Darussalam Nutrition Journal, November 2026, 10 (2): 190-207
DOI: 10.21111/dnj.v10i2.154 *P-ISSN 2579-8588*
E-ISSN 2579-8618

GAPLEK FLOUR SUBSTITUTION IN DIMSUM AS A POTENTIAL DIETARY FIBER-SOURCE SNACK

(*Substitusi Tepung Gaplek Pada Dimsum Sebagai Camilan Potensial Sumber Serat Pangan*)

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ABSTRACT

Introduction: *Obesity is associated with inadequate dietary fiber intake, highlighting the need for acceptable fiber-source snack alternatives. Gaplek flour, a local cassava-based ingredient, has potential for use in food products, but its application in dimsum remains limited.* ***Objective:*** *This study aimed to develop gaplek flour-substituted dimsum, evaluate sensory acceptance, and determine the dietary fiber and proximate composition of the formulation with the highest total product value (NP) based on the De Garmo effectiveness index.* ***Methods:*** *An experimental study using a Completely Randomized Design with one factor was conducted using three substitution levels: F1 (20%), F2 (40%), and F3 (60%). Each formulation was produced in one batch. Sensory acceptance was evaluated by 46 semi-trained panelists, each assessing all three formulations using a five-point hedonic scale. Sensory data were analyzed using the Friedman test. Laboratory analyses of dietary fiber and proximate composition were conducted only on F2, which was selected based on the De Garmo effectiveness index.* ***Results:*** *No statistically significant differences were observed among formulations for color ($p = 0.317$), aroma ($p = 0.247$), texture ($p = 0.971$), taste ($p = 0.821$), or overall appearance ($p = 0.549$). F2 (40% substitution) had the highest total product value (NP = 0.53) according to the De Garmo effectiveness index and was selected for laboratory analysis; this selection did not indicate statistically superior sensory acceptance. F2 contained 5.05% dietary fiber, 2.39% fat, 32.33% carbohydrate, 5.13% protein, 59.08% moisture, 1.05% ash, and 171.43 kcal/100 g. Its dietary fiber content met the numerical threshold for a "source of fiber" claim.* ***Conclusion:*** *These findings suggest that gaplek flour-substituted dimsum may be a potential local fiber-source snack alternative. Further studies with independent production batches and physiological outcomes are needed to confirm its nutritional consistency and potential health effects.*

Key words: *Dietary fiber; dimsum; gaplek flour; hedonic test.*

INTRODUCTION

Obesity is a global and national public health problem with a steadily increasing prevalence. Globally, the number of individuals with obesity has nearly tripled over the past five decades (Blüher, 2019). In Indonesia, the prevalence of obesity among adults aged >18 years increased from 21.8% in 2018 to 23.4% in 2023 (Kemenkes RI, 2018, 2023). Body mass index (BMI) is calculated as body weight in kilograms divided by the square of height in meters. According to the 2023 Indonesian Health Survey, obesity was classified as a BMI of ≥27.0 kg/m², while overweight was classified as a BMI of ≥25.0 to <27.0 kg/m² (Kemenkes RI, 2023). Obesity is closely associated with an increased risk of degenerative diseases, including type 2 diabetes mellitus and cardiovascular disease (Blüher, 2019).

Modern lifestyle changes characterized by busy daily activities, easy access to food delivery services, and the influence of globalization of food consumption patterns have contributed to increased consumption of fast food and processed products, which are generally high in energy and low in dietary fiber (Amin & Sulaiman, 2025; Sembor & Kowel, 2018; Setyawati & Rimawati, 2016). This condition contributes to inadequate daily dietary fiber intake, despite the important role of dietary fiber in metabolic health (Nurohmi, 2017). The recommended dietary fiber intake for productive-age adults in Indonesia is approximately 30 g/day (Kemenkes RI, 2018). However, actual intake remains below the recommended level. Low dietary fiber intake has been reported to significantly increase the risk of obesity (Shanti et al., 2017).

Although various government programs have been implemented to reduce obesity prevalence, their effectiveness remains limited, highlighting the need for complementary strategies through healthier and more acceptable food-based interventions (Salsabila, 2023). One potential approach is to support dietary improvement through increased dietary fiber intake. The utilization of local tuber-based food resources, such as cassava processed into gaplek flour, may enhance the functional value of food products. Gaplek flour has the potential to serve as an alternative ingredient in food products because of its dietary fiber content (Yenny, 2018). However, its utilization remains largely limited to traditional food products (Aswita & Chayati, 2021).

Dimsum is a popular snack consumed across various age groups and is commonly prepared using tapioca flour, which contains relatively low dietary fiber (Violalita et al., 2024). Previous studies have developed dimsum products incorporating various local food ingredients, such as moringa leaf flour, seaweed flour, and oyster mushrooms, to improve product quality (Wulandari et al., 2024; Anjasmoro & Lastariwati, 2023; Violalita et al., 2024). These studies demonstrate that local food ingredients have been incorporated into dimsum through different formulation approaches. However, based on the literature reviewed, the combined use of gaplek flour as the sole flour ingredient in the wrapper and as a partial substitute for tapioca flour in the chicken filling has not been examined. Therefore, the present study explores the use of gaplek flour as the sole flour ingredient in the wrapper, with dragon fruit puree added as a natural colorant, and as a partial substitute for tapioca flour in the chicken filling at substitution levels of 20%, 40%, and 60%.

This study aimed to evaluate the sensory acceptance of the three formulations and analyze the dietary fiber content and proximate composition of the formulation with the highest total product value (NP) based on the De Garmo effectiveness index.

METHODS

This experimental study employed a Completely Randomized Design (CRD) with one treatment factor, namely the substitution level of tapioca flour with gaplek flour in the dimsum filling. Three formulations were tested: F1 (20%), F2 (40%), and F3 (60%). The independent variable was the gaplek flour substitution level, while the dependent variables were sensory acceptance and the dietary fiber content and proximate composition of the selected formulation. Each formulation was prepared in a single production

batch without independent production-batch replication. All 46 panelists evaluated all three formulations; therefore, the sensory observations represented repeated measures from the same panelists, not independent production replicates. The formulation with the highest De Garmo effectiveness index was selected for laboratory analysis.

The study was conducted at the Nutrition Dietetics Laboratory (Room 204) and Organoleptic Laboratory (Room 202), Building B25, Universitas Negeri Malang, Malang, East Java, Indonesia, from November to December 2025. Ethical approval was obtained from the Ethics Committee of Universitas Negeri Malang (No. 17.11.09/UN32.14.2.8/LT/2025), and all panelists provided informed consent.

Forty-six semi-trained panelists were purposively recruited from fifth- and seventh-semester undergraduate Nutrition students. They had completed Food Science and Food Technology courses, providing foundational knowledge of food properties and sensory evaluation. The accessible population comprised 59 students after excluding five enumerators, including the researcher. The Slovin formula was used as an initial approach to estimate the minimum panel size because the accessible population was known and finite; with a 10% error tolerance, the minimum was 38 panelists. A total of 46 eligible students participated because more students were available and willing to participate than the calculated minimum. The larger panel size was also considered to support the reliability of sensory evaluation (Sipos et al., 2021). Eligible panelists had no conditions or medication use affecting sensory perception, had not smoked or consumed alcohol, and provided informed consent. Students who were ill, had relevant allergies, used medications affecting sensory perception, or withdrew were excluded.

The main ingredients were gaplek flour (Kampung Telo; PIRT No. 2063374061834-26), tapioca flour, chicken thigh fillet, vegetables, egg white, seasonings, dragon fruit puree, and mineral water. Main equipment included digital scales, food chopper, steamer, blender, and sensory evaluation materials, while laboratory analyses used an analytical balance, drying oven, muffle furnace, desiccator, Soxhlet apparatus, and Kjeldahl apparatus.

Dimsum fillings were formulated by replacing tapioca flour with gaplek flour at 20% (F1), 40% (F2), and 60% (F3), while maintaining a total flour weight of 170 g per formulation. The proportions of the main filling ingredients are presented in Table 1, while seasonings, ice, and oils were kept constant across formulations. The recipe was adapted from Anjasmoro and Lastariwati (2023) and Leko (2022). The wrapper was prepared as one shared batch using 750 g of gaplek flour, 400 g of dragon fruit puree, and 80 g of mineral water. The dough was sheeted and cut into circular pieces with a diameter of 6.5 cm. Filling ingredients were prepared separately for each formulation and mixed until homogeneous. A 0% gaplek control was not included because the study aimed to compare the sensory acceptance of three gaplek-containing formulations and select the formulation with the highest De Garmo effectiveness index for further nutritional analysis. The same wrapper composition and production batch were used for all formulations to maintain consistency; therefore, the sensory results were interpreted in the context of the complete dimsum product, including its wrapper.

Table 1. Main Ingredient Proportions of Dimsum Filling Formulations

Main ingredient	F1 (%)	F2 (%)	F3 (%)
Gaplek flour	20	40	60
Tapioca flour	80	60	40
Chicken thigh fillet	25	25	25
Egg white	5	5	5
Wood ear mushroom	10	10	10
Carrot	10	10	10
Green beans	10	10	10
Edamame	10	10	10
Seasonings, ice, oils	Fixed	Fixed	Fixed

Note: Gaplek and tapioca flour percentages represent their respective proportions of the total flour weight (170 g). Percentages of other main ingredients are rounded formulation proportions. Seasonings, ice, and oils were maintained at the same proportions across formulations.

Each dimsum consisted of 5 g of wrapper and 10 g of filling before steaming and was steamed for 15 minutes. The cooked dimsum weighed approximately 15 g per piece. After steaming, the samples were cooled for 10 minutes until visible steam had dissipated, then stored in food-grade, lidded thinwall plastic containers in a chiller at approximately 4–5°C for 15 hours. Before sensory evaluation, the samples were reheated for 5 minutes in two batches using three separate steamers, one for each formulation (F1, F2, and F3). Each steamer contained 1 L of water that had been boiled beforehand, and fresh water was used for the second batch. The samples were served warm according to the randomized presentation sequence.

For laboratory analysis, 10 pieces from each formulation (approximately 150 g) were vacuum-sealed and frozen after initial cooling. F2, which had the highest De Garmo effectiveness index, was selected for laboratory analysis after 62 hours of freezing and transported in a styrofoam box with ice gel to Saraswanti Indo Genetech Laboratory, Surabaya, Indonesia. Total dietary fiber was determined using the enzymatic-gravimetric method (AOAC 991.43 and AOAC 985.29). Protein content was determined using the Kjeldahl method with a nitrogen-to-protein conversion factor of 6.25. Fat was analyzed using the Weibull–Stoldt method, moisture and ash using gravimetric methods, carbohydrate by difference, and energy using Atwater factors.

Sensory acceptance was assessed using a five-point hedonic scale (1 = strongly dislike; 5 = strongly like) for color, aroma, texture, taste, and overall appearance. A within-subject design was used, in which all 46 panelists evaluated all three formulations (F1, F2, and F3). Samples were assigned random codes, and panelists were not informed of the specific formulation or substitution level. Six presentation sequences were randomized using Google Sheets, with different sequences assigned to panelists close to one another in participant order to reduce order effects. Each panelist received 220 mL of mineral water, and the questionnaire instructed panelists to drink or rinse their mouths with water before and after tasting the samples. The evaluation generally took 6–10 minutes per panelist, depending on the time needed to complete the assessment.

Sensory data were analyzed using the Friedman test to compare the three

formulations for each sensory attribute, accounting for the within-subject design. Statistical significance was set at $\alpha = 0.05$. Descriptive statistics were used to summarize the hedonic scores. If the Friedman test indicated a statistically significant difference, pairwise comparisons using the Wilcoxon Signed-Rank test were planned. Because none of the Friedman tests was statistically significant, no post-hoc tests were performed. Statistical analyses were conducted using IBM SPSS Statistics version 27.

The De Garmo method was used to determine sensory-attribute importance weights and the effectiveness index of each formulation. The importance of each attribute was assessed individually using a five-point De Garmo scale. Panelists ranked the five attributes from 1 (most important) to 5 (least important), and the rankings were converted to scores of 5–1. The normalized weight (NB) was calculated as the attribute score divided by the total score. The effectiveness value (NE) was calculated as NE = (treatment value − lowest value)/(highest value − lowest value), and the normalized product value (NP) as NP = NE × NB. The effectiveness index was calculated by summing NP across attributes. The formulation with the highest index was selected for laboratory analysis; this selection did not indicate statistically significant superiority in sensory acceptance.

RESULTS AND DISCUSSION

The mean hedonic scores of gaplek dimsum for each sensory attribute are presented in Table 2.

Table 2. Sensory Acceptance Scores and Friedman Test Results for Gaplek Dimsum

Sensory attribute	F1 (20%)				F2 (40%)				F3 (60%)			
	Mean ± SD; Median (IQR)	χ^2	df	*p*-value	Mean ± SD; Median (IQR)	χ^2	df	*p*-value	Mean ± SD; Median (IQR)	χ^2	df	*p*-value
Color	3.37 ± 0.95; 3.5 (1.00)	2.298	2	0.317	3.70 ± 0.84; 4 (1.00)	2.298	2	0.317	3.54 ± 1.00; 3 (1.00)	2.298	2	0.317
Aroma	3.63 ± 0.93; 4 (1.00)	2.793	2	0.247	3.85 ± 0.87; 4 (1.25)	2.793	2	0.247	3.85 ± 0.84; 4 (1.25)	2.793	2	0.247
Texture	3.28 ± 0.89; 3 (1.00)	0.059	2	0.971	3.24 ± 0.99; 3 (1.25)	0.059	2	0.971	3.24 ± 1.04; 3 (2.00)	0.059	2	0.971
Taste	3.24 ± 0.90; 3 (1.00)	0.394	2	0.821	3.20 ± 0.86; 3 (1.00)	0.394	2	0.821	3.20 ± 0.86; 3 (1.00)	0.394	2	0.821
Overall appearance	3.63 ± 0.74; 4 (1.00)	1.200	2	0.549	3.78 ± 0.66; 4 (1.00)	1.200	2	0.549	3.67 ± 0.70; 4 (1.00)	1.200	2	0.549

Note: Values are presented as mean ± standard deviation (SD) and median (interquartile range, IQR). Friedman tests were used to compare the three formulations for each sensory attribute at $\alpha = 0.05$. No post-hoc tests were performed because no significant differences were found.

Color

Food color represents freshness, flavor intensity, and product characteristics, thereby influencing panelists' expectations (Wongthahan et al., 2026). In this study, the red dimsum wrapper made with dragon fruit puree was used consistently across all formulations. Panelists' comments describing the wrapper as "too red" suggest that the wrapper's appearance was noticeable during sensory evaluation. This may have influenced their color judgments toward the wrapper rather than the filling, which was the component directly affected by the experimental substitution of gaplek flour for tapioca flour. Although this observation may suggest a potential halo effect, such an effect was not directly assessed in this study.

The color of the filling may have been influenced by heat-induced reactions during steaming, including the Maillard reaction (Qi *et al.*, 2025). However, the occurrence and contribution of this reaction to the color of the dimsum filling were not directly assessed in the present study. Color characteristics may also have been influenced by the inherent pigments of the ingredients. These factors may have contributed to the limited differences in color acceptance observed among the formulations, although the underlying mechanisms cannot be confirmed from the sensory data alone. Similar findings have been reported in studies on mocaf meatballs and gaplek brownies, where cassava flour substitution did not significantly affect color acceptance despite its tendency to produce darker-colored products (Azmi, 2022; Hajriatun et al., 2017).

Aroma

Aroma is a sensory attribute formed through interactions between raw material components and processing conditions, primarily via volatile compounds such as aldehydes, alcohols, esters, and acids (Al-Khalili *et al.*, 2025). In this study, no significant differences in aroma liking were detected among the three formulations. This finding is consistent with previous studies reporting no significant differences in aroma acceptance in gaplek flour brownies and mocaf meatballs (Azmi, 2022; Hajriatun et al., 2017).

The steaming process may also have influenced aroma perception by affecting the release and retention of volatile compounds (Yuan *et al.*, 2022). In addition, the aroma of sesame oil may have contributed to the overall aroma profile and potentially reduced the perceptibility of subtle differences associated with gaplek flour substitution. Compounds such as pyrazines and furans are associated with the characteristic aroma of roasted sesame seeds (Takemoto *et al.*, 2022). However, the volatile composition of the dimsum was not analyzed in this study; therefore, the contributions of steaming and sesame oil to the observed sensory responses remain possible explanations rather than confirmed mechanisms. Overall, aroma liking did not differ significantly among the gaplek dimsum formulations.

Texture

The substitution of gaplek flour for tapioca flour may theoretically influence the texture of the product due to differences in compositional characteristics. Tapioca flour consists primarily of pure starch composed of two main fractions, amylose and amylopectin, which play key roles in determining the physical properties of starch gels (Rashwan et al., 2024; Chamorro et al., 2025). Amylose has a

linear structure that tends to form dense and rigid gel networks, whereas amylopectin, with its branched structure, contributes to the elastic and viscoelastic properties of gels (Mauro, Vela and Ronda, 2023). The relative proportions and characteristics of these starch fractions may influence gelatinization behavior, viscosity, and gel strength during heating. These properties may help explain the chewy and elastic texture commonly associated with tapioca-based products, although they were not directly measured in the present study (Mauro et al., 2023).

Gaplek flour, produced from whole cassava tubers, contains not only starch but also non-starch components such as dietary fiber, protein, and a small amount of fat (Charoenkul et al., 2011; Chamorro et al., 2025). The presence of these non-starch components may affect starch hydration and interactions during gelatinization, potentially influencing gel network formation compared with systems containing purified starch (Charoenkul *et al.*, 2011). Such compositional differences may contribute to variations in density and elasticity, as discussed in previous studies (Chamorro et al., 2025). However, the sensory results in the present study did not indicate significant differences in texture acceptance among the three formulations. The proposed effects of flour composition on gel formation and texture remain theoretical explanations because the starch properties and instrumental texture of the dimsum were not evaluated.

Moisture from the formulation ingredients, including vegetables, may also have influenced starch hydration during steaming (Mauro et al., 2023; Akinwotu et al., 2025). Adequate water availability can facilitate starch granule swelling during heating and may influence the resulting gel structure (Chamorro et al., 2025). Moreover, steaming provides heat and moisture that may support starch gelatinization across formulations (Mauro et al., 2023). These processing conditions may have contributed to the similar sensory texture acceptance observed among treatments, but this explanation cannot be confirmed without direct measurements of moisture distribution, starch gelatinization, or instrumental texture.

Taste

Gaplek flour may contribute a characteristic flavor to food products, although its properties may vary depending on the processing methods used (Pasca et al., 2021). In fermented cassava flour, microbial activity can alter the profile of flavor-related volatile compounds (Du *et al.*, 2025). However, the traditional sun-drying process used to produce the gaplek flour in the present study does not establish whether fermentation occurred. The flavor profile of the filling was not clearly distinguished by panelists across the formulations. One possible explanation is that the dimsum wrapper, which was made entirely from gaplek flour, contributed a common flavor component across all samples, potentially making differences associated with the varying gaplek-to-tapioca ratios in the filling more difficult to perceive.

Additionally, the characteristic flavor of gaplek may have been unfamiliar to some panelists. This observation is consistent with sensory evaluation principles indicating that familiarity with an ingredient can influence taste acceptance. Such unfamiliarity may have contributed to lower hedonic scores, as sensory acceptance is influenced by cultural

exposure and habitual consumption patterns (Lawless & Heymann, 2010). Several panelists also described the product as relatively bland, which may have contributed to the relatively lower taste scores observed across all formulas. This perception was likely associated with suboptimal seasoning levels, suggesting that future studies could improve flavor acceptance by optimizing seasoning intensity.

Overall Appearance

Overall appearance reflects panelists' perceptions of the product's visual characteristics as a whole. Although no statistically significant differences were observed among formulations, F2 received the highest mean overall appearance score. This numerical difference suggests that F2 tended to receive more favorable appearance ratings; however, it does not indicate significantly greater acceptance of its appearance or overall liking of the product.

Table 3. De Garmo Effectiveness Index of Gaplek Dimsum Formulations

Sensory attribute	Attribute weight (NB)	NP		
		F1 (20%)	F2 (40%)	F3 (60%)
Color	0.07	0.00	0.07	0.04
Aroma	0.20	0.00	0.20	0.20
Texture	0.13	0.13	0.00	0.00
Taste	0.33	0.33	0.00	0.00
Overall appearance	0.27	0.00	0.27	0.08
Effectiveness index	**1.00**	**0.47**	**0.53**	**0.31**

Note: NB, normalized weight; NP, normalized product value. Attribute weights were derived from the importance rankings provided by 46 panelists. The effectiveness index was calculated as the sum of NP values across the five sensory attributes. Values are rounded to two decimal places.

The De Garmo effectiveness index was highest for F2 (40% gaplek flour substitution), at 0.53, followed by F1 (20%) at 0.47 and F3 (60%) at 0.31 (Table 2). The index was calculated by multiplying the normalized weight of each sensory attribute by its effectiveness value and summing the resulting normalized product values (NP) across all five attributes. The calculation procedure for the De Garmo effectiveness index was adapted from Kurniawati (2023). The higher index for F2 was primarily associated with its higher scores for color and overall appearance, which had combined normalized weights of 0.33, while its aroma score was equal to that of F3. For example, the effectiveness index for F1 was obtained by summing its NP values across the five attributes: 0.00 + 0.00 + 0.13 + 0.33 + 0.00 = 0.47, using unrounded values for the final calculation. Although F2 had the highest De Garmo effectiveness index, the Friedman test showed no statistically significant differences in sensory acceptance among the three formulations. Therefore, F2 was selected for laboratory analysis based on its highest effectiveness index, rather than being considered statistically superior to the other formulations.

Previous studies have reported favorable sensory outcomes at moderate levels of cassava flour substitution in certain food products (Hendrik & Lunatri, 2024; Aqmar & Pangesthi,

2025). Similar findings were reported by Rosianti, who observed that the most favorable sensory characteristics of mocaf meatballs were achieved at a 40% substitution level (Rosianti et al., 2024). These findings provide a point of comparison for the present results; however, differences in product composition and processing conditions limit direct comparisons across studies. In the present study, the De Garmo effectiveness index provided a means of selecting a formulation by integrating the relative importance of sensory attributes with their observed scores, but it did not establish statistically significant differences in sensory acceptance.

Table 4. Dietary Fiber and Proximate Analysis of the Formulation with the Highest Total Product Value (F2)

Parameter	Value	Unit
Total dietary fiber	5.05	%
Fat content	2.39	%
Carbohydrate content	32.33	%
Protein content	5.13	%
Total energy	171.43	kcal/100 g
Moisture content	59.08	%
Ash content	1.05	%

Total Dietary Fiber

The dietary fiber content of the formulation with the highest total product value (NP) based on the De Garmo effectiveness index (F2) was 5.05 g per 100 g of product. According to Regulation of the Indonesian Food and Drug Authority Number 1 of 2022 on the Control of Claims on the Label and Advertising of Processed Food, solid processed foods may bear a “source of fiber” claim if they contain at least 3 g of dietary fiber per 100 g of product. Therefore, the dietary fiber content meets the criterion for a “source of fiber” claim under this regulation. Based on one dimsum piece weighing approximately 15 g, the dietary fiber content was equivalent to approximately 0.76 g per piece (BPOM, 2022). The dietary fiber content of the product was supported primarily by the use of gaplek flour, which contains 6.7 g of dietary fiber per 100 g. In addition, the vegetables used in the formulation, namely edamame (10 g/100 g), wood ear mushroom (5.1 g/100 g), green beans (1.9 g/100 g), and carrots (1.0 g/100 g), also contributed to the overall dietary fiber content of the product (Kemenkes RI, 2020).

Food processing may influence the measured dietary fiber content. Steaming causes starch gelatinization, while subsequent chilled storage may promote starch retrogradation and the formation of resistant starch type 3 (RS3). Heating–cooling cycles are known to promote RS3 formation (Arp et al., 2020). Resistant starch formed through retrogradation is less susceptible to enzymatic digestion (Kapelko-Żeberska *et al.*, 2024). Because RS3 has physiological characteristics similar to dietary fiber and may be quantified as part of total dietary fiber by certain analytical methods, RS3 formation may be one possible mechanism contributing to the measured dietary fiber content of this product (McCleary and McLoughlin, 2023). However, RS3

was not directly analyzed in this study; therefore, this mechanism cannot be confirmed. This difference may help explain why laboratory analysis showed a higher dietary fiber content (5.05%) than the NutriSurvey estimate (2.88%). The difference may also be influenced by raw material characteristics and limitations of food composition databases in representing changes occurring during food processing (Kusumastuty et al., 2016).

According to the Indonesian Recommended Dietary Allowance (RDA), the daily dietary fiber requirement for adults is approximately 30 g (Kemenkes RI, 2019). Each piece of gaplek dimsum weighs approximately 15 g; therefore, consumption of four pieces corresponds to approximately 60 g of product. Based on the laboratory-determined dietary fiber content of 5.05 g/100 g, consumption of 60 g of gaplek dimsum is estimated to provide 3.03 g of dietary fiber (5.05 × 60/100), equivalent to approximately 10% of the daily dietary fiber requirement. This amount indicates that consuming four pieces of gaplek dimsum as a snack has the potential to contribute to meeting daily dietary fiber requirements. Adequate dietary fiber intake may also support satiety and appetite regulation (Akhlaghi, 2024). However, the contribution of the product to daily dietary fiber requirements depends on the amount consumed and the overall dietary pattern.

Fat Content

The fat content of F2 was 2.39 g per 100 g of product. This value was below the maximum fat limit of 12% specified in SNI 7756:2020 for fish dimsum. However, because the present product was made with chicken rather than fish, this comparison should be interpreted as a reference rather than direct evidence of compliance with the standard. The fat content may be related to the formulation, in which chicken thigh meat and sesame oil were the main fat sources, while gaplek flour contributed relatively little fat. Steaming may also have helped limit additional fat uptake because the product was not fried (Al Rasyid et al., 2018).

The fat content estimated using NutriSurvey was 7.63%, compared with the laboratory-measured value of 2.39%. This difference may reflect differences between ingredient-based estimates and the composition of the finished product after processing (Kusumastuty et al., 2016). Nevertheless, the laboratory result indicates a relatively low fat content in the analyzed F2 sample. Further analyses of independently prepared batches are needed to determine whether this composition is consistent across production batches.

Carbohydrate Content

Carbohydrates play a crucial role as the primary source of energy, especially in snack products (Fitri et al., 2020). The carbohydrate content of gaplek dimsum was 32.33%, as determined using the by-difference method. The carbohydrate content was primarily derived from gaplek flour and tapioca flour, which contain 83.1 g and 88.2 g carbohydrates per 100 g, respectively (Kemenkes RI, 2020).

During steaming, starch granules from both flours undergo gelatinization, resulting in granule swelling and increased water-binding capacity (Akinwotu et al., 2025). The

addition of vegetables also contributed to the moisture content of the product (Mauro et al., 2023). Consequently, the final moisture proportion may affect the carbohydrate value because carbohydrate content was calculated using the by-difference method, which is influenced by the proportions of other proximate components, particularly moisture content. The lower carbohydrate value estimated by NutriSurvey (24.67%) should be interpreted as supporting information based on food composition databases and may not fully represent the composition of the final product after processing.

Protein Content

The protein content of gaplek dimsum was 5.13%, while NutriSurvey estimated a protein content of 6.01 g/100 g based on ingredient composition. The protein content was mainly derived from chicken meat and egg white, which contain 18.2 g and 10.8 g protein per 100 g, respectively. Edamame also contributed plant protein, while gaplek flour provided 2.4 g protein per 100 g, which is higher than that of tapioca flour (1.1 g/100 g) (Kemenkes RI, 2020).

SNI 7756:2020 specifies quality requirements for fish dimsum. Although the measured protein content of F2 exceeded the 5% minimum cited from this standard, the standard's applicability to chicken-based dimsum should be interpreted cautiously because the product evaluated in this study was made with chicken rather than fish. Therefore, this comparison provides a reference point and does not establish formal compliance with the standard.

Heat treatment during steaming induces structural changes in proteins that may affect their chemical properties and interactions within the food matrix (Khalid *et al.*, 2023).

Total Energy

The total energy content of the formulation with the highest De Garmo effectiveness index (F2) was 171.43 kcal/100 g, corresponding to an energy density of 1.71 kcal/g. Based on the dietary energy density classification, this value falls within the moderate energy-density category (1.5–4.0 kcal/g) (Takeda *et al.*, 2021). Based on the approximate cooked weight of 15 g per piece, a four-piece serving (approximately 60 g) provides an estimated 102.86 kcal. This is approximately 4.8% of the Indonesian adult daily energy reference of 2,150 kcal (Kemenkes RI, 2019).

The frequently used 10% daily-energy benchmark for a snack is a general dietary planning reference rather than a universal requirement. Accordingly, the estimated energy contribution of this serving should be interpreted in relation to individual energy needs and the overall dietary pattern. The product's measured energy content describes its composition but does not, by itself, demonstrate an effect on body weight or obesity management.

Moisture Content

The moisture content of gaplek dimsum (F2) was 59.08%, which remained below the maximum limit of 60% established by SNI 7756:2020. This value was comparable to the NutriSurvey estimate of 62.40%, which is presented as supporting information.

The moisture content of the product was influenced by both ingredient composition and processing methods.

Although the measured value was below the 60% maximum cited from SNI 7756:2020, this standard is intended for fish dimsum. Therefore, the comparison should be interpreted as a reference rather than confirmation of compliance for the chicken-based product. In addition, the measured value was close to the cited limit, and the available laboratory results do not establish measurement uncertainty or between-batch variability. Thus, compliance should not be concluded definitively from this result alone.

Vegetables incorporated into the formulation, including wood ear mushrooms, carrots, green beans, and edamame, contain relatively high moisture levels that are released during heating. This water can subsequently be retained within the dough matrix, particularly by dietary fiber from gaplek flour and hydroxyl groups present in tapioca starch, thereby increasing water-holding capacity (Cheng *et al.*, 2025). Tapioca starch also contributes to water retention through granule swelling during heating (Pereira *et al.*, 2020). Furthermore, steaming facilitates interactions between water and the starch–protein matrix through gelatinization, resulting in a greater proportion of bound water retained within the product (Fitriani, 2018). These findings are consistent with the characteristics of dimsum as a moist snack product and are comparable to those reported by Violalita et al. (2024), who observed a moisture content of 60.4% in oyster mushroom dimsum.

Ash Content

Ash content represents the inorganic residue remaining after combustion and reflects the total mineral content of a food product (Hervidea and Dalimunthe, 2024). The ash content of food products generally increases with the diversity and mineral composition of the ingredients used (Violalita et al., 2024).

SNI 7756:2020 specifies a maximum ash content of 2.5% for fish dimsum. Although the measured value was below this limit, the standard's applicability to chicken-based dimsum requires caution. Therefore, the result should not be interpreted as definitive evidence of compliance with the fish-dimsum standard.

The ash content was derived from mineral-rich ingredients, including gaplek flour, tapioca flour, vegetables, chicken meat, and seasonings. According to the Indonesian Food Composition Table, 100 g of gaplek flour contains 18 mg calcium and 95 mg phosphorus, while tapioca flour contains 84 mg calcium and 125 mg phosphorus. Vegetables also contributed minerals, with carrots providing 45 mg calcium and 74 mg phosphorus, wood ear mushrooms containing 3 mg calcium and 94 mg phosphorus, and green beans supplying 101 mg calcium and 42 mg phosphorus (Kemenkes RI, 2020). In addition, salt contributed trace minerals such as iodine (Ariana et al., 2022).

However, these database values describe the individual ingredients and are not measurements of the mineral content of the finished F2 product. Because specific minerals were not analyzed in the present study, the ash result cannot establish

the concentrations of individual minerals, such as calcium or phosphorus. The measured value should therefore be interpreted as total ash content rather than evidence of a specific mineral profile.

Strengths and Limitations of the Study

This study explored the use of local gaplek flour in dimsum development and evaluated sensory acceptance across three substitution levels. However, the study had several limitations, including the absence of a 0% substitution control, independent production-batch replication, and nutritional analyses of all formulations. The use of semi-trained undergraduate Nutrition students as panelists may also limit generalizability. Furthermore, resistant starch, glycemic index, and physiological outcomes related to satiety and obesity were not assessed. Future studies should address these limitations to strengthen the evidence regarding the product's nutritional characteristics and potential health benefit.

CONCLUSIONS AND SUGGESTION

F2, containing 40% gaplek flour substitution in the filling, obtained the highest De Garmo effectiveness index and was selected for laboratory analysis. The formulation contained 5.05% dietary fiber, 2.39% fat, 32.33% carbohydrate, 5.13% protein, 171.43 kcal/100 g energy, 59.08% moisture, and 1.05% ash. Its dietary fiber content met the numerical criterion for a “source of fiber” claim under Indonesian BPOM Regulation No. 1 of 2022. Four pieces (approximately 60 g) provide an estimated 3.03 g of dietary fiber, equivalent to approximately 10% of the recommended daily intake. No significant differences in sensory acceptance were found among the three formulations ($p > 0.05$); however, this does not establish equivalence. Further studies should include a 0% control, independent production batches, nutritional analyses of all formulations, and assessments of resistant starch, glycemic response, and relevant physiological outcomes before drawing conclusions about potential benefits for obesity management.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to Universitas Negeri Malang for providing financial assistance to support the publication of this research.

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