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Exploring the Potential of Durian Seed Flour, Jack Bean Sprouts Flour, and Chia Seeds in Biscuits for Underweight Toddlers as an Alternative Complementary Foods

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ABSTRACT
Biscuits with sufficient energy and protein can be provided as complementary feeding to meet the dietary needs of underweight toddlers. This study contributes to determine the effect of the proportion of durian seed flour, jack bean sprout flour, and chia seeds on the protein content, fat content, and hedonic quality of biscuits. This study uses the Completely Randomized Design (CRD) method with three biscuit proportions, with the ratio of durian seed flour:jack bean sprout flour:chia seeds T1 (35%:45%:5%), T2 (45%:35%:5%), and T3 (55%:20%:5%). Total protein and fat content testing were carried out in duplicate on each sample, 6 times, then analyzed using SPSS 25 using the ANOVA method and DMRT further test ($p<0.05$). While the hedonic test and hedonic quality were analyzed using the Friedman test followed by DMRT ($p<0.05$). The best treatment was selected based on the effectiveness index test. The proportion of durian seed flour biscuits, jack bean sprout flour, and chia seeds affects protein, fat, color quality, aroma quality, aftertaste quality, texture quality, aroma preference, aftertaste preference, texture preference, and overall preference. The best formula biscuit is biscuit with a proportion of 45% durian seed flour, 35% jack bean sprout flour, and 5% chia seeds, containing 459.28 kcal of energy, 15.33% db protein, 16.72% db fat, 61.87% db carbohydrates, 4.82% wb water, 1.26% db ash, and a serving size of 19 pieces biscuit will provide 20% of toddler daily protein requirements.

KEYWORDS
Chia seeds; Durian seeds; Jack bean sprout flour; MPASI biscuits; Toddlers

1. INTRODUCTION

Underweight prevalence among children under five remains a global public health concern, with recent estimates indicating that 14.6% of children worldwide are underweight [1]. Underweight is a measure of nutritional status based on the weight index for a child's age, with a Z-Score threshold of less than -2 standard deviations (SD), indicating that the child has not reached the appropriate weight for their age [2], [3]. Underweight children are more susceptible to infection and developmental issues because they have weakened immune systems [4], [5]. The need for intake in children aged 6–24 months has increased, while the nutritional content of breast milk only contributes one-third of the overall needs [6]. The findings of Gwela et al. (2019) [4] indicate that insufficient food intake is the primary cause of underweight. Therefore, breast milk complementary foods or commonly known as MPASI with adequate energy and protein content are necessary to maintain the child's growth and prevent a decline in nutritional status [7]. Biscuits are one of MPASI that Indonesian youngsters frequently choose [8], [9]. Biscuits can be given to children aged 12–23 months, characterised by a distinctive crunchy texture and density [10], [11].

Additionally, SNI 01-7111.2-2005 for nutritional quality guidelines for MPASI biscuits state that they must include an energy content of 400 kcal per 100 g, a maximum of 30 g of carbohydrates per 100 g, a minimum of 6 g of protein per 100 g, and a minimum of 6 g of fat per 100 g [12].

Wheat flour is typically used as the primary component to make biscuits, but there are now a variety of alternatives that use regional foods [13], [14], including durian seed flour. Indonesia produces 1.169 million tons of durian annually, of which the seed content is around 20–25%, which adds to a significant amount of waste because it is not utilized to its full potential and is thrown away instead [15], [16], [17]. Durian seeds contain 76.8 g of carbohydrates, 7.6 g of protein, and 0.4 g of fat, therefore, durian seeds can be used as an alternative food ingredient to replace wheat flour. Meanwhile, the flour made from durian seeds has a number of nutrients, including 6.92% protein, 0.74% fat, and 75.19% carbohydrates [18]. Durian seed flour has a high energy value of 388 kcal per 100 g, making it suitable for use as an energy source in MPASI biscuits [19]. Underweight toddlers need sufficient energy intake to maintain their nutritional status and prevent it from deteriorating by balancing body metabolism and pursuing the growth process [20].

According to the SNI standard for MPASI biscuits, which requires a relatively high minimum protein level, jack beans are a food ingredient that can be used to enhance the protein content of biscuits. Jack beans have a protein content of 23.3%, however, they also include antinutritional substances, one of which is hydrocyanic acid (HCN) [21]. According to Chove et al. (2010) [22] and Urugo et al. (2023) [23], one of the processes that can reduce the HCN levels in jack beans is germination into a sprout. The 60-hour germination process in jack beans can reduce the HCN levels from 30.83 ppm to 9.62 ppm, while increasing soluble protein content from 5.09% to 5.85% [24]. Jack beans undergo a flouring process to increase their suitability as a raw ingredient in food preparations. Jack bean sprout flour, with a germination period of 60 hours, has a protein content of 33.60%, making it an ideal food ingredient as a source of protein [24], [25]. Protein intake is important in underweight toddlers because it is a component of muscle and fat tissue that contributes to body weight and improves nutritional status [20]. Therefore, a total protein content analysis was conducted to assess the suitability of the protein content in biscuits for the nutritional needs of underweight toddlers and the quality standards of MPASI biscuit protein.

Durian seeds and jack bean sprout-based biscuits require the addition of other ingredients that are expected to provide a distinctive texture to the biscuits, namely chia seeds. The addition of chia seeds significantly improved the texture scores in the sensory evaluation of gluten-free biscuits formulated with a combination of buckwheat and chestnut flour [26]. According to the Center of Decease Control and Prevention [27], in addition to the combination of food types and flavors, MPASI providers must also consider the combination of textures to keep toddlers from becoming bored and maximize food intake. Therefore, in this study, hedonic tests and hedonic quality tests were carried out to determine the value of consumer acceptance and preference for the sensory properties of biscuits, such as color, aroma, taste, and texture.

Chia seeds are included in food ingredients that are beneficial to health because they are high in nutrients, one of which is a fat of 25–40% consisting of ALA (alpha-linolenic acid) and LA (linoleic acid), both of which are essential unsaturated fatty acids that can increase appetite in toddler with malnutrition [28], [29]. Children with low body weight often experience a lack of fat reserves because they are broken down too frequently to be converted into energy; therefore, sufficient fat intake is necessary to restore body fat reserves and increase body weight [30]. According to earlier research findings, adding chia seeds to biscuits can boost total protein levels from 4.8% to 5.7% and boost fat levels from 17.7% to 18.3% [26]. In addition to its nutritional content, the selection of chia seeds is due to their abundant availability and easy accessibility in both offline stores and e-commerce, making this functional food accessible [31]. Therefore, this study aims to evaluate the formulation of biscuits based on durian seed flour, jack bean sprout flour, and chia seeds as complementary foods for underweight toddlers. The novelty of this research lies in the combined use of these three local and underutilized food ingredients to provide sufficient energy, protein, and fat while maintaining sensory acceptability. The resolution method involves a nutritional analysis of protein and energy content, as well as sensory evaluation, to ensure compliance with SNI standards and consumer acceptance.

2. MATERIALS AND METHODS

2.1. Materials

Materials used in the research include biscuit-making materials and chemical analysis materials. Biscuit-making materials include durian seeds (*Durio zibethinus* Murr), jack bean [*Canavalia ensiformis* (L.) DC] from farmers in Wonogiri, chia seeds (*Salvia hispanica* L.), eggs, margarine, powdered sugar, powdered milk, table salt, baking powder, wheat flour, tapioca flour, and vanilla extract. The chemicals needed for the analysis of total protein content, total fat, water, ash, and carbohydrates by difference are H_2SO_4 (Sigma Aldrich, USA), protein catalyst, 40% NaOH (Sigma Aldrich, USA), $NaHCO_3$ (Sigma Aldrich, USA), 4% H_3BO_3 (Sigma Aldrich, USA), 0.02 N HCl (Sigma Aldrich, USA), 0.5 N methylene red (Sigma Aldrich, USA), and petroleum benzene pro analyst (Sigma Aldrich, USA).

2.2. Durian Seed Flour Preparation

The preparation of durian seed flour, as described by Suparno et al. (2024) [32], was modified. The flour-making process began by cleaning durian seeds under water flow to remove the flesh and sap. Afterward, the seeds were boiled for 10 minutes at 80 °C, and then their skin was peeled. The peeled durian seeds were then cut into 4 parts and soaked in a 5% NaCl solution for 3 hours. The durian seeds were rinsed using clean water, drained before thinly cut, and dried in a cabinet dryer at 55 °C for 5 hours or until completely dry. The dried durian seeds were ground using a grinder and sieved using a 60-mesh sieve.

2.3. Jack Bean Sprouts Flour Preparation

The preparation of jack bean sprout flour refers to Agustia et al. (2023) [24], which was modified. A total of 100 g of jack beans was cleaned and soaked in 500 mL of warm $NaHCO_3$ solution (1% w/w, 50 °C) for 24 hours at room temperature, and the solution was renewed every 6 hours. After the soaking process, the jack bean was rinsed and dried before continuing to the germination process. After that, the jack bean was arranged on a wide, perforated tray and covered with a damp cloth. Furthermore, the jack bean was germinated for 60 hours at room temperature with 100% humidity, which must always be maintained. Afterwards, the jack bean sprouts were harvested and sliced. The sliced jack bean sprouts were dried using a cabinet dryer at 55 °C for 5 hours. The dried sprouts were ground using a grinder and sieved using a 60-mesh sieve.

2.4. Biscuits Preparation

The preparation of biscuits refers to Khafsah et al. (2024) [32], which was modified. All dry ingredients (durian seed flour, jack bean sprout flour, milk powder, baking powder, salt, and wheat flour) were evenly mixed. Next, it was mixed with wet ingredients (margarine, vanilla, eggs, and powdered sugar) using a mixer for 2 minutes. Mixing was continued using a spatula. The chia seeds were added when the biscuit dough was evenly mixed. Then, using a rolling pin, the biscuit dough was flattened and molded using a biscuit mold. The dough was arranged on a baking sheet and baked in an oven at 150 °C for 30 minutes.

2.5. Total Protein Content Analysis

The protein analysis procedure using the Kjeldahl method [33], began with weighing a sample of 0.1 g with the addition of 0.7 g of selenium and 3 mL of concentrated H_2SO_4 into the Kjeldahl flask. Then it was heated for 2 hours until it boiled and the solution turned clear greenish. Furthermore, the solution was left to cool and continued to the dilution process using a 250 mL measuring flask to the limit mark. The dilution solution was added with 17.5 mL of 40% NaOH. Furthermore, distillation was carried out for 10 minutes using a 10% distillate container of 5 mL of H_3BO_3 solution mixed with an indicator. Furthermore, using distilled water, rinsing was carried out at the end of the cooler, the distillate mixture solution was titrated using 0.02 N HCl solution, and then a blank determination was carried out. The total protein content can be calculated using equation (1), (2), and (3).

$$\text{N content (\%)} = \frac{(\text{mL HCl sample} - \text{mL HCl blank}) \times \text{N HCl} \times 14.007 \times 1000}{\text{Sample weight (g)}} \quad (1)$$

$$\text{Total protein content (\% wb)} = \text{N content (\%)} \times 6.25 \quad (2)$$

$$\text{Total protein content (\% db)} = \frac{\text{Total protein content (\% wb)} \times 100\%}{100 - \text{moisture content (\% wb)}} \quad (3)$$

2.6. Fat Content Analysis

The fat analysis procedure, using the Soxhlet method [34], began with weighing 5 g of the sample, which was wrapped in filter paper. Then it was heated overnight and continued with weighing while hot. The sample was then placed in a Soxhlet flask, and a petroleum ether (PE) solution was added to carry out the extraction process for 5 hours, until the liquid became clear. The sample was then put in the oven for 1 day. The sample that had been removed from the oven was placed in a desiccator for 15 minutes and weighed, after which it was calculated using equation (4) and (5).

$$\text{Total fat content (\% wb)} = \frac{\text{Fat weight}}{\text{Sample weight}} \times 100\% \quad (4)$$

$$\text{Total fat content (\% db)} = \frac{\text{Total fat content (\% wb)} \times 100\%}{100 - \text{moisture content (\% wb)}} \quad (5)$$

2.7. Sensory Analysis

Ethical approval for the use of sensory testing was obtained under number 1614/EC/KEPK/X/2024. The panellists used in this sensory analysis were 50 untrained panellists, plus five people (10%) to 55 people to anticipate *drop out* [34]. The panellists were active students of Universitas Jenderal Soedirman with an age range of 18–24 years. Toddlers were not involved in sensory analysis due to ethical considerations and their inability to provide valid hedonic ratings. Adult panellists were selected to ensure reliable and consistent evaluations of the product's sensory characteristics. Product segmentation for toddlers was explained in the informed consent form. Panellist selection was based on the inclusion criteria (Table 1).

Table 1. Inclusion criteria for sensory analysis.

No	Inclusion criteria
1	Male/female aged 18 years and over
2	Neither hungry nor full (approximately 2 hours after the last meal)
3	Interested and willing to participate
4	Complete the informed consent form knowingly and without coercion
5	Committed to completing the test form honestly until the end
6	Healthy/not sick

Table 2. Hedonic quality sensory scale.

Scale	Color	Aroma	Aftertaste	Texture
1	Dark brown	Very beany	Very bitter	Very crumbly
2	Brown	Beany	Bitter	Crumbly
3	Quite brown	Quite beany	Quite bitter	Quite crumbly
4	Less brown	Less beany	Less bitter	Less crumbly
5	Not brown	Not beany	Not bitter	Not crumbly

Each panellist gave an assessment based on a predetermined numeric scale. The sensory analysis tested includes hedonic quality and hedonic testing. The hedonic quality and hedonic sensory analysis scales (5-point scale) can be seen in Table 2 and Table 3.

Table 3. Hedonic sensory scale.

Scale	Color	Aroma	Aftertaste	Texture	Overall
1	Dislike	Dislike	Dislike	Dislike	Dislike
2	Slightly like	Slightly like	Slightly like	Slightly like	Slightly like
3	Moderately like	Moderately like	Moderately like	Moderately like	Moderately like
4	Like	Like	Like	Like	Like
5	Very like	Very like	Very like	Very like	Very like

2.8. The Best Formula Determination

The best biscuit formula is determined using the de Garmo effectiveness index test [35], which is based on the analysis of total protein, fat, hedonic, and hedonic quality. Determination of the best formula using the de Garmo method began with weighting (scoring), which continued with determining the weight value, determining the effectiveness value, and ending with determining the product value. The calculation formula for the effectiveness value and product value can be seen at equation (6) and (7).

$$\text{Effectiveness value} = \frac{\text{Treatment value} - \text{The worst value}}{\text{The best value} - \text{The worst value}} \tag{6}$$

$$\text{Product value} = \text{Effectiveness value} \times \text{Value weight} \tag{7}$$

2.9. Serving Size Determination

Determination of serving size using Recommended Dietary Allowance (AKG) of protein for toddlers aged 1–3 years with underweight conditions [36] with energy needs of 1,550 kcal, protein of 15%, and fat of 35% each day. The calculation was done by calculating the percentage (%) of AKG fulfilment from the best formula. The formula for calculating serving size follows equation (8).

$$\frac{\text{The best formula protein content}}{\text{20\% of the daily protein requirement}} = \frac{100}{\text{Serving size}} \tag{8}$$

2.10. Experimental Design

This study used a Complete Random Design (CRD) Experimental Non-Factorial research design. The treatment factor is T regarding the proportion of durian seed flour, jack bean sprout flour, and chia seeds consisting of 3 proportions including T1 (35%:45%:5%), T2 (45%:35%:5%), T3 (55%:20%:5%) with 6 repetitions. The control variables are biscuits made from wheat flour. The biscuit formula made from durian seed flour, jack bean sprout flour, and chia seeds is seen in Table 4.

2.11. Data Analysis

Data analysis was performed using IBM SPSS for Windows version 25. Total protein and fat content data were analyzed using the One-way ANOVA, while hedonic and hedonic quality data were analyzed using the Friedman test. If differences were found, the data were further analyzed using the Duncan Multiple Range Test (DMRT) at a 95% confidence level. The best formula was determined using the effectiveness index based on total protein, fat, hedonic, and hedonic quality. Then, a nutritional content test at the best formula includes parameters of ash content and water content, and continued with a nutritional content test at the best formula including parameters of ash content, water content, and carbohydrate content by difference.

Table 4. Biscuit formulation.

Ingredients	Formula (g)			
	T0	T1	T2	T3
Durian seed flour	0	35	45	55
Jack bean sprouts flour	0	40	30	20
Chia seeds	0	5	5	5
Wheat flour	100	15	15	15
Tapioca flour	0	5	5	5
Baking powder	1	1	1	1
Salt	1	1	1	1
Vanilla extract	1	1	1	1
Margarine	30	30	30	30
Eggs	20	20	20	20
Powdered sugar	30	30	30	30
Milk powder	10	10	10	10

3. RESULTS AND DISCUSSION

3.1. Total Protein and Fat Content

The proportions of durian seed flour, jack bean sprout flour, and chia seeds had an effect (p value<0.05) on the total protein and fat content of biscuits. The results of the DMRT test are shown in Table 5. There was a significant difference in the total protein content of biscuits from T1 compared to other treatments, whereas there was no significant difference between T2 and T3. T1 biscuits have the highest protein content (17.70% db), while T3 biscuits have the lowest protein content (13.93% db). However, the protein content of T3 biscuits is higher than that of the control (T0) biscuits.

Table 5. Total protein and fat content of durian seed flour, jack bean sprout flour, and chia seed-based biscuits.

Formula	Total protein content (% db) (p value=0.00)**	Fat content (% db) (p value=0.01)*
T0	$11.90^{c} \pm 1.54$	$18.44^{a} \pm 0.99$
T1	$17.70^{a} \pm 0.88$	$15.60^{c} \pm 1.67$
T2	$15.33^{b} \pm 0.80$	$16.72^{bc} \pm 1.28$
T3	$13.93^{b} \pm 1.55$	$17.30^{ab} \pm 1.22$

Different letter notations in each of the same columns indicate that there is a real difference in the DMRT test at a level of 5%. *, significant effect; **, very significant effect. T, Durian seed flour:Jack bean sprout flour:Chia seeds. T1, 35%:40%:5%; T2, 45%:30%:5%; T3, 55%:20%:5%.

The protein content of biscuits in this study ranged from 13.93% db to 17.70% db, while the SNI standard requirement for MPASI biscuit protein content is ≥ 6 g/100 g. According to Verawati and Yanto's study on the development of durian seed biscuit [19], their products have not met the SNI standard requirements, especially in terms of protein content, because they only contain 5.57% db protein. The protein content in jack bean sprout flour reached 33.60% db [24], which is higher than the protein content of durian seed flour, which is only 6.92% db [18]. It is proven in the results of this study that the use of jack bean sprout flour as an alternative raw material to increase the protein content of durian seed biscuits can significantly increase the protein content of biscuits. The increase in protein content occurs along with the addition of jack bean sprout flour in biscuits. This is in line with Hanuji (2017) [37] which states that the increasing addition of jack bean flour to koro cookies increases their protein content. The results of our study are also in line with the research results of Affandi et al. (2016) [38], the concentration of jack bean flour in making baked brownies significantly increased protein content.

Based on the results of the DMRT test, the fat content of the treatment of the proportion of durian seed flour, jack bean sprout flour, and chia seeds did not provide significant differences in each treatment on biscuit formulas T2 and T3. Still, it was significantly different between formulas T0 and T1. Formula T3 had the highest fat content of 17.30% db, and T1 had the lowest fat content of 15.60% db among other treatments. The results of the DMRT test showed that there was a significant effect of the proportion of durian seed flour, jack bean sprout flour, and chia seeds on the fat content of biscuits in line with the results of research by Nathanael et al. (2016) [39], namely that the addition of durian seed flour in making white bread had an effect on reducing the fat content of white bread. According to Imawan et al. (2020) [40], the increase in fat content in wheat flour cookies occurred along with the low ratio of the addition of jack bean flour, this was caused by the fat content in wheat flour being greater than the fat content in jack bean flour. The results of the study showed that the lower the percentage of jack bean sprout flour and the higher the percentage of durian seed flour, the higher the fat content in biscuits. This is in line with the results of research by Nathanael et al. (2016) [39], the lower fat content in the dough is influenced by the presence of protein that functions as a fat emulsifier. Therefore, the increase in protein content in biscuits is accompanied by a decrease in fat content.

3.2. Sensory Characteristics

The results of the Friedman test show that the proportion of durian seed flour, jack bean sprout flour, and chia seeds had a significant effect (p value<0.05) on all sensory test variables of hedonic quality, aroma hedonic, aftertaste hedonic, texture hedonic, overall hedonic, and had no significant effect on color hedonic. The sensory test values of hedonic quality and hedonic of the biscuits are shown in Table 6 and Table 7.

Table 6. Results of hedonic quality sensory test.

Formula	Color** (p value=0.00)	Aroma** (p value=0.00)	Aftertaste** (p value=0.00)	Texture** (p value=0.00)
T0	$4.66^{a} \pm 0.52$	$4.80^{a} \pm 0.53$	$4.60^{a} \pm 1.01$	$2.72^{c} \pm 1.16$
T1	$2.46^{c} \pm 0.84$	$3.20^{c} \pm 1.12$	$3.40^{c} \pm 1.01$	$3.50^{a} \pm 1.07$
T2	$2.80^{b} \pm 0.64$	$4.08^{b} \pm 0.94$	$4.06^{b} \pm 0.84$	$3.40^{ab} \pm 1.09$
T3	$2.70^{bc} \pm 0.76$	$4.12^{b} \pm 1.00$	$4.26^{ab} \pm 0.90$	$3.00^{bc} \pm 1.09$

Different letter notations in each of the same columns indicate that there is a real difference in the DMRT test at a level of 5%. **, very significant effect. T, Durian seed flour:Jack bean sprout flour:Chia seeds. T1, 35%:40%:5%; T2, 45%:30%:5%; T3, 55%:20%:5%.

3.2.1. Color

The hedonic color quality test was conducted to assess the color quality of each biscuit formula. Based on the results of the DMRT analysis, it was found that there were differences between the treatment biscuits with an average value of 4.66–2.70 which included in the category of brown to not brown. The results of the hedonic color quality assessment of biscuits, which received the highest score were T0 with a score of 4.66 (less brown–not brown), while the biscuit with the lowest hedonic color quality assessment results was formula T1 with a score of 2.46 (brown–quite brown). The color hedonic test was conducted to assess the panellists' preference for the color of each biscuit formula. Panellists prefer brown or quite brown compared to dark brown, less brown, and not brown.

The color differences produced by the 4 biscuit formulas are caused by differences in the proportion of durian seed flour and jack bean sprout flour. The T1 biscuit formula with a proportion of 35% durian seed flour and 40% jack bean sprout flour has a brown to quite brown color, so it can be interpreted that the higher the proportion of jack bean sprout flour, the more it affects the brown color of the biscuits. These results align with the research of Imawan et al. (2020) [40], which states that the higher the percentage of jack bean flour, the higher the protein content in wheat flour cookies, which affects the brown color of the biscuits due to the Maillard reaction. Increasing the proportion of legume flour (e.g. common bean) in composite biscuits leads to decreased lightness values during baking, suggesting more intense Maillard browning due to amino group-carbohydrate reactions at high temperature [41]. Meanwhile, the results of

the Friedman test data on the preference value of the biscuit color parameter are in line with Khafsah et al. (2024) [32], the proportion of purple sweet potato flour and jack bean flour does not affect the level of panellists' color preference for biscuits. The substitution of durian seed flour did not provide a significant difference in the color of the biscuits because the use of durian seed flour produced a brownish-yellow [19]. Therefore, the panellists gave almost the same preference value, namely, quite like to like all biscuit formulas.

Table 7. Hedonic sensory test results.

Formula	Color (p value=0.08)	Aroma** (p value=0.00)	Aftertaste** (p value=0.00)	Texture** (p value=0.00)	Overall** (p value=0.00)
T0	$3.58^{c} \pm 1.13$	$4.38^{a} \pm 0.72$	$4.04^{a} \pm 1.05$	$3.90^{a} \pm 0.95$	$4.12^{a} \pm 0.77$
T1	$3.78^{ab} \pm 0.84$	$2.82^{c} \pm 1.04$	$2.60^{d} \pm 1.07$	$2.90^{c} \pm 1.15$	$2.88^{c} \pm 1.04$
T2	$3.98^{a} \pm 0.82$	$3.56^{b} \pm 0.95$	$3.12^{c} \pm 0.94$	$3.14^{bc} \pm 1.16$	$3.42^{b} \pm 0.97$
T3	$3.74^{ab} \pm 0.90$	$3.64^{b} \pm 0.94$	$3.62^{b} \pm 1.01$	$3.44^{b} \pm 1.16$	$3.72^{b} \pm 0.99$

Different letter notations in each of the same columns indicate that there is a real difference in the DMRT test at a level of 5%. **, very significant effect. T, Durian seed flour:Jack bean sprout flour:Chia seeds. T1, 35%:40%:5%; T2, 45%:30%:5%; T3, 55%:20%:5%.

3.2.2. Aroma

The results of the DMRT test showed a very significant effect of the proportion of durian seed flour, jack bean sprout flour, and chia seeds on the hedonic quality and hedonic aroma of biscuits. The results of the DMRT test showed no significant difference in formulas T2 and T3. Formulas T1 and T0 had different notations, so that it could be interpreted that there was a significant difference. The lowest hedonic aroma quality assessment result was in formula T1 with a value of 3.20 (quite beany–less beany). The highest percentage of jack bean sprout flour is in formula T1, which makes T1 a formula that has a quite beany to less beany aroma when compared to the other two treatments which have a less beany to not-beany aroma, so it can be interpreted that the more jack bean sprout flour in the biscuits, the more beany the biscuit aroma will be.

The hedonic aroma test was conducted to assess the panellists' level of preference for the aroma of each biscuit formula. Based on the results of the DMRT test, the biscuit formula T1 had a significant difference from T2, T3, and T0 biscuits. Meanwhile, the biscuit formulas T2 and T3 had no significant difference between the two. The biscuit formula with the lowest value for aroma was T1 at 2.82 (slightly like–moderately like) with the largest amount of jack bean sprout flour; therefore, the higher the percentage of jack bean sprout flour, the lower the panellists' preference for the resulting aroma.

The ratio of wheat flour and jack bean flour affects the aroma of the resulting koro cookies [37]. The higher the ratio of jack bean flour in making milk pie, the more the beany aroma of the product [42]. The beany aroma in legumes and bean-based bakery products is often attributed to lipoxygenase activity, which catalyzes the oxidation of unsaturated fatty acids to produce volatile compounds (such as hexanal, nonanal, ketones, and furans) contributing to off-flavors [43]. The results of the biscuit aroma preference level test align with the research of Khafsah et al. (2024) [32], biscuits with the lowest ratio of jack bean flour received the highest preference score. This is because jack bean has a rancid odor. The rancid odor produced from jack bean sprout flour affects the aroma of the biscuit and the level of panellist preference, so that the control biscuit has the highest preference with an average score of 4.38 (like–very like) from a total score of 5, the second highest formula is formula T3 with the lowest ratio of jack bean sprout flour from the other 3 treatments and gets an average preference score of 3.64 (moderately like–like) from a total score of 5.

3.2.3. Aftertaste

The results of the DMRT test showed a very significant effect of the proportion of durian seed flour, jack bean sprout flour, and chia seeds on the hedonic quality and hedonic aftertaste of biscuits. The hedonic aftertaste quality test was conducted to assess the taste quality of each biscuit formula. The results of the DMRT test showed a significant difference between the control biscuits and the 3 treatment biscuits, with

an average value of 4.60 to 3.40, or quite bitter to not bitter. The highest hedonic aftertaste quality assessment result of the 3 treatments was the T3 formula biscuit with a score of 4.26, or having an aftertaste less bitter to not bitter. In comparison, the biscuit with the lowest score of the 3 treatments was the T1 formula biscuit with a score of 3.40, or there was a quite bitter to less bitter aftertaste.

The hedonic aftertaste test was conducted to assess the panellists' level of preference for the taste of each biscuit formula. Based on the results of the DMRT test, it was found that there were differences between treatments in all biscuit formulas with an average value of 2.60–4.04, or included in the category of slightly like to very like. The biscuit with the highest aftertaste preference value was the control biscuit. The biscuit with the lowest preference value was the T1 formula biscuit, with a score of 2.60 (slightly like–moderately like).

The Friedman test found that the higher the proportion of jack bean flour in biscuits, the lower the hedonic quality value of the aftertaste or the bitter aftertaste in the biscuits was increasingly felt. The addition of jack bean flour in purple sweet potato biscuits increases, the bitter taste produced will be increasingly felt [32]. The bitter taste is caused by the HCN content that remains in jack bean flour at a small concentration even though it has undergone several preliminary processes [40].

The preference value for biscuits' aftertaste parameter increased as the jack bean sprout flour ratio decreased. The proportion of purple sweet potato flour and jack bean flour significantly affects the panellists' level of aftertaste preference for biscuits [32]. The addition of jack bean flour in making baked brownies can reduce the panellists' preference for the taste of brownies because there is a distinctive aftertaste in jack bean flour that affects the taste of brownies [38]. The distinctive taste of jack bean flour is a bitter aftertaste resulting from the remaining HCN content with a small concentration after processing [40]. Therefore, the higher the proportion of jack bean sprout flour, the more the bitter aftertaste in biscuits increases, thus reducing the panellists' preference for the aftertaste of biscuits.

3.2.4. Texture

The results of the DMRT test showed a very significant effect of the proportion of durian seed flour, jack bean sprout flour, and chia seeds on the hedonic and hedonic quality of biscuit texture. The hedonic texture quality test was conducted to assess the texture quality of each biscuit formula. The DMRT test showed that there was a significant difference in texture quality between formula T1 and T0 biscuits. In contrast, formula T2 and T1, T3 and T0 biscuits showed no significant difference. The biscuit formula with the highest score of the 3 treatments in the hedonic texture quality assessment was formula T1, with a score of 3.50 or had a quite crumbly to less crumbly texture. The formula with the lowest score was formula T3, with a score of 3.0, or a formula that had a quite crumbly texture, but the crumbly value of formula T3 was higher than that of the T0 biscuit, which means that the T0 biscuit had a crumbly texture.

The hedonic texture test was conducted to assess the panellists' level of preference for the texture of each biscuit formula. Based on the results of the DMRT test, it was found that there was a significant difference in the level of preference between biscuits T1, T3, and control biscuits. Biscuit formula T2 was not significantly different from biscuit formula T3. The biscuit formula that received the highest preference value for the texture parameter was the control biscuit with a score of 3.90 (moderately like–like), and the second highest was biscuit formula T3 with a score of 3.44 (moderately like–like). Biscuit formula T1 became the biscuit with the lowest texture preference value, with a score of 2.90 (slightly like–moderately like).

Increasing the percentage of jack bean sprout flour in the biscuit dough improves the texture and reduces crumbliness. One of the flour components that can affect the texture of cookies is protein content [40]. The nature of protein that can bind water is caused by the presence of carboxyl groups in the protein, which makes the texture of the biscuits firm to hard [44], [45]. Therefore, the higher the protein content in the flour, the firmer and less crumbly the biscuit texture. The comparison of the proportion of wheat flour and jack bean flour in making koro cookies affects the panellists' preference for the biscuit texture [37]. Based on the assessment results, the decrease in the value of preference for biscuit texture occurred along with the increasing percentage of jack bean sprout flour. The decrease in panellists' preference for the texture of wheat flour cookies occurs along with the addition of jack bean flour [40]. The addition of more

jack bean flour will affect the harder texture of the dough after the baking process because the amylose content in jack bean flour reaches 25.28–27.99% where amylose can form crystals and strengthen the structure of starch granules, which makes the dough hard, thus reducing the panellists' preference scores [38].

3.2.5. Overall

The overall hedonic test was conducted to assess the panellists' level of preference for each biscuit formula. Based on the results of the DMRT test, it was found that there was a significant difference in the overall preference level of the panellists for the 3 treatment biscuits and control biscuits, with an average value of 2.88 to 4.12. T0 formula or control biscuits became the biscuits with the highest preference with a score of 4.12 (like–very like). The biscuits with the highest overall preference value of the three treatments were T3 formula biscuits with a score of 3.72, or included in the category of moderately like to like, and the biscuits with the lowest value were T1 formula biscuits with a score of 2.88 or included in the category of slightly like to moderately like.

The level of panellists' preference for the color, aroma, aftertaste, and texture of biscuits shows that the overall level will decrease along with the increase in the percentage of jack bean sprout flour in making biscuits. There is an influence of the comparison of purple sweet potato flour and jack bean flour on the overall level of panellists' preference for biscuits [32]. The greater the addition of jack bean flour in making cookies, the more the panellists overall disliked the cookies [40].

3.3. Determining the Best Formula

The product value for determining the best formula is shown in Table 8. Based on the effectiveness index test, the best biscuit formula from durian seed flour, jack bean sprout flour, and chia seeds is in formula T2 biscuits with the highest product value of 0.70. Formula T2 biscuits contain 45% durian seed flour, 30% jack bean sprout flour, and 5% chia seeds. Formula T2 biscuits contain a total protein of 15.33% db, fat of 16.72% db, and have a brown to quite brown color, a less beany aroma, a less bitter aftertaste, and a quite crumbly to less crumbly texture. Formula T2 biscuits get a preference value of moderately like to like on all hedonic parameters of biscuits.

Table 8. Biscuit product value.

Parameters	Treatment		
	T1	T2	T3
Protein	0.16	0.06	0.00
Fat	0.00	0.09	0.14
Texture quality	0.13	0.10	0.00
Texture	0.00	0.06	0.13
Color quality	0.00	0.10	0.07
Color	0.02	0.10	0.00
Aroma quality	0.00	0.06	0.06
Aroma	0.00	0.06	0.06
Aftertaste quality	0.00	0.04	0.05
Aftertaste	0.00	0.02	0.05
Overall	0.00	0.02	0.03
Total	0.30	0.70	0.59

3.4. Best Formula Nutritional Value

Nutritional value of the best formula biscuit compared to the SNI standard of MPASI biscuit is shown in Table 9. Based on the results of the comparison of the nutritional value composition of biscuits, the quality of the best formula biscuits has met the requirements for the quality of biscuits with water content of ≤ 5.0% with a water content of 4.82% wb and ash content of 1.26% db and meets the requirements for the quality of biscuit ash content of ≤ 3.5%. The protein content of the best formula biscuits has met the

requirements for the quality of MPASI biscuits, namely, the protein content is ≥ 6 or reaches 15.33% db. The energy content of the best formula biscuits is 459.28 kcal. Meanwhile, the energy quality requirements for MPASI biscuits are ≥ 400, so the best formula biscuits meet the requirements for the quality of MPASI biscuits. In addition, the best formula biscuits is still within the safe limits of total daily energy intake from added sugar (< 5%) so it is perfectly safe to consume for toddlers.

Table 9. Nutritional value of the best formula biscuits.

Parameters	T2 formula	MPASI biscuit standard (SNI 01-7111.2-2005)
Water content (% wb)	4.82	≤5.0
Ash content (% db)	1.26	≤3.5
Energy (kcal)	459.28	≥400
Protein (% db)	15.33	≥6
Fat (% db)	16.72	≥18
Carbohydrates (by difference)	61.87	≥70

T2, 45% Durian seed flour:30% Jack bean sprout flour:5% Chia seeds.

The quality requirements for MPASI biscuits are to contain ≥ 18% fat and ≥ 70% carbohydrates, while the best formula biscuits contain 16.72 % fat and 61.87 % carbohydrates. Therefore, the best formula biscuits do not meet the quality requirements for fat and carbohydrates for MPASI biscuits. The water content in the best formula biscuits has met the water content quality requirements for MPASI biscuits. The water content in biscuits is influenced by protein, which has a high water-binding capacity because there are hydrophilic carboxyl groups [32]. In addition, the content of raw materials used in making biscuits also affects the water content of biscuits. Still, the baking process can reduce the water content through evaporation in the biscuit dough [46]. The baking process of biscuit dough reduces the water content, thus it can also increase the shelf life of biscuits because the water content affects the decline in food quality chemically and microbiologically [47]. In addition to the water content, the ash content of the best formula biscuits has also met the ash content quality requirements for MPASI biscuits. The amount of mineral content in the ingredients used in making cookies can affect the ash content in cookies [48]. In addition, the ash content in biscuits is also affected by the water content of the raw materials; the higher the water content in the biscuit raw materials, the lower the ash content because water has dissolving properties [49].

The energy and protein content of the best formula biscuits has also met the energy and protein quality requirements for MPASI biscuits. The energy content of biscuits is determined by the amounts of protein, fat, and carbohydrates, where protein and carbohydrate each contribute about 4 kcal per gram, and fat contributes about 9 kcal per gram [50], [51]. In formulations where fat content is higher among the macronutrients, total energy of the biscuits tends to be higher [52]. The best formula biscuits have the highest fat content among the other 2-treatments, which affects the high energy in biscuits because fat is the highest energy contributor. Adding raw materials with a higher fat content than other ingredients can increase the energy content of biscuits because fat contributes the most to energy [53]. Adding or substituting wheat flour with other high protein flours can increase the protein content of biscuits and become a solution to fulfilling the protein requirements for MPASI biscuit quality [54]. In addition to flour as the main ingredient, other ingredients affect the protein content of biscuits, such as milk and eggs [55].

The fat content of the best formula biscuits does not yet meet the quality requirements for the fat content of MPASI biscuits. The fat content of a product is influenced by the protein content of the raw materials used to make it, because one of the functions of protein is to emulsify fat [39]. During baking, increased thermal stress may lead to denaturation of proteins and structural breakdown, thereby reducing the emulsifying capacity of protein and enabling fat to migrate or volatilize, which leads to lower residual fat content in the final product [56], [57]. The best formula biscuits also do not meet the carbohydrate quality requirements of MPASI biscuits. This is because the carbohydrate content obtained from the by difference calculation is influenced by protein, fat, water, and ash levels [58]. Low content of other nutrients can affect the increase in carbohydrate levels and vice versa [57]. To further increase the fat and carbohydrate content of biscuits for toddlers, future formulations could incorporate higher amounts of fat-

rich ingredients such as vegetable oils, nuts, or seeds, and carbohydrate-rich sources such as cereals (wheat, rice, oats) or starchy tuber flours (cassava, sweet potato). Previous studies demonstrated that such additions improve both the energy density and macronutrient balance of complementary foods, while still maintaining sensory acceptability [28], [59], [60].

3.5. Serving Size

The results of the biscuit serving size calculations are shown in Table 10. Based on the calculations, to meet 20% of the daily protein needs of underweight toddlers aged 1–3 years, approximately 75.67 g of biscuits are required daily. One biscuit weighs 4 g, so approximately 19 biscuits are required. The nutritional content and percentage of each serving size are shown in Table 11.

Table 10. Results of calculating the serving size of biscuits.

Protein content (g/100g) of best formula	20% of daily needs	Product weight per serving size (g)
15.33	11.60	75.67

Based on the nutritional content of the best formula biscuit serving size, 19 biscuits or 76 g are needed in one day of MPASI to meet the daily energy, protein, fat, and carbohydrate needs. The nutritional content of biscuits in each serving size can meet the daily energy intake needs of underweight toddlers (1550 kcal) of 22.5%, protein (58 g) of 20.1%, fat (60 g) of 21.2%, and carbohydrates (194 g) of 24.2%. However, this calculation of biscuits needed in one day is supplementary and should not replace balanced meals. The 3 main meals remain the foremost source of nutrition for toddlers, while complementary foods, such as these biscuits, only serve to fill nutrient gaps.

Table 11. Nutritional content per serving size of the best formula biscuits.

Parameters	Nutrient content at 76 g biscuits	Daily needs of underweight toddlers	Daily needs of 20% underweight toddlers	Daily fulfilment (%)
Energy (kcal)	349	1550	310	22.5
Protein (g)	11.65	58	11.60	20.1
Fat (g)	12.71	60	12	21.2
Carbohydrates (g)	47	194	38.80	24.2

4. CONCLUSION

Biscuits with a proportion of 45% durian seed flour, 30% jack bean sprout flour, and 5% chia seeds were selected as the best formula biscuits. These biscuits were quite liked by the panellists, had a fairly brown color with a less pronounced beany aroma, a less pronounced bitter aftertaste, and a quite crumbly texture. Every 100 g of biscuits contained 459.28 kcal of energy, 15.33% protein, 16.725% fat, 61.87% carbohydrate by difference, 1.26% ash, and 4.82% water. These biscuits can be used as an alternative MPASI as a source of energy and protein, with a recommended consumption of 19 pieces per day, weighing 4 g per piece. These biscuits can meet the daily energy intake needs of underweight toddlers by 22.5%, protein by 20.1%, fat by 21.2%, and carbohydrate by 24.2%.

AUTHOR CONTRIBUTION

Alfin Nur Izzati: Investigation, writing (original draft), formal analysis. **Friska Citra Agustia**: Investigation, writing (original draft), writing (review & editing), supervision, conceptualization, funding acquisition, formal analysis. **Gumintang Ratna Ramadhan**: Investigation, writing (original draft), writing (review & editing), supervision, conceptualization. **Kifayati Rosiyanti Dewi**: Writing (review & editing), formal analysis. **Ponjan Walter**: Review and editing manuscript.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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