, viscosity, mouthfeel, aftertaste, and overall acceptance. The hedonic quality test assessed the intensity of appearance (reddish color), spreadability, characteristic peanut aroma, palm oil aroma, red palm oil aroma, sweetness, peanut flavor, palm oil flavor, red palm oil flavor, texture (smoothness), viscosity, mouthfeel (stickiness), and aftertaste. Organoleptic testing involving pregnant women was limited to the hedonic test to assess product acceptability. The results of the organoleptic evaluation are presented in Table 1.

Table 1. Organoleptic characteristics of peanut spread across formulations

Attribute	**Formula**		
	F0	**F1**	**F2**
Hedonic Test			
Color/Appearance	5.50±2.01 [b]	6.90±1.57 [a]	6.85±1.56 [a]
Spreadability	6.60±2.12 [a]	6.95±1.88 [a]	6.24±1.98 [a]
Aroma	7.16±1.74 [b]	5.68±1.92 [a]	6.28±2.12 [a]
Taste	6.36±2.06 [a]	5.64±1.82 [a]	5.83±1.90 [a]
Texture	6.29±2.26 [a]	6.22±1.96 [a]	6.37±1.94 [a]
Viscosity	5.76±2.58 [a]	6.64±1.88 [a]	5.99±1.82 [a]
Mouthfeel	6.27±2.29 [a]	6.24±1.44 [a]	5.96±2.12 [a]
Aftertaste	6.13±1.76 [a]	5.83±2.05 [a]	5.67±2.19 [a]
Overall acceptance	6.28±2.07 [a]	6.31±1.65 [a]	5.90±1.91 [a]

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Hedonic Quality Test			
Color/Appearance	1.05±1.61[a]	6.03±2.28[b]	6.20±2.61[b]
Spreadability	5.84±2.71[a]	7.11±1.69[b]	6.45±1.98[b]
Peanut Aroma	7.87±1.44[a]	6.75±1.53[b]	6.46±1.83[b]
Palm Oil Aroma	3.01±2.52[a]	6.16±2.11[b]	6.47±2.06[b]
Red Palm Oil Aroma	2.22±2.26[a]	6.61±1.91[b]	7.13±1.92[b]
Sweetness	4.53±2.33[a]	4.78±2.17[a]	4.86±2.21[a]
Peanut Flavor	8.05±1.38[b]	6.92±1.52[a]	6.71±1.51[a]
Regular Palm Oil Flavor	3.52±2.54[a]	6.44±1.73[b]	6.62±1.65[b]
Red Palm Oil Flavor	2.69±2.56[a]	6.84±1.90[b]	6.93±2.04[b]
Texture	6.31±2.50[a]	6.49±1.55[a]	6.31±1.73[a]
Viscosity	6.71±2.18[a]	6.58±1.81[a]	6.97±2.12[a]
Mouthfeel (stickiness)	6.44±1.97[a]	6.39±1.78[a]	6.06±1.96[a]
Aftertaste (bitter)	6.08±1.86[a]	6.64±1.72[a]	6.69±1.81[a]

[1] Note**:** Values with the same superscript letters (a, b) indicate no significant difference at the 5% level according to Duncan's multiple range test.

Organoleptic testing involving pregnant women was limited to a hedonic test to assess product acceptability. The hedonic evaluation used a 5-point Likert scale. This approach was chosen because pregnant women were considered untrained panelists, and a simpler scale facilitates easier assessment. The results of the organoleptic test are presented in Table 2.

Table 2. Hedonic evaluation of peanut spread by pregnant women

Attribut	**Formula**		
	F0	**F1**	**F2**
Hedonic Test			
Color/ Appearance	3.33±1.12[a]	3.67±1.32[a]	3.33±1.58[a]
Spreadability	3.89±1.05[a]	3.78±0.97[a]	3.67±1.12[a]
Aroma	3.67±1.22[a]	3.67±1.22[a]	3.44±1.51[a]
Taste	4.00±1.00[a]	3.89±1.36[a]	3.00±1.58[a]
Texture	3.56±1.13[a]	3.78±0.97[a]	3.67±1.41[a]
Viscosity	3.44±1.24[a]	3.89±1.05[a]	3.67±1.41[a]
Mouthfeel	3.33±1.12[a]	3.67±1.22[a]	3.33±1.21[a]
Aftertaste	3.56±1.13[a]	3.44±1.67[a]	3.33±1.41[a]
Overall acceptance	3.56±1.16[a]	3.60±1.49[a]	3.56±1.45[a]

[1] Note**:** Values with the same superscript letters (a, b) indicate no significant difference at the 5% level based on Duncan's multiple range test.

Nutrient content analysis was conducted on all three formulations of the peanut and red palm oil spread. The analyses included moisture, ash, protein, fat, carbohydrate, and beta-carotene content. The results of the macronutrient analysis are presented in Table 3.

Table 3. Nutrient composition of peanut and red palm oil spread across formulations

Component	**F0**	**F1**	**F2**
Moisture (%)	4.48±0.19[a]	4.34±0.56[a]	4.80±0.59[a]
Ash (%)	2.01±0.03[a]	2.15±0.08[a]	2.13±0.04[a]
Protein (%)	22.76±2.40[a]	25.80±0.68[a]	25.88±2.98[a]
Fat (%)	13.06±1.35[a]	23.07±16.27[a]	12.41±0.54[a]
Carbohydrate (%)	62.15±1.01[a]	48.97±15.52[a]	59.57±2.40[a]
Beta-carotene (mg/100 g)	89.20±0.00[a]	359.15±16.59[b]	464.78±33.20[b]

[1] Note**:** X ± SD represents the mean ± standard deviation of macronutrient content for each formulation. F0: formulation containing 0% red palm oil; F1: formulation containing 50% red palm oil; F2: formulation containing 75% red palm oil. Values with the same superscript letters (a, b) indicate no significant difference at the 5% level based on Duncan's multiple range test.

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As shown in Table 3, altering the ratio of red palm oil did not produce statistically significant differences in the core macronutrient composition across the formulations, including moisture, ash, protein, fat, and carbohydrate content. However, the addition of red palm oil resulted in a significant, proportional increase in beta-carotene. Formulations F1 and F2 demonstrated exponentially higher beta-carotene levels (359.15±16.59 mg/100 g and 464.78±33.20 mg/100 g, respectively) compared to the control formulation F0 (89.20±0.00 mg/100 g), which contained no red palm oil.

The serving size of the peanut spread was set at 20 g, in accordance with the Indonesian Food and Drug Authority Regulation (11) on Nutrition Facts Labeling for processed foods, which specifies a serving size of 10–20 g for purees and spreads made from vegetables, legumes, and seeds. The contribution of nutrient intake from the selected formulation to the Nutritional Label Reference (NLR) for pregnant women is presented below.

Table 4. Nutrient contribution of the selected formulation to NLR for pregnant women

Component	Per 100 g	Per serving (20 g)*	NLR (pregnant women)**	%NLR (pregnant women)
Energy (kcal)	485	97	2510	19
Protein (g)	24.7	4.9	76	32.5
Fat (g)	22.1	4.4	84	26.3
Carbohydrate (g)	46.8	9.4	345	13.6
Beta-carotene (mg/100 g)	359.15	71.83	-	-

[1] Note: Nutritional Label Reference (NLR) for pregnant women follow the Regulation of the Head of the Indonesian Food and Drug Administration No. 9 of 2016 on Nutrition Labeling Guidelines.

Table 4 details the practical nutritional contribution of the optimal formulation (F1) based on a standard 20 g serving size. A single serving provides 97 kcal, meeting 19% of the Nutritional Label Reference (NLR) for pregnant women. Notably, the spread serves as a strong source of macronutrients, fulfilling 32.5% of the daily protein requirement (4.9 g) and 26.3% of the daily fat requirement (4.4 g) per serving. Furthermore, each 20 g serving delivers 71.83 mg of beta-carotene, a substantial amount to help address vitamin A deficiencies

DISCUSSION

Based on the hedonic test results, color acceptance ranged from 5.50–6.90 and was categorized as moderately liked. ANOVA results showed that the addition of red palm oil had a significant effect on color preference ($P<0.05$). Meanwhile, color acceptance among pregnant women ranged from 3.33–3.67 and was also categorized as moderately liked, with no significant effect of red palm oil addition ($P>0.05$). Based on attribute intensity testing, F1, with the highest acceptance, showed a moderately strong reddish color. The reddish color was influenced by the addition of red palm oil, which contains carotene levels 60 times higher than regular palm oil and provides an orange to red color (12).

Spreadability acceptance ranged from 6.24–6.95, with no significant effect of red palm oil addition ($p>0.05$). Among pregnant women, acceptance ranged from 3.67–3.89 and was categorized as moderately liked, also with no significant difference ($P>0.05$). Panellists tended to prefer F1 compared to F0 and F2, likely due to easier spreadability. Spreadability is related to oil content, where low oil content reduces spreadability, while excessive oil results in a more fluid and greasy texture (13).

Aroma acceptance ranged from 5.68–7.16 and was significantly affected by red palm oil addition ($p<0.05$). Among pregnant women, acceptance ranged from 3.44–3.67 and was categorized as moderately liked, with no significant effect ($P>0.05$). Aroma acceptance was highest in F0, characterized by the highest peanut aroma intensity and the lowest intensity of red palm oil and regular palm oil aromas. F1 showed the lowest acceptance, with stronger combined aroma intensities. Red palm oil has a distinct aroma associated with its high carotene content (14).

Taste acceptance ranged from 5.64–6.36, with no significant effect of red palm oil addition ($p>0.05$). However, hedonic quality testing showed a significant effect on all taste attributes except sweetness ($p>0.05$). Among pregnant women, acceptance ranged from 3.00–4.00 and was categorized as moderately liked, with no significant difference ($P>0.05$). F0 had the highest peanut flavor intensity, while F2 had the highest intensity of regular and red palm oil flavors. Red palm oil has a distinctive taste and aroma due to its high carotene content

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(15), while regular palm oil has a weaker taste due to deodorization (16).

Texture acceptance ranged from 6.22–6.37. ANOVA results showed that the addition of red palm oil had no significant effect (p>0.05) on texture acceptance. Meanwhile, texture acceptance among pregnant women ranged from 3.56–3.78 and was categorized as moderately liked, with no significant effect of red palm oil addition (P>0.05). Texture variation in peanut spread is influenced by oil content and grinding process. Oil separation can lead to rapid oxidation, rancidity, and suboptimal texture due to an overly oily surface and hardened bottom layer, whereas minimal separation helps maintain better taste and texture. Therefore, high oil separation is undesirable in spreads (17).

Viscosity acceptance ranged from 5.76–6.64. ANOVA results showed that the addition of red palm oil had no significant effect (p>0.05) on viscosity acceptance. However, acceptance tended to be higher in F1, which had a relatively thick consistency. Among pregnant women, viscosity acceptance ranged from 3.44–3.89 and was categorized as moderately liked, with no significant effect (P>0.05). Viscosity is closely related to texture, spreadability, and mouthfeel (17). Optimal fat content improves spreadability, enhances smoothness, and increases resistance to separation or drying during application (13).

Mouthfeel acceptance ranged from 5.96–6.27. ANOVA results showed that the addition of red palm oil had no significant effect (p>0.05) on mouthfeel acceptance. The highest acceptance was observed in F0, which had the highest slightly sticky mouthfeel intensity. Among pregnant women, acceptance ranged from 3.33–3.67 and was categorized as moderately liked, with no significant effect (P>0.05). Mouthfeel is influenced by oil content, where excessive oil results in a greasy and overly fluid sensation, while low oil content leads to a dry and coarse sensation (16).

Aftertaste acceptance ranged from 5.67–6.13. ANOVA results showed that the addition of red palm oil had no significant effect (p>0.05) on aftertaste acceptance. The highest acceptance was observed in F0, which had the lowest bitter aftertaste. Among pregnant women, acceptance ranged from 3.33–3.56 and was categorized as moderately liked, with no significant effect (P>0.05). Bitter aftertaste may be caused by phenolic compounds in peanut skin (18).

Overall acceptance ranged from 5.90–6.28 and was categorized as moderately liked, with no significant effect of red palm oil addition (p>0.05). Among pregnant women, acceptance ranged from 3.56–3.60 and was also categorized as moderately liked, with no significant effect (P>0.05).

Physical characteristics analysis was conducted on all three formulations of peanut spread, including color and viscosity tests using a colorimeter and a digital rotary viscometer, respectively. Color is defined as the wavelength of visible light (390–760 nm) detectable by the human eye (19). The addition of red palm oil affected L*, a*, and b* values, with b* increasing significantly as the proportion of red palm oil increased. The b* value of F0 differed significantly from F1 and F2, while F1 and F2 did not differ significantly from each other. F0 had the highest L* value, whereas F1 and F2 had higher a* values, indicating stronger reddish and yellowish colors. This is associated with the high carotenoid content of red palm oil, which imparts an orange to red color (12).

Viscosity affects the ability of a material to flow and move across different phases, where materials with lower viscosity flow more easily (20). ANOVA results showed that the addition of red palm oil significantly affected viscosity (p<0.05). Duncan's test indicated that F0, F1, and F2 differed significantly from one another. This difference is associated with the type of oil used, as red palm oil has higher viscosity than regular palm oil (21). F0, which used only regular palm oil, produced a more fluid consistency, whereas F1 and F2, which included red palm oil, produced a thicker consistency (22).

Based on Table 3, ANOVA results showed no significant effect of red palm oil addition (p>0.05) on moisture content. According to SNI 01-2979-1992, the maximum moisture content for peanut spread is 3%bb, and all formulations did not meet this requirement due to the addition of honey. High-moisture ingredients such as honey or corn syrup can increase moisture content and affect taste and viscosity (23). Therefore, it is recommended to replace honey with powdered sugar to reduce the moisture content.

Ash content is related to mineral content (24). The primary contributor to the ash content in peanut butter is the peanut itself. The peanut hull contains high levels of minerals (25). The minerals most abundantly found in peanut hulls are potassium, calcium, magnesium, and phosphorus. In addition, iron, copper, zinc, and manganese are also present as trace minerals (26) The roasting process can alter mineral concentrations, resulting in a significant decrease in calcium and iron. During peanut butter production, the peanut skins are removed (dehulling) to reduce the bitterness of the peanut butter and result in a lower ash content in the product. This aligns

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with previous research indicating that peanut skins contain minerals and that removing them leads to a decrease in ash content in the dehulled peanuts (27).

The main protein source is peanuts, with approximately 27.9 g protein (28). F1 and F2 met the SNI requirement (25%bb), while F0 was slightly lower. The variation is likely due to natural variation in raw materials or component interactions rather than the type of oil used (29). Roasted peanut skin contains approximately 8.88–12.7% protein (26). Protein requirements increase during pregnancy due to increased protein metabolism and the utilization of absorbed amino acids and peptides to support fetal growth and development as well as maternal tissue (30). Protein deficiency in pregnant women during fetal development can affect the structural and functional characteristics of the offspring and increase the risk of chronic diseases (31). Therefore, adequate protein intake is essential for pregnant women.

ANOVA results for fat content showed no significant effect of red palm oil addition ($p > 0.05$) on the fat content of the peanut spread. According to SNI 01-2979-1992, the required fat content for peanut spread is 5–55%bb, and all formulations met this requirement. The fat content was derived from peanuts 43.3 g (32), red palm oil 100 g (33), and regular palm oil 100 g (34). Red palm oil contains higher levels of free fatty acids than regular palm oil. High levels of free fatty acids are precursors to oil deterioration and can accelerate the oxidation process, resulting in color deterioration and causing rancidity (35). Lipid oxidation can significantly affect the taste of peanut butter in two ways. First, during the roasting process, lipids in peanuts can degrade and produce volatile compounds that directly alter the flavor or influence it through the Maillard reaction and Strecker degradation. Second, during storage, lipids undergo oxidation and cause the loss of the desired peanut butter flavor (36). Fat is an important component of a healthy diet during pregnancy. Fats have three main functions: providing energy, aiding in the transport of fat-soluble vitamins (A, D, E, and K), and producing essential fatty acids that the body cannot produce on its own. The fats in peanut butter can aid in the absorption of beta-carotene (37).

Most carbohydrates in the product originated from honey, which mainly consists of fructose and glucose (38). Peanuts, like other legumes, are high in protein but low in carbohydrates (39). The carbohydrates in peanuts include fiber, oligosaccharides, sucrose, raffinose, and stachyose (40). Peanuts are low in sugar and contribute to a low glycemic index and glycemic load (41). The carbohydrate content of peanut butter is calculated using the "by difference" method, which involves subtracting the combined content of other nutrients—namely moisture, ash, protein, and fat—from 100% (42).

ANOVA results for beta-carotene content showed a significant effect of red palm oil addition ($p<0.05$), with Duncan's test indicating significant differences among all formulations ($p<0.05$). Beta-carotene content increased proportionally with the addition of red palm oil, as it contains higher levels than regular palm oil. The beta-carotene content was 89.20 mg/100 g (F0), 359.15 mg/100 g (F1), and 464.78 mg/100 g (F2). Beta-carotene is a carotenoid known as provitamin A and an antioxidant but is not classified as an essential nutrient and is therefore not directly associated with recommended intake values (43). Red palm oil, which contains provitamin A, is obtained by processing crude palm oil without bleaching, resulting in a high natural beta-carotene content. Beta-carotene can prevent blindness caused by xerophthalmia, help prevent cancer, and boost the immune system (44). Additionally, beta-carotene acts as an effective antioxidant even at low oxygen concentrations. As a natural antioxidant, it helps lower blood sugar levels, reduce oxidative stress, inhibit cell proliferation, and lower cholesterol (45). In this study, beta-carotene content was compared with carrot (24.05 mg/100 g) (46) and tomato (4.55 mg/100 g) (47). F0 was 3.7 times higher than carrot and 19.6 times higher than tomato, F1 was 14.9 times higher than carrot and 78.9 times higher than tomato, and F2 was 19.3 times higher than carrot and 102.1 times higher than tomato. Carrot is considered a primary source of beta-carotene (48).

The selection of the optimal formulation was based on using F0 (100:0) as the control. F1 showed organoleptic properties closest to F0, with no significant differences in most attributes, including spreadability, taste, texture, viscosity, mouthfeel, aftertaste, and overall acceptance. F2 was generally less preferred. Based on nutritional content, F1 met the requirements for ash, protein, and fat, whereas F0 did not meet the protein requirement. Therefore, F1 was selected as the optimal formulation.

Based on Table 4, the peanut spread provides 485 kcal (19%), 24.7 g protein (32.5%), 22.1 g total fat (26.3%), and 46.8 g total carbohydrates (13.6%) per 100 g relative to the requirements for pregnant women. To include a product claim, the product must comply with PerBPOM No. 1 of 2022. According to this regulation, a claim is any statement that expresses, suggests, or implies specific characteristics of a food related to its origin, nutritional content, properties, production, processing, composition, or other quality factors. Products may include

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label claims if they meet the required intake criteria per serving.

The peanut spread meets the criteria for a "source of protein" claim, as it provides more than 20% of the Nutritional Label Reference (NLR) per 100 g (32.5%). Furthermore, while beta-carotene does not have an established NLR for a formal nutritional claim, the selected F1 formulation provides a highly concentrated amount of this provitamin A, significantly exceeding the levels found in primary natural sources like carrots, as detailed previously. The peanut and red palm oil spread contains higher beta-carotene than carrot, which is considered a primary source of beta-carotene (48).

Production cost analysis was calculated based on raw material cost (food cost). The food cost per 100 g of the selected formulation was IDR 17.864. The cost structure consists of 40% raw materials, 20% labor, 20% overhead, and 20% profit (34). The estimated selling price was IDR 44.660 per 360 g package, slightly higher than commercial peanut spread priced at IDR 39.000 per 340 g, but with added nutritional value in terms of protein and beta-carotene content. Each package contains approximately 1294,02 mg of beta-carotene, with an estimated cost of IDR 34,47 per mg.

CONCLUSION

Three formulations of peanut spread were developed based on the percentage of red palm oil added: F0 (0%), F1 (50%), and F2 (75%). Based on organoleptic evaluation and nutrient analysis, F1 was selected as the optimal formulation. It has a relatively bright color with reddish and yellowish tones and a very thick consistency. The selected F1 formulation yields an actual beta-carotene content of 359.15 mg/100 g, making this peanut and red palm oil spread a highly concentrated provitamin A source that significantly exceeds the levels found in primary natural sources like carrots and tomato.The product qualifies for a "source of protein" claim and contains higher beta-carotene than carrot.

The peanut and red palm oil spread had moisture content exceeding the SNI standard. Therefore, future studies are recommended to replace honey with powdered sugar. If developed as a commercial product, packaging in single-use stick form is suggested, as beta-carotene is prone to oxidation and single-serving packaging may help maintain product quality.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest associated with this study.

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