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Protein Quality of Legume-Based Milk Pudding as an Alternative Snack for Malnourished Toddlers

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Abstract: Malnutrition in early childhood can hinder children's development and their potential in their upcoming productive ages. The prevalence of wasting among children under five in Indonesia was 7.4% in 2025. This study developed a complementary feeding product in the form of milk pudding with the addition of mung beans, soybeans, and red beans. The study aimed to analyze the protein content, protein digestibility, and acceptability of the legume-based milk pudding. A completely randomized design (CRD) was used, consisting of treatment groups with the addition of mung beans, soybeans, and red beans (F1, F2, F3) and a control group (FK). Each treatment group was replicated twice, resulting in a total of eight experimental units. The results showed that pudding F2, with the addition of 120 g mung beans, 60 g soybeans, and 120 g red beans, had the highest total protein content (2.80%) and a protein digestibility value of 61.86%. There was a significant difference among groups in total protein content (P = 0.002), but no significant difference in protein digestibility (P = 0.834). The highest acceptance value was found in pudding F3, with color, aroma, texture, and taste scores ranging from 3.13 to 3.80. There were no differences among groups in aroma, taste, and texture (P > 0.05), whereas color showed significant differences among treatment groups (P = 0.001). Milk pudding with mung beans, soybeans, and red beans can serve as an alternative local snack food, contributing approximately 12.25% to the daily protein requirements of toddlers.

Keywords: legumes, mung beans, protein, pudding, red beans, soybeans

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INTRODUCTION

Nutrition is a crucial determinant of toddlers' healthy growth and development, as they grow and develop rapidly and irreversibly; therefore, nutritional deficiencies occurring during this phase cannot be fully corrected in later stages of life (Ramlah, 2021). Undernutrition in early childhood adversely affects physical growth, cognitive development, and productivity in adulthood. One of the primary causes of undernutrition among toddlers is inadequate energy and protein intake, which is often associated with inappropriate complementary feeding practices and limited parental nutrition knowledge (Nuradhiani, 2023).

According to the 2024 Indonesian Nutrition Status Survey (SSGI), the prevalence of wasting among children under five years of age in Indonesia is 7.4%, while West Java Province reported a prevalence of 4.4%. However, several districts and cities in West Java show relatively high prevalence rates, including Cirebon City (6.9%) and Karawang Regency (7.3%) (Ministry of Health of the Republic of Indonesia, 2025). One of the key strategies for overcoming undernutrition is the provision of supplementary foods formulated with balanced nutritional composition and standardized portion sizes (Aghnita, 2017).

Protein is an essential macronutrient that plays a vital role in the formation of body tissues, enzymes, and hormones (Panjaitan & Sutriningsih, 2021). Adequate protein intake is critical for preventing growth and developmental disorders in children (Mayar & Astuti, 2021). The recommended daily protein intake for toddlers is 15 g for children between 6 and 11 months, 20 g for children from 1 to 3 years, and 25 g for children aged 4 to 5 years (Ministry of Health of the Republic of Indonesia, 2019).

Legumes are among the most accessible and affordable sources of protein for the community, including mung beans, soybeans, and red beans. Mung beans contain 22.9 g of protein per 100 g, while soybeans and red beans contain 40.4 g and 22.1 g, respectively, per 100 g (Ministry of Health of the Republic of Indonesia, 2018). The protein digestibility of cooked red beans is reported to be 63.74% (Nosworthy et al., 2018), while boiled soybeans and mung beans have digestibility values of 48.71% and 49.9%, respectively (Ketnawa & Ogawa, 2021; Prachansuwan et al., 2019). In addition to their protein content, these legumes are rich in dietary fiber, vitamins, and minerals that contribute to overall health (Sahasakul et al., 2022).

Milk pudding is a popular snack among children due to its soft texture and sweet taste. This product has the potential to be developed into a high-energy and high-protein snack by incorporating local nutrient-dense food ingredients, such as legumes (Al Fatin, 2021). The protein and calcium content of milk further enhances the nutritional value of milk pudding, making it beneficial for supporting bone growth and overall child development (Adina, 2022; Santi, 2021).

The development of milk pudding enriched with mung beans, soybeans, and red beans offers potential as a nutritious snack alternative for undernourished toddlers. This study aimed to evaluate the protein content and quality, protein digestibility, and acceptability of milk pudding formulated with these legumes. The product was expected to serve as a nutritious supplementary food that could increase protein intake and support optimal growth and development in undernourished toddlers.

METHODS

Study Site and Period

The development of the pudding formulations and the acceptability tests were conducted at the Nutrition Laboratory of KHAS Kempek Institute of Health Sciences. Analysis of protein content and protein digestibility was carried out at the Laboratory of the Department of Food Technology and Agricultural Products, Faculty of Agricultural Technology, Universitas Gadjah Mada. The study was conducted from June to August 2023.

Design and Samples

This study employed an experiment using a completely randomized design (CRD). The treatments consisted of different types and amounts of legumes added to the milk pudding formulations. Four treatment levels were applied, namely milk pudding without legume addition (FK); milk pudding with the addition of 60 g mung beans, 120 g soybeans, and 120 g red beans (F1); milk pudding with 120 g mung beans, 60 g soybeans, and 120 g red beans (F2); and milk pudding with 120 g mung beans, 120 g soybeans, and 60 g red beans (F3).

Table 1

Experimental Design of Legume-Based Milk Pudding

Formulation Ratio (M: S: R)	Replication	
	1	2
FK = 0 g : 0 g : 0 g	FK-1	FK-2
F1 = 60 g : 120 g : 120 g	F1-1	F1-2
F2 = 120 g : 60 g : 120 g	F2-1	F2-2
F3 = 120 g : 120 g : 60 g	F3-1	F3-2

Notes: FK = Control formulation (without legume addition)
F1,2,3 = Formulations 1, 2, and 3 (with legume addition)
M = mung beans, S = soybeans, R = red beans

Each treatment was conducted in two replications, with duplicate analyses performed for protein content and protein digestibility. The total number of samples consisted of eight experimental units, comprising four treatment groups with two replications each. Protein content and protein digestibility analyses were performed on all experimental units.

The acceptability test was conducted by 30 semi-trained panelists, who evaluated the milk pudding products formulated with mung beans, soybeans, and red beans based on color, aroma, texture, and taste attributes.

Legume-Based Milk Pudding Preparation Procedure

The study began with the preparation of milk pudding products formulated with mung beans, soybeans, and red beans. Subsequently, protein content was analyzed using the Kjeldahl method, protein digestibility was evaluated using an in vitro multi-enzyme method, and product acceptability was assessed using a five-point Likert scale ranging from 1 (strongly dislike) to 5 (strongly like).

The product formulations are presented in Table 2. The pudding preparation process began with the sorting and washing of mung beans, soybeans, and red beans, followed by a 6-hour soaking at room temperature to improve sensory quality and reduce antinutritional compounds (Sari, 2020; Cindy, 2019; Soeparyo et al., 2018). Subsequently, mung beans and red beans were boiled for approximately 20 minutes, while soybeans were boiled for approximately 30 minutes over low heat until evenly cooked (Oktafira & Setiawan, 2022; Soeparyo et al., 2018; Palupi et al., 2015), followed by a blending process until smooth.

Table 2

Formulation of Legume-Based Milk Pudding

Ingredients	Formulation			
	FK	F1	F2	F3
Mung beans (g)	0	60	120	120
Soybeans (g)	0	120	60	120
Red beans (g)	0	120	120	60
Jelly powder (g)	3.5	3.5	3.5	3.5
Sugar (g)	35	35	35	35
Milk (ml)	100	100	100	100
Water (ml)	100	100	100	100

The preparation of pudding was done by mixing unflavored jelly powder, granulated sugar, water, and milk until homogeneous, followed by heating with continuous stirring until the pudding was boiled. After heating was discontinued, the blended legumes were added to the mixture according to the formulation, allowed to stand for approximately 5 minutes to reduce the steam, and then poured into molds to set.

The equipment used in this study included a digital kitchen scale, plastic measuring cups, a glass blender, a stainless-steel saucepan and tablespoons, bowls, and pudding molds. The sample materials used in this study consisted of mung beans, soybeans, red beans, unflavored jelly powder, granulated sugar, and Ultra-High-Temperature (UHT) full-cream milk.

Protein Quality Analysis Procedures

Protein content was determined using the Kjeldahl method, which involved sample preparation, digestion, distillation, and titration. Approximately 1 g of the sample was placed in a Kjeldahl flask, and potassium sulfate and copper sulfate were added as catalysts, along with concentrated sulfuric acid. The mixture was heated until a clear solution was obtained. After cooling, the solution was diluted with distilled water, followed by the addition of zinc and 50% NaOH to release ammonia. The solution was then filtered, and the liberated ammonia was collected in a 0.1 N HCl solution using phenolphthalein as an indicator. Subsequently, the distillate was titrated with 0.1 N NaOH until a stable pink endpoint was reached. All analyses were performed in triplicate with blank determination. Protein content was calculated based on the nitrogen percentage (%N) obtained through multiplying the nitrogen value by an appropriate conversion factor (Hartono et al., 2016).

In vitro protein digestibility was determined using a multi-enzyme method involving trypsin, chymotrypsin, and peptidase. This method was based on the enzymatic hydrolysis of sample proteins by the enzyme mixture, resulting in a decrease in the pH of the protein suspension. The pH value was measured at 10 minutes and used to calculate protein digestibility using the regression equation $Y = 210.464 - 18.103X$, where Y represents protein digestibility (%); X denotes the pH of the protein suspension at 10 minutes (Kanaka & Ayustaningwarno, 2015).

Data Analysis

Protein content and protein digestibility data were analyzed using one-way analysis of variance (ANOVA) to determine differences in mean values among the four treatment groups. Product acceptability data were analyzed using the Kruskal–Wallis test; when significant differences were observed, the Mann–Whitney U test was applied to identify differences between samples. Statistical analyses were performed using SPSS software, with the significant level set at $p < 0.05$.

RESULTS AND DISCUSSION

Protein Content of Legume-Based Milk Pudding

The total protein content of the control formulation (FK) was 2.45%, while the F1 formulation contained 2.16% protein. The protein content of formulation F2 was 2.80%, and formulation F3 showed the lowest protein content at 1.76%. Statistical analysis revealed a p-value of 0.002 ($p < 0.05$), indicating a significant difference in protein content among the treatments. This result demonstrated that the addition of mung beans, soybeans, and red beans had a statistically significant effect on the total protein content of the milk pudding.

Legume-based milk pudding exhibited protein contents ranging from 1.76 to 2.80 g/100 g, which were lower than those of raw legumes. Protein degradation may occur due to thermal and mechanical processing, causing protein denaturation. This finding is consistent with the study by Agustina and Rahmawati (2016), who report that the average protein content of mung bean sprouts decreases 1.66% and 0.63%, respectively, before and after cooking.

Table 3

Protein Content Analysis (%)

Formulation	Mean ± SD	p value*
FK	2.45 ± 0.30	
F1	2.16 ± 0.41	0.002
F2	2.80 ± 0.08	
F3	1.76 ± 0.25	

Notes: *One-way ANOVA test

Furthermore, formulation F1 showed a lower protein content than the control formulation (2.16% vs. 2.45%). Legumes contain antinutritional compounds such as phytates, which can form insoluble complexes with proteins, thereby reducing protein bioavailability. Phytate levels can be reduced through fermentation, particularly in soybeans; however, heat treatment alone is less effective in decreasing phytate content (Perdani & Utama, 2020).

Protein content may also decline during the soaking process due to the leaching of water-soluble proteins into the soaking medium. Amino acids such as lysine, arginine, histidine, aspartic acid, and glutamic acid are among the most water-soluble and are prone to loss during soaking (Widjajaseputra et al., 2019). This result aligns with previous findings by Widjajaseputra et al. (2019), which demonstrates that soaking mung beans reduces crude protein content from 26.64% to 23.52%, resulting in protein solubilization into the soaking water.

The boiling process may further reduce protein content, as soluble peptide molecules can leach into the boiling water or be lost during prolonged heating. A study by Roy et al. (2021) reports a reduction in protein content of red beans from 26.08% to 24.30% after boiling. Similar results are observed in soybeans, where boiling resulted in lower protein content compared to steaming (17.38% vs. 18.84%) (Anggreany & Ganesy, 2024).

Overall, formulations F1 and F3 exhibited lower protein content compared to the control formulation, which could be attributed to the combined effects of soaking and boiling processes that reduce legume protein content, as well as the limited effectiveness of heat treatment alone in eliminating antinutritional phytates.

Protein Digestibility of Legume-Based Milk Pudding

The control formulation (FK), consisting of milk pudding without legume addition, exhibited the highest protein digestibility value (74.32%). However, statistical analysis showed that the mean protein digestibility among all formulations did not differ significantly, with a p-value of 0.480 ($p > 0.05$). Among the legume-based formulations, product F3 demonstrated the highest protein digestibility (74.17%), followed by F1 (71.26%), while formulation F2 showed the lowest protein digestibility (61.86%). The addition of mung beans, soybeans, and red beans did not result in a statistically significant effect on the protein digestibility of the milk pudding.

Table 4

Protein Content Analysis (%)

Formulation	Mean ± SD	p value*
FK	74.32 ± 10.34	
F1	71.26 ± 18.12	0.480
F2	61.86 ± 3.02	
F3	74.17 ± 17.05	

Notes: *Kruskal-Wallis test

Overall, the protein digestibility of milk pudding formulated with mung beans, soybeans, and red beans ranged from 61.86% to 74.32%. It indicates that consuming 100 g of legume-based milk pudding would allow approximately 61.86–74.32% of the contained protein to be digested. These findings are consistent with a study by Palupi and Rahmatika (2022), that protein digestibility values range from 45.08% to 66.66% in various soybean-based products. In that study, black soybean tempeh exhibits the highest protein digestibility, whereas black soybean tempeh milk shows a reduced digestibility value. Such variations suggest that both the type of raw material and processing methods play a crucial role in determining protein digestibility (Palupi & Rahmatika, 2022).

Extended processing and exposure to high temperatures may reduce protein digestibility due to increased interactions between proteins and antinutritional compounds (Palupi & Rahmatika, 2022). Besides, the presence of dietary fiber and polysaccharides in food materials may further decrease protein digestibility by limiting the access of protease during protein hydrolysis, as reported by Opazo-Navarrete et al. (2019). These findings support the present study, indicating that both raw material characteristics and the applied processing techniques influence the protein digestibility of legume-based milk pudding.

Acceptability of Legume-Based Milk Pudding

Data obtained from the panelists were first tested for normality using the Shapiro–Wilk test, as the sample size was fewer than 30. The results indicated a p-value < 0.01, demonstrating that the data were not normally distributed; therefore, further analysis was conducted using the Kruskal–Wallis test. The results showed that the addition of mung beans, soybeans, and red beans did not result in significant differences in aroma, texture, and taste of the legume-based milk pudding, with p-values of 0.108, 0.170, and 0.446, respectively (p > 0.05). However, a significant difference was observed for the color parameter among the FK, F1, F2, and F3 formulations (p = 0.001).

Table 5

Formulation of Legume-Based Milk Pudding

Parameter	Formulation				p value*
	FK	F1	F2	F3	
Color	4.13 ± 0.51[a]	3.03 ± 0.72[b]	3.17 ± 0.75[b]	3.27 ± 0.69[c]	0.001
Aroma	3.67 ± 1.09	3.37 ± 0.62	3.43 ± 0.77	3.13 ± 0.63	0.108
Texture	3.73 ± 0.58	3.43± 0.82	3.50 ± 0.73	3.80 ± 0.71	0.170
Taste	3.47± 0.94	3.30 ± 0.70	3.30 ± 0.75	3.63 ± 0.85	0.446

Notes : *Kruskal-Wallis test
[a, b, c] Different symbols indicating significant differences

Color of Legume-Based Milk Pudding

Panelists gave the highest preference for the color of the control formulation (FK), with a mean score of 4.13 (liked) because it exhibited a brighter white appearance compared to puddings containing mung beans, soybeans, and red beans (F1, F2, and F3). The addition of legumes resulted in a cloudy white color in the milk pudding. According to a study by Afiska et al. (2021), panelists tend to prefer pudding formulations with brighter colors; reporting the greatest color acceptance rate in puddings containing 70 g of red beans compared to formulations with 100 g and 120 g red beans. Increasing the amount of red beans leads to a more reddish and turbid appearance due to the natural pigments present in red beans (Afiska et al., 2021).

Formulation F3 achieved a color score of 3.27, which fell into the moderately liked category and showed better color quality compared to F1 and F2. This difference was likely attributable to the lower amount of red beans used in F3 (60 g), whereas F1 and F2 each contained 120 g. Higher levels of red bean produced a darker and more turbid pudding color. As color is a primary determinant of food appearance, an attractive one can significantly influence panelists' preferences for a product (Ummah et al., 2020). It also plays a crucial role in shaping consumer acceptance and willingness to try a food product (Kusuma et al., 2022).

Aroma of Legume-Based Milk Pudding

The control formulation (FK) received the highest aroma acceptance score from panelists, with a mean value of 3.67 (liked). Milk pudding generally revealed a pleasant and acceptable aroma to consumers. Among the legume-based formulations, F1 achieved the highest aroma score (3.43; moderately liked) compared to F2 and F3. However, statistical analysis revealed no significant differences in aroma among treatments ($p = 0.108$). This finding is consistent with the study by Afiska et al. (2021), which reveals no significant differences in aroma among three egg pudding formulations supplemented with red beans ($p = 0.331$).

According to Kusuma et al. (2022), the addition of red beans may introduce a beany or grassy aroma that is less preferred by panelists. This off-flavor is associated with lipoxygenase activity originating from red beans (Afiska et al., 2021). Similar findings have been reported in soyghurt products, where the addition of soybeans resulted in lower aroma acceptance due to the presence of volatile compounds such as n-pentanal and n-hexanal, which naturally occur in soybeans (Afiatna et al., 2025). Furthermore, studies on biscuit products have shown that increasing the amount of mung beans added results in reduced aroma acceptance due to a stronger beany odor (Kamilia & Riandini, 2023).

Texture of Legume-Based Milk Pudding

The highest texture acceptance was observed in formulation F3, with a mean score of 3.80 (liked). Nevertheless, no significant differences were found among treatments for texture ($p = 0.170$). This result could be attributed to the use of the same total amount of legumes (200 g) in formulations F1, F2, and F3, which minimized differences in textural characteristics. In addition, all formulations used an identical ratio of liquid to jelly powder, consisting of 200 mL of liquid and 3.5 g of jelly powder.

The organoleptic evaluation of texture showed relatively uniform acceptance scores across all formulations, ranging from 3.43 to 3.80, which fall within the moderately liked to liked categories. Since milk pudding generally has a soft and elastic texture, increasing the amount of mung beans, soybeans, and red beans will raise the concentration of dissolved solids relative to the solvent in the pudding mixture before processing, and may result in a slightly firmer texture (Afiska et al., 2021; Kusuma et al., 2022).

Taste of Legume-Based Milk Pudding

Panelists' preference for taste indicated that formulation F3 received the highest acceptance score, with a mean value of 3.63 (liked). This formulation contained 120 g of mung beans, 120 g of soybeans, and 60 g of red beans. However, statistical analysis demonstrated no significant differences in taste among the treatments ($p = 0.446$). This outcome was likely due to the uniform formulation of sweetness across all samples, as each pudding contained the same amounts of granulated sugar (35 g) and UHT milk (100 mL), as well as an equal total amount of legumes (200 g).

These findings are consistent with the study by Solikhah et al. (2023), reporting no significant differences in taste among three pudding formulations made from red bean milk and mung beans (p = 0.350). Moreover, Kusuma et al. (2022) have discovered that mung beans, which contain glucose, can enhance the sweetness intensity of pudding products. In line with this observation, formulation F3, containing 120 g of mung beans, exhibited the highest taste acceptance compared to the control formulation (without legume addition) and formulation F1 with only 60 g of mung beans.

Serving Size of Legume-Based Milk Pudding

According to Badan Pengawas Obat dan Makanan (BPOM) or Indonesian Food and Drug Authority, serving size is defined as the amount of processed food consumed in a single eating occasion, and it is expressed in appropriate household measurement units for the specific food product (Indonesian Food and Drug Authority, 2019). As stated in the 2019 Recommended Dietary Allowances (RDA), children aged 1–5 years require approximately 20–25 g of protein per day (Ministry of Health of the Republic of Indonesia, 2019). Based on the Indonesian Food and Drug Authority (2019), a food product may be classified as high in protein if it provides at least 20% of the recommended RDA, indicating that the pudding should contain a minimum of 4–5 g of protein per serving.

Table 6

Contribution of Legume-Based Milk Pudding to the RDA

Age Group	Nutrient	Formulation	Pudding Content	BPOM Standard	RDA	%RDA per Serving
Children aged 1-5 years	Protein	FK	2.45 g	4 g	20 g	12.25
		F1	2.16 g			10.8
		F2	2.80 g			14.0
		F3	1.76 g			8.8

Formulation F2 of the legume-based milk pudding contained 2.80 g of protein per 100 g, with a protein digestibility value of 61.87%, and acceptability scores for color, aroma, texture, and taste ranging from 3.17 to 3.50. Based on these findings, the recommended serving size for formulation F2 is 150 g, which provides approximately 20% of the Recommended Dietary Allowance (RDA), corresponding to a protein content of 4.2 g per 150 g of product.

CONCLUSION

Formulation F2 of legume-based milk pudding, containing 120 g of mung beans, 60 g of soybeans, and 120 g of red beans, exhibited the highest protein content (2.80 g/100 g) with a protein digestibility value of 61.87%. Statistical analysis demonstrated that protein content differed significantly among treatments (p = 0.002), whereas protein digestibility did not show significant differences across formulations (p = 0.480). The highest overall acceptability was observed in formulation F3 (120 g mung beans, 120 g soybeans, and 60 g red beans), with mean scores for color, aroma, texture, and taste of 3.27, 3.13, 3.80, and 3.63, respectively. Statistical testing revealed a significant difference in color among milk pudding formulations (p = 0.001), while no significant differences were found for aroma, texture, or taste (p > 0.05).

Legume-based milk pudding formulated with mung beans, soybeans, and red beans may serve as a locally available snack alternative for toddlers, providing 2.80 g of protein per 100 g and contributing approximately 12.25% of the Recommended Dietary Allowance (RDA) for protein. Future studies are recommended to optimize processing temperatures and to utilize high-protein milk to further enhance protein content and protein digestibility of the product.

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Author Contribution Statement

Mir'ah Firdausi: Conceptualization, product development, data analysis, manuscript writing. **Utami Harjantini**: Manuscript writing and review, data validation. **Muhana Rafika**: Data validation, manuscript review. **Husnul Khatimah**: Manuscript review, translation.

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