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SUBSTITUTION OF SHRIMP FLOUR AND TEMPEH IN MAKING TORTILLA CHIPS AS A HIGH-PROTEIN SNACK

Substitusi Tepung Udang Rebon dan Tempe pada Pembuatan Tortilla Chips sebagai Camilan Tinggi Protein

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ABSTRACT

One of the snacks that are widely favored by children is tortilla chips, but generally contain high carbohydrates but low protein. Shrimp flour and tempeh can be substituted in making tortilla chips to increase protein content. Shrimp flour contains 48.83% protein, while tempeh flour contains 27.73% protein. This study aims to substitute shrimp flour and tempeh in making tortilla chips as a high-protein snack. This study used a true experimental design with a Completely Randomized Design (CRD) with 3 treatment levels, namely F1 (10:20), F2 (15:15), and F3 (20:10). The results showed that the best formulation was F2 (15:15) with the characteristics of brownish yellow color, slightly fragrant shrimp, slightly salty taste, crunchy texture, and slightly bitter aftertaste. The best formulation contains 3.42% water, 0.09% acid-insoluble ash, 16.28% protein, 19.44% fat, 53.04% carbohydrates, and 452.24 kcal/100 g total energy. The protein content of the best formulation has met the requirements for a high protein claim. The conclusion of this study is that the substitution of rebon shrimp flour and tempeh in tortilla chips can be used as a high-protein snack. This product has the potential to be used as a functional snack to prevent stunting in children.

Keyword : *rebon shrimp; snacks; tempeh; tortilla chips*

ABSTRAK

Salah satu camilan yang banyak digemari oleh anak-anak adalah *tortilla chips*, namun umumnya mengandung tinggi karbohidrat tetapi rendah protein. Tepung udang rebon dan tempe dapat disubstitusikan ke dalam pembuatan *tortilla chips* untuk meningkatkan kandungan protein. Tepung udang rebon mengandung 48.83% protein, sedangkan tepung tempe mengandung 27.73% protein per 100 g. Penelitian ini bertujuan untuk melakukan substitusi tepung udang rebon dan tempe pada pembuatan *tortilla chips* sebagai camilan tinggi protein. Penelitian ini menggunakan *true experimental design* dengan Rancangan Acak Lengkap (RAL) 3 taraf perlakuan, yaitu F1 (10:20), F2 (15:15), dan F3 (20:10). Hasil penelitian menunjukkan bahwa formulasi terbaik adalah F2 (15:15) dengan karakteristik warna kuning kecoklatan, agak beraroma udang rebon, rasa agak asin, tekstur renyah, dan *aftertaste* sedikit pahit. Formulasi terbaik mengandung 3.42% air, 0.09% abu tidak larut asam, 16.28% protein, 19.44% lemak, 53.04% karbohidrat, dan 452.24 kkal/100 g energi total. Kadar protein formula terbaik telah memenuhi syarat klaim tinggi protein. Kesimpulan penelitian ini adalah substitusi tepung udang rebon dan tempe pada *tortilla chips* dapat dijadikan sebagai camilan tinggi protein. Produk ini berpotensi dijadikan camilan fungsional untuk pecegahan stunting pada anak.

Kata Kunci : camilan; tempe; *tortilla chips*; udang rebon

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INTRODUCTION

Stunting is a condition in which children experience growth failure, both in physical development and brain development, due to long-term malnutrition. This condition occurs from the fetal stage in the womb until the first 1000 days of life (Kementrian Kesehatan RI, 2024). Based on data from the World Health Organization, the global prevalence of stunting among children under five years old in 2022 was 22.3% (WHO, 2024). The results of Indonesian Health Survey in 2023 showed that the prevalence of stunting in Indonesia reached 21.5% in 2023. At the provincial level, the prevalence of stunting in West Java in 2023 reached 21.7%, while in Karawang Regency, the stunting rate increased from 14.0% in 2022 to 17.1% in 2023 (SKI, 2023). Stunting can be influenced by various factors, one of which is inadequate nutritional intake. Therefore, fulfilling nutritional needs is an important step in supporting children's growth and development. One of the efforts to prevent stunting is by increasing and improving the intake of hight-protein foods (Ummah et al., 2020). This effort can be carried out through the utilization of innovative food products made from high-protein ingredients, such as small shrimp (rebon shrimp) and tempeh (Meilasari & Adisasmito, 2024).

Rebon shrimp (*Acetes sp.*) are one of the marine products classified as white shrimp with a very small size of around 1-3 cm and are rich in protein (Multazam et al., 2023). The protein content in dried rebon shrimp is higher than that of chicken eggs (12.4 g), beef (17.5 g), and chicken meat (18.2 g) (Kementrian Kesehatan RI, 2020). In addition to having high nutritional value, its affordable price and abundant availability make rebon shrimp highly potential as an alternative source of animal protein for stunting prevention (Meilasari & Wiku Adisasmito, 2024). Rebon shrimp contains glutamic amino acid, which plays a role in enhancing the savory taste of food products (Suparmi et al., 2021). Tempeh is also a source of protein that can be utilized in stunting prevention. Tempeh is a fermented soybean product made using the mold *Rhizopus sp* which has high nutritional value and is considered a functional food. The protein contained in tempeh is easily digestible, making it beneficial for increasing body weight in toddlers (Yarmaliza & Syahputri, 2020). Based on data from the

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Indonesian Food Composition Table in 2020, 100 g of tempeh contains 20.8 g of protein (Kementrian Kesehatan RI, 2020).

The level of consumption of tempeh by Indonesian people as an alternative protein source food tends to remain relatively low, amounting to only 0.136 kg per week (BPS, 2024). Tempeh and rebon shrimp are food ingredients that have the potential to increase the protein content of food products. Rebon shrimp contains animal protein with a complete composition of essential amino acids, especially lysine, methionine, and tryptophan, resulting in a high biological value of protein. Meanwhile, tempeh is a source of plant-based protein that is rich in lysine and easily digestible because the fermentation process by the mold *Rhizopus sp* increases its protein bioavailability. The combination of animal protein from rebon shrimp and plant-based protein from tempeh produces complementary protein, in which the amino acids lacking in one ingredient can be complemented by the other. Therefore, the use of these two ingredients in tortilla chips formulation not only increases the total protein content but also improves the overall protein quality, making it more suitable for helping meet the protein needs of early childhood in efforts to prevent stunting.

Tempeh and rebon shrimp are food ingredients that are highly perishable (Multazam et al., 2023). Processing these two ingredients into flour form provides several advantages, including extending shelf life, facilitating handling and mixing in product formulations, and improving dough homogeneity. Drying food ingredients into flour can also increase their economic value and simplify their application in food products, while maintaining and even enhancing their nutritional content. However, the drying and flouring processes may also cause several drawbacks, such as color changes, stronger aroma, and potential alterations in the functional properties of proteins. In this study, the potential drawbacks were controlled through standardized drying and sieving processes, as well as flour proportion formulations that were tested organoleptically to ensure they did not interfere with the characteristics of the final product. Tortilla chips are snack foods that are widely favored by children and adolescents (Silvia et al., 2024). This product is a type of snack similar to traditional Mexican chips made primarily from corn flour (Panjaitan et al., 2020). Tortilla chips

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have a crispy texture, yellow color, flat triangular shape, and a distinctive corn flavor (Wijayati et al., 2022). Traditionally, tortilla chips are made from corn flour; however, various studies and commercial tortilla chip products have developed formulations by partially substituting corn flour with other food ingredients. As long as the physical characteristics and processing methods remain consistent with the general tortilla chip production process, the partial substitution of corn flour with rebon shrimp flour and tempeh flour can still be categorized as tortilla chips, with the purpose of improving nutritional value without eliminating the product's basic identity.

Tortilla chips are a type of snack food that is high in carbohydrates but low in protein. Therefore, one effort that can be made to increase the protein content of tortilla chips is through the substitution of rebon shrimp flour and tempeh flour (Indriyani et al., 2022). Processing the ingredients into flour does not significantly damage their protein content because the drying process is carried out at a relatively safe temperature (approximately 60–70°C). At this temperature, proteins only undergo mild denaturation, which does not reduce the total protein content. In addition, the protein content used in this study was based on laboratory analysis of the final tortilla chips product, meaning that the reported value represents the actual protein content consumed. Besides improving nutritional value, this substitution can also enhance the sensory quality of tortilla chips products (Indriyani et al., 2023). Based on the background above, the researcher is interested in substituting rebon shrimp flour and tempeh flour in making of tortilla chips as a high-protein snack.

METHOD

Design, Setting, and Timeline

This study employed a true experimental design using a Completely Randomized Design (CRD). The production of tortilla chips substituted with rebon shrimp flour and tempeh was carried out using three treatment levels. The treatment ratios of rebon shrimp flour and tempeh substitution used in this study consisted of: F1 (10:20), F2 (15:15), and F3 (20:10). These percentages indicate the proportion of rebon shrimp flour and tempeh relative to the corn flour used. Thus, the F1 treatment (10:20) means that

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30% of the total corn flour was substituted with tempeh flour (10%) and rebon shrimp flour (20%), while the remaining 70% consisted of corn flour. This composition was consistently applied in F2 and F3 according to the predetermined substitution percentages. The production of tortilla chips and organoleptic testing were conducted at the Food Industry Laboratory, Faculty of Health Sciences, University of Singaperbangsa Karawang. Nutritional content analysis (moisture, ash, protein, fat, and carbohydrate content) was carried out at the Nutrient Analysis Laboratory, Faculty of Health Sciences, University of Singaperbangsa Karawang. Sodium content testing was conducted at the Regional Health Laboratory Jakarta. This study was conducted from March to June 2025.

Research Tools and Materials

Tools used in the production of tortilla chips substituted with rebon shrimp flour and tempeh flour included a digital scale, knife, cutting board, spoon, baking tray, basin, stove, spatula, blender, pot, measuring cup, oven, pasta roller, oil strainer, 4 × 4 cm triangular mold, and frying pan. Tools used for nutritional content analysis included porcelain crucibles, oven, desiccator, analytical balance, crucible tongs, muffle furnace, complete distillation apparatus, complete Kjeldahl heating apparatus connected to a steam suction device, Soxhlet extraction apparatus (condenser and electric heater), and Inductively Coupled Plasma – Optical Emission Spectroscopy (ICP-OES). The materials used to make tortilla chips consisted of corn flour,

The ingredients used to make tortilla chips consisted of corn flour, tapioca flour, wheat flour, dried rebon shrimp, tempeh, salt, pepper, garlic, and cooking oil. The materials used for nutritional content analysis included tortilla chips samples, 15 ml of H_2SO_4 (sulfuric acid), 1 g Kjeldahl tablets, 4 boiling stones, 250 ml of 40% NaOH, 10 ml of 3% H_3BO_3 (boric acid), 2 ml of 0.1% methyl red, 10 ml of 0.1% bromocresol green, 50 ml of 0.1 N HCl (hydrochloric acid), 2–3 drops of phenolphthalein indicator, non-polar solvent (hexane), distilled water (aquadest), and HNO_3 (nitric acid).

Preparation of Rebon Shrimp Flour

The preparation of rebon shrimp flour referred to the study by Yani (2022) with

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modifications. The initial stage of making rebon shrimp flour involved sorting and cleaning the previously purchased dried rebon shrimp from any attached impurities, followed by washing them thoroughly. After that, the rebon shrimp were drained to reduce their moisture content, then dry-roasted over medium heat at a temperature of 70°C for approximately 10 minutes to produce dried rebon shrimp. The dried shrimp were ground using a blender to obtain a fine flour texture, then sieved using an 80-mesh sieve.

Preparation of Tempeh Flour

The preparation of tempeh flour referred to the study by Lailatul & Anna (2019). The tempeh selected for making tempeh flour was fresh tempeh, which was then thinly sliced and steamed in hot water vapor at a temperature of 105°C for 10 minutes. After steaming, the tempeh was drained to reduce its moisture content and cooled at room temperature. The next process was drying, which was carried out using an oven at 60°C for 6–7 hours. After that, the tempeh was ground using a blender for 3 minutes until a fine tempeh flour was obtained. The resulting flour was then sieved using an 80-mesh sieve.

Preparation of Tortilla Chips Substituted with Rebon Shrimp Flour and Tempeh Flour

The first step in making tortilla chips substituted with rebon shrimp flour and tempeh flour was preparing all ingredients, including corn flour, tapioca flour, wheat flour, rebon shrimp flour, tempeh flour, salt, pepper, mashed garlic, and warm water. Next, all ingredients were mixed and stirred evenly. The well-mixed dough was then steamed for 15 minutes at a temperature of 70°C. The procedure continued with flattening the dough using a pasta roller at setting number 5 to achieve a thickness of approximately 3 mm. After that, the dough was shaped using a 4 × 4 cm triangular mold, and the tortilla pieces were dried in an oven at 60°C for 20 minutes. In the final step, the dough was fried in hot oil at a temperature of 100°C for approximately 7 seconds, then removed and drained.

Nutrient Content Analysis

Nutrient content analysis included moisture content analysis using the oven method, ash content analysis using the gravimetric method, protein content analysis using the Kjeldahl method, fat content analysis using the Soxhlet method, and

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carbohydrate content analysis using the by-difference method. Sodium content testing was conducted using the Inductively Coupled Plasma–Optical Emission Spectroscopy method.

Data Analysis

Data analysis was conducted using SPSS 26 and Microsoft Excel 2021. The data obtained from the organoleptic tests included hedonic tests, hedonic quality tests, and ranking tests. Statistical analysis for the hedonic and hedonic quality tests was performed using one-way ANOVA (Analysis of Variance) followed by the DMRT (Duncan Multiple Range Test) to determine the effect of rebon shrimp flour and tempeh flour substitution on each product treatment. Meanwhile, the data from the nutritional content analysis were analyzed descriptively.

RESULTS AND DISCUSSION

Organoleptic Test

The organoleptic test was conducted by 30 semi-trained panelists. The results of the hedonic and hedonic quality tests on tortilla chips substituted with rebon shrimp flour and tempeh flour using three formulations showed the average scores for the parameters of color, aroma, taste, texture, and aftertaste. The data from the hedonic test of tortilla chips with rebon shrimp flour and tempeh flour substitution can be seen in Table 1.

Table 1. Results of hedonic test

Parameter	Mean Value ± Standard Deviation		
	F1	F2	F3
Color	4.57 ± 0.568[a]	3.93 ± 0.640[b]	3.23 ± 0.817[c]
Aroma	3.90 ± 0.803[a]	4.13 ± 0.973[a]	3.30 ± 1.119[b]
Taste	3.67 ± 0.844[a]	3.70 ± 0.750[a]	4.07 ± 0.944[a]
Texture	4.07 ± 0.740[a]	4.37 ± 0.669[a]	3.53 ± 0.681[b]
Aftertaste	3.60 ± 0.814[a]	3.80 ± 0.961[a]	3.67 ± 1.213[a]

Note:
1 = very dislike; 2 = dislike; 3 = slightly dislike; 4 = like; 5 strongly like
Different superscript letters[a, b, c] within the same row indicate a significant difference at the 5% level based on Duncan's Multiple Range Test, while the same letters indicate no significant difference.

Data analysis obtained from the hedonic and hedonic quality tests was carried out using ANOVA followed by Duncan's Multiple Range Test (DMRT) to determine differences among treatments. The average results of the hedonic quality test on tortilla

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chips substituted with rebon shrimp flour and tempeh flour are presented in Table 2.

Table 2. Results of hedonic quality test

Parameter	Mean Value ± Standard Deviation		
	F1	F2	F3
Color	4.50 ± 0.820[a]	3.20 ± 0.714[b]	2.33 ± 0.922[c]
Aroma	1.80 ± 1.126[a]	3.67 ± 0.758[b]	4.03 ± 0.809[b]
Taste	3.77 ± 0.568[a]	3.50 ± 0.777[a]	3.37 ± 1.217[a]
Texture	4.10 ± 0.759[a]	4.23 ± 0.626[a]	3.67 ± 0.844[b]
Aftertaste	4.73 ± 0.583[a]	4.77 ± 0.430[a]	4.50 ± 0.777[a]

Note:
Color : 1 = dark brown; 2 = brown; 3 = brownish yellow; 4 = yellow; 5 = bright yellow.
Aroma : 1 = no rebon shrimp aroma; 2 = slightly rebon shrimp aroma; 3 = moderately rebon shrimp aroma; 4 = rebon shrimp aroma; 5 = strongly rebon shrimp aroma.
Taste : 1 = very salty; 2 = salty; 3 = slightly salty; 4 = savory; 5 = very savory.
Texture : 1 = very hard; 2 = hard; 3 = slightly hard; 4 = crispy; 5 = very crispy.
Aftertaste : 1 = very bitter; 2 = bitter; 3 = moderately bitter pahit; 4 = slightly bitter; 5 = not bitter.
Different superscript letters[a, b, c] within the same row indicate a significant difference at the 5% level based on Duncan's Multiple Range Test, while the same letters indicate no significant difference.

Color

Color is a visual perception produced by the reflection of light from an object and captured by the sense of sight. Color plays an important role in determining the level of panelists' acceptance of food products (Parwati et al., 2021). The results of the ANOVA test on the hedonic and hedonic quality tests showed a value of 0.000 ($p<0.05$), indicating a significant difference in the panelists' preference levels toward the color of each formulation. Significant differences were found among formulations F1, F2, and F3. The differences among the three formulations were caused by the increasing proportion of rebon shrimp flour added, which resulted in a darker-colored product. Consequently, panelists tended to prefer the color of tortilla chips in F1, which contained the lowest addition of rebon shrimp flour. This finding is in line with the study conducted by Rosida (2024), which reported that the lowest addition of rebon shrimp flour, namely 2.5%, with a corn flour to tapioca flour proportion of 95:5, showed the highest level of preference for the color of tortilla chips. Meanwhile, tortilla chips substituted with rebon shrimp flour and tempeh flour in F3, with a proportion of 20% : 10%, caused the tortilla chips to turn brown in color. This may be due to the high proportion of rebon shrimp flour, as 100 g of rebon shrimp contains a high protein content of 59.4%. The high protein content in rebon

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shrimp flour triggers the Maillard reaction during the frying process. This reaction occurs between reducing sugars and amino groups (NH2) from proteins, producing melanoidin compounds. The presence of these melanoidins causes the brown color to develop in tortilla chips during frying (Nafsiah et al., 2022). The results of this study are consistent with the research conducted by Ramadhania (2022), which found that higher concentrations of rebon shrimp flour resulted in crackers with a darker brown color.

Aroma

Aroma is the response of the sense of smell to volatile compounds released by food products. Aroma greatly contributes to the perception of palatability, because the more pleasant and fragrant a food product is, the higher the panelists' level of preference for the product tends to be (Suparmi et al., 2021). Based on the results of the hedonic and hedonic quality tests on the aroma parameter, there were significant differences in the panelists' preference levels toward aroma, with values of 0.004 ($p<0.05$) and 0.000 ($p<0.05$), respectively. Based on Table 1, the hedonic test showed a significant difference in formulation F3. This was caused by the strong characteristic aroma of rebon shrimp, which originated from volatile compounds formed through the degradation of proteins and amino acids in rebon shrimp during processing, resulting in a dominant fishy marine aroma. The strong aroma of rebon shrimp may reduce the panelists' preference ratings for the aroma of tortilla chips (Rosida, et al., 2023). The study conducted by Suparmi (2021) stated that there was a significant difference in the aroma parameter due to the addition of rebon shrimp flour, where the most preferred treatment was the one with the lowest addition of rebon shrimp flour, resulting in a less intense rebon shrimp aroma. Meanwhile, Table 2 shows that formulation F1 exhibited a significant difference because the resulting tortilla chips tended not to have a very pronounced rebon shrimp aroma. This may be due to the low proportion of rebon shrimp flour, which was only 10%, causing its aroma to be masked by the characteristic aroma of tempeh flour.

This finding is consistent with the study conducted by Indriyani (2023), which reported a significant difference in tortilla chips formulation F3 with the highest

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addition of tempeh, namely 30% of the corn flour percentage used. The substitution of tempeh flour in a greater amount than rebon shrimp flour most likely caused the tempeh aroma to become dominant and weakened the aroma of rebon shrimp. Tempeh flour has a distinctive aroma known as "langu." This aroma arises because tempeh is produced through fermentation by the mold *Rhizopus oligosporus*. The mold has high protease and lipase enzyme activities but low amylolytic activity, resulting in the formation of antioxidant compounds that contribute to the characteristic aroma of tempeh (Ledo, 2020). The langu aroma in tempeh has the potential to create an unpleasant perception if present in excessive amounts. However, in this tortilla chips formulation, the langu aroma did not emerge as a disturbing odor because the variation of other ingredients (seasonings, oil, and the frying process) could reduce its intensity. In addition, based on the sensory test results in this study, the panelists still showed good acceptance, indicating that the langu aroma did not lead to an unpleasant taste perception.

Taste

Taste plays a role as one of the main indicators for panelists in determining the level of acceptance of a food product. The taste of food products may originate from natural raw materials, the addition of food additives, or the processing techniques applied (Breemer et al., 2023). The results of the organoleptic hedonic and hedonic quality tests on the taste parameter showed that there were no significant differences among the formulations, with values of 0.135 ($p > 0.05$) and 0.218 ($p > 0.05$), respectively. Based on Table 1, the highest average hedonic test score was found in formulation F3, with a value of 4.07 (liked), because formulation F3 tended to have a more savory taste due to the increasing proportion of rebon shrimp flour added. Rebon shrimp flour contains glutamic acid, which contributes an umami (savory) taste to the product. However, no significant differences were found among the three formulations because the addition of salt was proportionally equal in each formulation, namely 2 g, which helped balance the salty taste of the product. The addition of 2 g of salt in each formulation represented the total amount of salt used in one batch of dough for each formulation to maintain consistency of

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taste among formulations and to control the research variables, allowing the effects of rebon shrimp flour and tempeh flour substitution on sensory characteristics to be assessed objectively. Based on Table 2, the hedonic quality test results showed that the average taste scores for each formulation exhibited a similar tendency. This finding is consistent with the study conducted by Ramadhania (2022), which reported no significant differences in the panelists' preference levels for the taste of four cracker formulations made from mocaf flour and rebon shrimp flour, because all formulations shared a savory and salty taste characteristic of rebon shrimp that tended to be more dominant.

Texture

Texture is a sensory response of the sense of touch to the physical properties of a product that can be perceived through activities in the mouth (Nafsiyah et al., 2022). Texture has an important influence on panelists' evaluations because even slight changes in texture characteristics that are considered unsuitable can reduce the panelists' level of preference for food products (Salsabila et al., 2022). The results of the ANOVA test on the hedonic and hedonic quality tests showed significant differences, with values of 0.000 ($p < 0.05$) and 0.012 ($p < 0.05$), respectively, in the texture of tortilla chips substituted with rebon shrimp flour and tempeh flour. The results of Duncan's Multiple Range Test indicated significant differences in both the hedonic and hedonic quality tests for the texture parameter in formulation F3. This difference is related to the formulation, as F3 contained the highest proportion of rebon shrimp flour and tended to produce a slightly harder texture compared to F1 and F2. This finding is consistent with the study by Rosida (2024) which stated that increasing the amount of rebon shrimp flour added can increase the hardness of tortilla chip products. The increasingly harder texture is caused by intramolecular protein interactions with other molecules present in the product. These interactions occur through hydrogen bonds, hydrophobic bonds, and covalent bonds, resulting in a denser or harder product. The F1 and F2 formulations produced a crispy texture, which may be attributed to the higher or more balanced proportion of tempeh flour compared to rebon shrimp flour. This study is consistent with the study conducted by

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Indriyani (2023), which stated that increasing the concentration of tempeh flour added to tortilla chips can produce tortilla chips that are crispy and less prone to breaking. This may be attributed to the relatively low moisture content of tempeh flour. Low moisture content can affect the texture of a product, particularly by enhancing its crispiness.

Aftertaste

Aftertaste is the sensation produced by certain compounds that remain in the mouth after consuming a food product. The perception of aftertaste experienced by panelists is influenced by the composition of the ingredients used in the food product (Asvelia & Seveline, 2023). The ANOVA results for the hedonic and hedonic quality tests showed values of 0.738 ($p > 0.05$) and 0.192 ($p > 0.05$), respectively, indicating that there were no significant differences in aftertaste among the formulations. All three formulations were categorized as having a slightly bitter aftertaste. The bitterness was attributed to both tempeh flour and rebon shrimp flour. According to a study conducted Cempaka (2018), the addition of tempeh flour in chip products can lead to a bitter aftertaste. This bitter aftertaste may result from the degradation of lipids, proteins, amino acids, and peptides during processing. The bitter aftertaste associated with tempeh flour may also result from the hydrolysis of amino acids that occurs during the Maillard reaction, both during the production of tempeh flour and throughout the frying process of tortilla chips. Several amino acids are known to contribute to a bitter taste, including lysine, arginine, proline, phenylalanine, and valine. Among these amino acids, lysine is considered the most dominant contributor to bitterness compared to the others (Lestari et al., 2023). Although rebon shrimp also contains amino acids, its contribution to bitterness is much lower than that of tempeh. This is because tempeh, as a fermented plant-based ingredient, contains higher levels of bitter-tasting amino acids. In addition, the bitter aftertaste may be attributed to the presence of soyasaponins and sapogenols, which are glycoside compounds naturally found in soybean tempeh (Depiyana et al., 2024). The shells of rebon shrimp may contribute to a bitter aftertaste because, during the processing of rebon shrimp into shrimp flour, protein–chitin hydrolysis, lipid oxidation, and the

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degradation of pigment compounds can occur, resulting in the formation of peptides that produce a bitter aftertaste.

Determination The Best Formulation

The determination of the best formulation was carried out using the Exponential Comparison Method (ECM) based on the results of the hedonic organoleptic evaluation. The ECM was applied using a set of decision-making criteria to determine the final outcome in the form of rankings or priorities (Khoirunnisa et al., 2021). The results of the best formulation determination using the Exponential Comparison Method (ECM) are presented in Table 3.

Table 3. Best Formulation Based on the Exponential Comparison Method (ECM)

Parameter	Weight	Alternative Component Scores					
		F1		F2		F3	
		Rank	Score*	Rank	Score*	Rank	Score*
Color	15%	1	0.15	2	0.3	3	0.45
Aroma	20%	2	0.4	1	0.2	3	0.6
Taste	30%	3	0.9	2	0.6	1	0.3
Texture	25%	2	0.5	1	0.25	3	0.75
Aftertaste	10%	3	0.3	1	0.1	2	0.2
Total Score	100%		2.25		1.45		2.3
Ranking		2		1		3	

As shown in Table 3, the ranking analysis based on the Exponential Comparison Method (ECM) indicated that F2 was the best formulation, having the lowest total score of 1.45. This result suggests that F2 was the optimal tortilla chips formulation, characterized by a yellowish-brown color, a slightly pronounced dried shrimp aroma, a slightly salty taste, a crispy texture, and a slightly bitter aftertaste.

Nutrient Content Analysis of the Best Formulation

Nutritional analysis was conducted on the best formulation. The analyses included proximate composition analysis, consisting of moisture, ash, protein, fat, and carbohydrate contents, as well as sodium content analysis of tortilla chips substituted with rebon shrimp flour and tempeh. The results of the nutritional analyses are presented in Table 4.

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Table 4. Results of Nutritional Content Analysis

Component	Analysis Results (% dry basis)	SNI*	RDA for Children Aged 1–3 Years	% of RDA per serving (30 g)	Nutrition NRV for children aged 1–3 years	% of NRV per 100 g
Moisture Content (%)	3.42	Max. 4	-	-	-	-
Total Ash Content (%)	11.23	-	-	-	-	-
Acid-Insoluble Ash Content (%)	0.09	Max. 0.1	-	-	-	-
Protein Content (%)	16.28		20	24.42	26	62.62
Fat Content (%)	19.44	Max. 38	45	12.96	-	-
Carbohydrate Content (%)	53.04	-	215	7.40	-	-
Total Energy (kcal)	452.24	-	1350	10.05	-	-
Sodium Content (mg)	772.3	-	800	28.96	-	-

Note:
*SNI 2886 : 2015 Extruded Snack Foods,
RDA = Recommended Dietary Allowance
NRV = Nutrition Labelling Reference Value

Moisture Content

Based on Table 4, the nutritional composition analysis showed that the moisture content of tortilla chips substituted with rebon shrimp flour and tempeh was 3.42%, indicating a low moisture level and compliance with the quality requirements specified in SNI 2886:2015 Extruded Snack Foods. The low moisture content of these tortilla chips has a positive impact on the product's shelf life, as lower moisture levels in a food product generally contribute to longer storage stability and extended shelf life (Panjaitan et al., 2020). According Indriyani (2023), low moisture content plays an important role in determining the texture of food products, as it contributes to a crispier texture. The moisture content reported by Rosida (2024) was higher than that of the tortilla chips substituted with rebon shrimp flour and tempeh. This difference may be attributed to variations in the analytical procedures and methods used during the study. In Rosida's (2024) study, moisture content was measured before the tortilla chips underwent the frying process, whereas the moisture content analysis of tortilla chips substituted with rebon shrimp flour and tempeh was conducted after frying. This difference in analytical stages may explain

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the lower moisture content observed in the tortilla chips containing rebon shrimp flour and tempeh. During frying, water evaporates from the dough, resulting in a reduction in the moisture content of the final product. This process can also promote oil absorption into the food matrix. Oil uptake occurs due to a decrease in water vapor pressure within the food, allowing oil present on the surface to penetrate and replace the water previously occupying the pores of the food structure. This mechanism continues until equilibrium is reached between the vapor pressure inside the product and at its surface, at which point further oil penetration ceases (Muchtar et al., 2023).

Acid-Insoluble Ash Content

Based on Table 4, the nutritional composition analysis showed that the acid-insoluble ash content of the tortilla chips substituted with rebon shrimp flour and tempeh was 0.09%, indicating compliance with the quality requirements specified in SNI 2886:2015 – Extruded Snack Foods, which sets a maximum limit of 0.1%. The relatively low acid-insoluble ash content indicates that the tortilla chips have a good level of cleanliness and are relatively free from acid-insoluble mineral or metallic contaminants, such as sand or soil particles. This finding suggests that both the processing conditions and the hygiene of the raw materials were well maintained, resulting in minimal levels of acid-insoluble mineral residues in the final product (Ernawati et al., 2023).

Protein Content

The nutritional composition analysis results presented in Table 4.4 showed that the protein content of the tortilla chips substituted with rebon shrimp flour and tempeh was 16.28%. This protein content was higher than that reported by Indriyani (2023) who found a protein content of 7.58% in tortilla chips supplemented with 10% tempeh flour. Furthermore, Multazam (2023) reported that crackers formulated with a ratio of rebon shrimp flour to tapioca flour of 10%:60% had a protein content of 9.03%. The protein content of the tortilla chips substituted with rebon shrimp flour and tempeh was also higher than that of the commercial tortilla chips product "*Happy Tos*", which contains 8% protein (Sholechah & Ismawati, 2023). The findings from these previous studies suggest that the combination

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of rebon shrimp flour and tempeh flour as substitution ingredients has a synergistic potential to enhance the protein content of the final tortilla chips product. Compared with the Recommended Dietary Allowance (RDA) for children aged 1-3 years, which is approximately 20 g of protein per day, a single serving (30 g) of these tortilla chips can provide 24.42% of the daily protein requirement for this age group. Furthermore, based on the Nutrition Reference Value (NRV), the product supplies 62.62% of the NRV for protein for children aged 1-3 years, which is 26 g. Therefore, the tortilla chips substituted with rebon shrimp flour and tempeh meet the requirements for a high-protein claim for children aged 1-3 years.

Fat Content

The fat content analysis of the tortilla chips substituted with rebon shrimp flour and tempeh showed a fat content of 19.44%, indicating a relatively low fat level and compliance with the quality requirements specified in SNI 2886:2015-Extruded Snack Foods, which establishes a maximum fat content of 38%. A single serving (30 g) of the tortilla chips can provide 12.96% of the daily fat requirement for children aged 1–3 years. In comparison, the commercial tortilla chips product "*Happy Tos*" contains 24 g of fat per 100 g of product (Sholechah & Ismawati, 2023). This indicates that the tortilla chips substituted with rebon shrimp flour and tempeh have a lower fat content than commercial tortilla chips.

The lower fat content may be attributed to the incorporation of protein-rich ingredients such as rebon shrimp flour, tempeh flour, and wheat flour. Gluten proteins, which consist of gliadin and glutenin, are capable of forming a dense network during hydration, thereby limiting fat absorption during the frying process. Gliadin tends to bind polar lipids through hydrophobic interactions, while glutenin contributes to the mechanical entrapment of lipids. Collectively, these mechanisms can reduce the amount of fat absorbed into the final product. In contrast, the higher fat content observed in the commercial product may be due to the absence of high-protein ingredients that help limit oil absorption, as well as industrial processing techniques that generally involve the use of larger amounts of frying oil (Krista, 2019).

Carbohydrate Content

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Based on Table 4, the carbohydrate content of the tortilla chips substituted with rebon shrimp flour and tempeh was 53.04%. Therefore, a single serving (30 g) of the tortilla chips can provide 7.40% of the daily carbohydrate requirement for children aged 1–3 years. These findings are consistent with those reported by Azizah et al., (2021), who found an average carbohydrate content of 55.71% in tortilla chips fortified with barracuda fish. Sholechah & Ismawati, (2023) reported that the carbohydrate content of the commercial tortilla chips product Happy Tos was 84%. This value is considerably higher than that observed in the tortilla chips substituted with rebon shrimp flour and tempeh. The difference may be attributed to the partial replacement of corn flour with rebon shrimp flour and tempeh flour, both of which contain higher levels of protein. This substitution reduces the proportion of carbohydrate-rich ingredients in the formulation, thereby altering the final nutritional composition of the product by increasing its protein content relative to its carbohydrate content (Azizah et al., 2021).

Total Energy Content

The results showed that the total energy content of the tortilla chips substituted with rebon shrimp flour and tempeh in the best formulation was 452.24 kcal per 100 g of product. Based on the Recommended Dietary Allowance (RDA), the daily energy requirement for children aged 1–3 years is approximately 1,350 kcal. Dietary guidelines for young children recommend that snacks or between-meal foods provide approximately 10% of the daily energy requirement per serving (Wirda, 2024). In this study, a single serving (30 g) of tortilla chips provided 135.67 kcal, contributing approximately 10.05% of the total daily energy requirement for children aged 1–3 years. Sholechah and Ismawati (2023) reported that the energy content of the commercial tortilla chips product Happy Tos was 520 kcal per 100 g. This finding indicates that the tortilla chips substituted with rebon shrimp flour and tempeh contain less energy than the commercial product. The lower total energy content of these tortilla chips is associated with their lower fat content compared to commercial tortilla chips. Among the macronutrients, fat contributes the greatest

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amount of energy, providing 9 kcal per gram (Rohmayanti et al., 2019).

Sodium Content

The nutritional composition analysis presented in Table 4 showed that the sodium content of the tortilla chips substituted with rebon shrimp flour and tempeh was 772.3 mg per 100 g of product. Therefore, a single serving (30 g) of the tortilla chips can provide 28.96% of the daily sodium requirement for children aged 1–3 years. The commercial tortilla chips product Happy Tos contains 400 mg of sodium per 100 g of product, which is lower than the sodium content of the tortilla chips substituted with rebon shrimp flour and tempeh. The higher sodium content in the substituted tortilla chips may be attributed to the use of rebon shrimp flour, which naturally contains a high level of sodium, approximately 3,432.9 mg per 100 g of flour. In addition, the formulation included 2 g of salt, which contributed approximately 774.5 mg of sodium to the product.

CONCLUSION

In conclusion, the best formulation of tortilla chips substituted with rebon shrimp flour and tempeh, based on the organoleptic evaluation results, was formulation F2. This formulation exhibited hedonic quality characteristics of a yellowish-brown color, a slightly rebon shrimp-like aroma, a moderately salty taste, a crispy texture, and a slightly bitter aftertaste. The product met the quality requirements of SNI 2886:2015 – Extruded Snack Foods for moisture content, acid-insoluble ash content, and fat content. Furthermore, the best formulation of tortilla chips substituted with rebon shrimp flour and tempeh met the criteria for a high-protein claim for children aged 1–3 years. These tortilla chips have the potential to serve as a high-protein snack to support stunting prevention efforts in children by helping to increase daily protein intake. Future studies should consider optimizing the sodium content and taste profile of the product, particularly regarding the amount of added salt, as the presence of rebon shrimp alone already provides a natural umami flavor to the tortilla chips.

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