Formulation and Acceptability of Spinach Pudding Sponge Cake as an Alternative Iron-Source Snack for Adults

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Abstract.
Spinach leaves are a food ingredient with potential for snack product development because they contain various nutrients, particularly iron. This study aimed to determine the nutritional content and acceptability of a green spinach leaf pudding sponge cake as an alternative snack for adults. An experimental study was conducted at the Laboratory of the Faculty of Psychology and Health, UIN Sunan Ampel Surabaya. Acceptability was assessed by 30 untrained panelists using a seven-point hedonic scale covering color, aroma, taste, texture, and overall acceptance. Nutritional content was estimated from the composition of the ingredients used, and differences in organoleptic scores were analyzed using the Wilcoxon test. The spinach product contained 196.08 kcal of energy, 4.02 g of protein, 29.66 g of carbohydrate, 0.36 g of fiber, and 0.41 mg of iron per piece. A significant difference was found in taste ($p = 0.031$), whereas color, aroma, texture, and overall acceptance did not differ significantly. However, the calculated iron content of both products was identical. Therefore, further development of this product requires re-verification of the nutrient calculations and laboratory analysis to confirm its iron content.
Keywords: *Acceptability, adults, iron, spinach.*

1. INTRODUCTION

Meeting essential micronutrient requirements in adults is often hindered by shifts toward a modern lifestyle and a tendency toward less diverse food consumption [1]. One of the critical nutritional problems that remains prevalent is iron deficiency, which can lead to hypochromic microcytic anemia [2]. Physiologically, iron (Fe) is a vital cofactor in hemoglobin synthesis, supporting optimal oxygen transport and cellular energy metabolism [3]. At the population level, this micronutrient deficiency directly contributes to reduced cognitive performance, chronic fatigue, and decreased work capacity [4]. Therefore, appropriate nutritional interventions are needed to maintain the daily productivity of the adult population.

In productive adults, high metabolic demands and physical activity require a consistent daily iron intake [5]. In particular, women of reproductive age experience periodic blood loss due to menstruation, which increases their risk of iron deficiency. A persistent decline in iron levels can suppress cellular immune function and reduce the body's resistance to disease [6]. Furthermore, inadequate intake of this micronutrient negatively affects long-term quality of life and physical fitness [7]. Fortification and nutrient enrichment strategies based on local food ingredients are therefore highly strategic promotive approaches.

Spinach leaves are a plant matrix with high potential as a source of non-heme iron [8]. This green leafy vegetable contains considerable amounts of iron, folic acid, and antioxidants, and it is widely available [8]. However, spinach naturally contains volatile compounds that produce a grassy off-flavor, as well as an astringent taste due to the presence of oxalate [9]. These sensory limitations often restrict its acceptability and direct consumption among adults [2]. Product development therefore requires a carrier matrix that can retain nutrients while optimizing the sensory profile of spinach to make it more appealing.

Processing spinach into an extract or puree for use in a sponge cake formulation is considered effective in overcoming these sensory barriers [10]. Sponge cake offers a porous and soft texture, high

palatability, and the ability to bind aroma [11]. Incorporating spinach leaves into a pudding sponge cake not only masks the characteristic taste of spinach but also produces an attractive snack with a dual texture [12]. The natural chlorophyll pigment of spinach also provides a green color that can enhance the visual appeal of the product [13]. This combination is expected to improve consumer acceptance of snack products based on functional vegetables.

Iron is required for the formation of hemoglobin in red blood cells, which transports oxygen throughout the body. Inadequate iron intake can lead to iron deficiency and eventually anemia, characterized by fatigue, reduced concentration, and a decreased ability to perform daily activities [14]. The iron in spinach is non-heme iron, whose absorption is influenced by other dietary components consumed at the same time: vitamin C enhances its absorption, whereas compounds such as oxalate and phytate reduce its bioavailability. Consequently, the use of spinach in food products should consider not only the amount added but also the processing method and the nutrient content of the final product, because the addition of spinach can diversify nutrient intake but does not automatically ensure that daily iron requirements are met [15].

Formulation determines the type and quantity of ingredients used to obtain a food product with the intended characteristics, including taste, aroma, color, texture, and nutrient content. Sponge cake has a soft and porous texture formed through whipping and mixing, which incorporate air into the batter. Whipping the egg whites is a critical step because the resulting foam supports cake expansion; therefore, mixing must be performed gently to preserve the foam structure and the texture of the cake [16]. In this study, the sponge cake was combined with a pudding layer to produce a snack with contrasting textures, and spinach extract was added to the pudding layer to provide a natural green color and diversify the nutrient content. Nevertheless, spinach extract may also alter the aroma, taste, and texture of the product. In addition, nutrient values estimated from food composition data are approximations that may differ from those obtained through direct laboratory analysis of the finished product.

Acceptability testing of color, aroma, taste, and texture is an essential instrument for verifying the acceptability of a product [17]. Because consumer acceptance depends not only on nutritional content but also on sensory attributes, sensory evaluation is a key step in new product development [18]. Organoleptic testing ensures that the developed formulation is not only nutritious but also acceptable to adult consumers. Such food diversification innovations are expected to provide a practical alternative for meeting daily iron requirements, and pudding sponge cake has strong potential to be developed as a marketable and competitive healthy snack. Previous studies have addressed iron requirements, the use of green vegetables in food products, and organoleptic testing separately. The present study combines the formulation of a spinach pudding sponge cake with acceptability testing and nutrient calculation. It was hypothesized that adding spinach leaves to the pudding sponge cake formulation would affect panelists' preference for color, aroma, taste, texture, and overall acceptance, as well as the estimated nutrient composition of the product. Accordingly, this study aimed to develop the formulation and to analyze the acceptability, through organoleptic testing, and the nutrient content of a pudding sponge cake with added spinach leaves as an alternative iron-source snack for adults.

II. METHODS

This study employed an experimental design to develop a pudding sponge cake with added green spinach leaves and to determine its acceptability and nutrient content, the latter being calculated using NutriSurvey. The study was conducted at the Laboratory of the Faculty of Psychology and Health, UIN Sunan Ampel Surabaya. Spinach leaves were used as an additional ingredient because they contain nutrients such as vitamin A, vitamin C, iron (Fe), and several other minerals. Their addition was expected to add value to the product in terms of both nutrient content and product characteristics, providing a natural green color and influencing the aroma, taste, and texture of the

product. Two products were prepared: a green (control) pudding sponge cake and a green spinach leaf pudding sponge cake. The equipment used included a blender, sieve, mixer, spatula, baking pan, steamer or oven, saucepan, stove, tablespoons, and teaspoons. The ingredients consisted of spinach leaves and other ingredients according to the predetermined formulation.

Data collection and measurement

Two samples, the control pudding sponge cake and the green spinach leaf pudding sponge cake, were evaluated by 30 untrained panelists. Each sample was served in a prepared container labeled with a code to ensure objective assessment. Panelists tasted each sample and rated its color, aroma, taste, texture, and overall acceptance on a test sheet using a seven-point hedonic scale (1 = dislike very much, 2 = dislike, 3 = dislike slightly, 4 = neutral, 5 = like slightly, 6 = like, 7 = like very much). The scores from all panelists were compiled and processed to determine the acceptability of each product. In addition, the nutritional value of each product was calculated based on the formulation and quantity of ingredients used, covering energy, protein, fat, carbohydrate, fiber, iron, vitamin A, and vitamin C.

Preparation of the control pudding sponge cake

The control pudding sponge cake was prepared by separating the yolks and whites of 10 eggs. The yolks were mixed with 223 mL of liquid milk using a balloon whisk until well combined. Subsequently, 350 g of wheat flour was sifted gradually into the mixture to prevent lumps and stirred until homogeneous, followed by the addition of ½ teaspoon of vanilla extract. Meanwhile, the egg whites were combined with 2.5 teaspoons of lemon juice and whipped with a mixer at medium to high speed until foamy. Sugar (250 g) was added gradually while whipping until the egg whites became stiff and did not fall when the mixer was lifted.

The whipped egg whites were then folded gradually into the yolk batter with a spatula, using gentle unidirectional strokes, until evenly combined. The pan was lined with baking paper, and its sides were lightly greased with oil to prevent sticking. The sponge cake batter was poured into the pan, leveled, and tapped gently several times to release trapped air. The batter was then steamed over high heat for approximately 40–45 min until cooked. For the pudding layer, 1,000 mL of liquid milk was heated to boiling, after which 5 teaspoons of food coloring, 250 g of sugar, 35 g of agar powder, and 15 g of cornstarch were added. All ingredients were stirred continuously during heating until boiling and free of lumps. The cooked pudding mixture was left to stand for approximately 5 min before being poured over the sponge cake. The product was then refrigerated for approximately 1 h until the pudding layer had set and adhered to the sponge cake, after which it was ready to be served and used for testing.

Preparation of the green spinach leaf pudding sponge cake

The spinach pudding sponge cake was prepared by separating 10 eggs into yolks and whites. The 10 yolks were mixed with 98.4 mL (90 g) of cooking oil and 223 mL of liquid milk using a balloon whisk until evenly combined. Next, 350 g of wheat flour was sifted gradually into the yolk mixture while stirring until a homogeneous batter was obtained, followed by the addition of ½ teaspoon of vanilla extract.

Three egg whites were combined with 2.5 teaspoons of lemon juice and whipped with a mixer at medium to high speed until bubbles formed. Granulated sugar (250 g) was then added gradually while whipping, with the speed increased from low to high, until the egg whites became stiff and could be lifted without falling. The egg white foam was folded gradually into the yolk batter with a spatula, using gentle unidirectional strokes to preserve the foam structure. The pan was lined with baking paper and its sides were greased with butter. The batter was poured into the pan, leveled, and tapped gently several times to release trapped air, then steamed over high heat for approximately 40–45 min until cooked. The cooked sponge cake was removed from the pan and prepared for the pudding layer.

For the pudding layer, 250 g of picked and cleaned spinach leaves was washed and blended with 2,000 mL of water until smooth, and the mixture was strained to obtain the spinach extract. The extract was brought to a boil, after which 1,000 mL of liquid milk, 250 g of granulated sugar, 35 g of agar powder, and 15 g of cornstarch were added. The mixture was stirred continuously until homogeneous and boiling. The cooked pudding was left to stand for approximately 5 min to cool slightly and then poured evenly over the sponge cake. The product was refrigerated for approximately 1 h until the pudding layer had set and adhered to the sponge cake, after which the spinach pudding sponge cake was ready to be served.

Data analysis

Nutrient content was estimated using NutriSurvey based on the composition and weight of the ingredients. The total nutrient content of each formulation was divided by the number of pieces produced and compared with 10% of the Indonesian Recommended Dietary Allowance (*Angka Kecukupan Gizi*, AKG). Differences in hedonic scores between the two products were analyzed using the Wilcoxon test at a significance level of 5% ($p < 0.05$).

III. RESULTS AND DISCUSSION

Nutritional value

Nutrient values were calculated to estimate the energy, protein, fat, carbohydrate, fiber, iron, vitamin A, and vitamin C content per piece of each product. The calculations were based on the composition and weight of the ingredients used, and the total nutrient content was divided by the number of pieces produced. The control pudding sponge cake served as the comparison product, and the nutrient value per piece was compared with 10% of the AKG. The results are presented in Tables 1 and 2.

Table 1. Nutritional value of the control pudding sponge cake

Ingredient	Weight (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbo-hydrate (g)	Fiber (g)	Iron (mg)	Vitamin A	Vitamin C (mg)
Egg	500	775	63	10.6	5.5	0	6	1,140	0
Wheat flour	350	1,273.5	7.2	36	267	9.5	4	0	0
Liquid milk	1,260	831	40.5	49	60.5	0	1.5	693	12.5
Sugar	500	1,935	0	0	499.5	0	0.5	0	0
Vanilla essence	2.5	17.5	0	0	0.5	0	0	0	35
Lemon juice	12.5	125	0.5	0.5	25	0	0.5	2.5	0
Food coloring	25	0	0	0	0	0	0	0	0
Water	2,000 mL	0	0	0	0	0	0	0	0
Agar powder	35	0	0	0	0	0	0	0	0
Cornstarch	15	57	0	0	13.5	0	0	0	0
Total	**4,700**	**5,014**	**111.2**	**96,1**	**871.5**	**9.5**	**12.5**	**1,835.5**	**47.5**
Per piece	**156.6**	**167.1**	**3.71**	**3,20**	**29.05**	**0.32**	**0.41**	**61.18**	**1.83**
10% of AKG		**225**	**6**	**6.5**	**36**	**3.2**	**1.8**	**60**	**7.5**

Note: AKG = Indonesian Recommended Dietary Allowance (*Angka Kecukupan Gizi*). Values were estimated using NutriSurvey based on the formulation.

Table 2. Nutritional value of the green spinach leaf pudding sponge cake

Ingredient	Weight (g)	Energy (kcal)	Protein (g)	Fat (g)	Carbo-hydrate (g)	Fiber (g)	Iron (mg)	Vitamin A	Vitamin C (mg)
Egg	500	775	63	10.6	5.5	0	6	1,140	0
Cooking oil	90	776	0	90	0	0	0	4,500	0
Wheat flour	350	1,273.5	7.2	36	267	9.5	4	0	0
Liquid milk	1,260	831	40.5	49	60.5	0	1.5	693	12.5
Sugar	500	1,935	0	0	499.5	0	0.5	0	0
Vanilla essence	2.5	17.5	0	0	0.5	0	0	0	35
Lemon juice	12.5	125	0.5	0.5	25	0	0.5	2.5	0
Spinach leaves	250	92.5	9.5	0.5	18.5	1.5	0	1,297.5	82.5
Water	2,000 mL	0	0	0	0	0	0	0	0
Agar powder	35	0	0	0	0	0	0	0	0
Cornstarch	15	57	0	0	13.5	0	0	0	0
Total	**5,015**	**5,882.5**	**120.7**	**187**	**890**	**11**	**12.5**	**7,633**	**130**
Per piece	**167.17**	**196.08**	**4.02**	**6.22**	**29.66**	**0.36**	**0.41**	**254.43**	**4.33**
10% of AKG		**225**	**6**	**6.5**	**36**	**3.2**	**1.8**	**60**	**7.5**

Note: AKG = Indonesian Recommended Dietary Allowance (*Angka Kecukupan Gizi*). Values were estimated using NutriSurvey based on the formulation.

Per piece, the control pudding sponge cake contained 167.1 kcal of energy, 3.71 g of protein, 122.03 g of fat, 29.05 g of carbohydrate, 0.32 g of fiber, 0.41 mg of iron, 61.18 of vitamin A, and 1.83 mg of vitamin C. The green spinach leaf pudding sponge cake contained 196.08 kcal of energy, 4.02 g of protein, 6.22 g of fat, 29.66 g of carbohydrate, 0.36 g of fiber, 0.41 mg of iron, 254.43 of vitamin A, and 4.33 mg of vitamin C. Thus, the spinach product had higher energy, protein, carbohydrate, fiber, vitamin A, and vitamin C values than the control, whereas the iron content of the two products was identical. These differences may be attributed to the overall composition and quantity of ingredients and therefore cannot be linked directly to the addition of spinach alone. The iron content of spinach leaves, which was recorded as zero in the ingredient table, needs to be verified using a valid food composition database or laboratory analysis. Hence, the product cannot yet be claimed as an iron-source snack until its iron value has been confirmed.

Organoleptic acceptability

The organoleptic test was conducted with 30 panelists to determine the acceptability of both products in terms of color, aroma, taste, texture, and overall acceptance (Table 3). The control pudding sponge cake obtained mean scores of 4.93 for color, 5.10 for aroma, 5.70 for taste, 5.23 for texture, and 5.50 for overall acceptance, whereas the green spinach leaf pudding sponge cake obtained mean scores of 5.17, 4.77, 4.80, 4.90, and 5.27, respectively. Thus, the spinach product received a higher mean score for color, whereas the control received higher mean scores for aroma, taste, texture, and overall acceptance.

Table 3. Mean hedonic scores and Wilcoxon test results (n = 30)

Parameter	Control	Spinach	p-value
Color	4.93	5.17	0.483
Aroma	5.10	4.77	0.128
Taste	5.70	4.80	0.031*
Texture	5.23	4.90	0.429
Overall acceptance	5.50	5.27	0.502

Note: Hedonic scale 1 = dislike very much to 7 = like very much. *Significant at $p < 0.05$.

The Wilcoxon test yielded p-values of 0.483 for color, 0.128 for aroma, 0.031 for taste, 0.429 for texture, and 0.502 for overall acceptance. At the 5% significance level, only taste showed a statistically significant difference ($p < 0.05$), whereas the other four parameters did not differ significantly. This indicates that the difference in panelists' assessments between the two products was most evident in taste, although this result should be interpreted with caution because five organoleptic parameters were tested.

Discussion

The calculation results showed that the green spinach leaf pudding sponge cake had higher energy, protein, carbohydrate, fiber, vitamin A, and vitamin C values than the control pudding sponge cake. These differences may be related to the composition of the ingredients used in the two products; therefore, they cannot be attributed solely to the addition of spinach leaves. Iacobellis *et al.* [19] showed that adding spinach leaves to food products can alter their nutritional composition, including their fiber content and several other nutrients. The iron content of both products was 0.41 mg per piece; thus, based on these calculations, no increase in iron was observed in the spinach product. These data need to be re-examined because the ingredient table used in the calculation listed the iron content of spinach leaves as zero, suggesting a possible recording or calculation error. Accordingly, the product cannot yet be claimed as an iron-source snack until its iron content has been verified through calculations based on a valid food composition database or through laboratory analysis.

The vitamin A and vitamin C values of the spinach product were also higher than those of the control based on the available data. Spinach is known to contain various nutrients and phytonutrients, but their final content in food can be affected by processing, temperature, and heating duration.

Explained that processing techniques influence changes in the nutrient compounds of spinach; hence, calculated values should be distinguished from those obtained through laboratory analysis.

In the organoleptic test, the spinach product obtained a higher mean score for color because its color appeared more intense and attractive, whereas the control obtained higher scores for aroma, taste, texture, and overall acceptance because it lacked the grassy off-flavor, tasted better, and had a softer and more tender texture than the spinach product. These results indicate that incorporating spinach leaves into the formulation produces product characteristics that panelists perceive differently, particularly in terms of color and taste. Prasad *et al.* [20] likewise reported that adding spinach can affect the sensory characteristics of foods, so the formulation must be adjusted to keep the characteristic attributes of spinach acceptable to consumers. The Wilcoxon test showed a significant difference in taste but not in color, aroma, texture, or overall acceptance at the 5% significance level. Although the spinach product had higher values for several calculated nutrients, its overall acceptance was slightly lower than that of the control; therefore, improvements in nutritional value need to be balanced with improvements in flavor and other product characteristics. In addition, the fat value of the control pudding sponge cake (122.03 g per piece) appears inconsistent with its energy value and ingredient composition, and the unit of vitamin A has not been specified; both should be verified before the final results are used to draw conclusions.

IV. CONCLUSION

The green spinach leaf pudding sponge cake has the potential to be developed as an alternative snack for adults. Per piece, the product contained 196.08 kcal of energy, 4.02 g of protein, 29.66 g of carbohydrate, 0.36 g of fiber, and 0.41 mg of iron. The acceptability test with 30 panelists revealed a significant difference in taste between the two products (p = 0.031), whereas color, aroma, texture, and overall acceptance did not differ significantly. However, the iron content of both products was identical; therefore, the potential of this product as an iron-source snack cannot be confirmed based solely on the available calculations. Moreover, these nutrient estimates were derived from NutriSurvey calculations and should be followed up with instrumental analysis in future studies.

Further development of the green spinach leaf pudding sponge cake should focus on improving the formulation, particularly to enhance taste acceptance without compromising its nutrient content. The nutrient calculations should also be re-examined, especially for fat, the unit of vitamin A, and iron content. Future studies are recommended to perform laboratory analysis of iron content to determine the nutritional value of the product more accurately, and to involve a larger and more diverse panel to obtain a broader picture of acceptability. In this way, further product development can be based on more accurate evidence regarding both nutrient content and consumer acceptance.

V. ACKNOWLEDGMENTS

The authors would like to thank their families for their continuous prayers and support, and the supervising lecturer for the time, guidance, and constructive feedback provided throughout this study.

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