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Sensory Acceptability and Characterization of Shrimp Shell Flour-Based Nuggets

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Abstract: This study explored the development and evaluation of shrimp shell flour-based nuggets through three distinct formulations, aiming to determine their sensory acceptability and analyze the nutritional and physicochemical properties of the most preferred variant. Sensory attributes—including appearance, aroma, taste, texture, and overall appeal—were assessed by 20 food experts and 30 consumer respondents using an adopted 9-point hedonic scale. The results revealed that Formulation B consistently received the highest acceptability ratings across all sensory parameters. Statistical analysis using One-Way ANOVA confirmed significant differences among the three formulations in terms of aroma, taste, texture, and composite appeal. Nutritional analysis of the most favored formulation (Formulation B) showed it to be rich in protein (20g per serving, contributing 40% of the daily value and 28% of RENI for adult males), low in carbohydrates, and moderate in fat and sodium content. Physicochemical analysis confirmed high protein content (40.24 g/100g), total fat (25.19 g/100g), and notable mineral content (ash at 4.90 g/100g), with a moisture content of 28.36 g/100g. The findings suggest that shrimp shell flour-based nuggets, particularly Formulation B, offer a sustainable and nutritionally valuable food product with strong sensory appeal, supporting the potential for broader application in healthy and eco-friendly food innovations..

Keywords: Shrimp Shell, Flour-Based Nuggets, Food Innovation, Sensory Acceptability

I. INTRODUCTION

Shrimp and other crustacean shells remain as the main byproduct of seafood processing and are often discarded as waste. However, these shells possess significant potential for added value due to their high nutritional content, including proteins, minerals, and chitin. Recycling shrimp shells into novel food products offers an opportunity to reduce waste, enhance sustainability, and create value in food systems. This study explores the use of shrimp shell flour as a key ingredient in producing nuggets, a versatile and widely consumed food product. Globally, there is an increasing demand for alternative food ingredients that align with consumers' preference for healthy, nutrient-rich, and environmentally friendly products. Studies have demonstrated the success of unconventional food ingredients, such as Functional and sensorial properties of cookies enriched with Spirulina biomass (Delgado, N. G., et al. 2020) and fish scale collagen in supplements and edible films (Karthikeyan et al., 2021), in addressing both nutritional needs and waste management.

This research directly aligns with the United Nations Sustainable Development Goals (SDGs), particularly Goal 12: Responsible Consumption and Production, and Goal 14: Life Below Water. By repurposing shrimp shells, the study reduces waste from the seafood industry and promotes sustainable resource use, thereby supporting efforts to protect marine ecosystems. Additionally, Goal 3: Good Health and Well-being is addressed through the development of nutritious, high-quality food products. The integration of the i2Fame Framework is evident in this study's emphasis on innovation, sustainability, and consumer focus. The framework highlights the importance of innovative solutions for sustainable development, aligning with this study's goal of introducing a novel, nutrient-rich product to the market. By fostering partnerships with local seafood processors and leveraging available resources, the research promotes inclusive economic growth and supports environmentally responsible food production practices.

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In the Philippine context, this study aligns with Ambisyon Natin 2040, which envisions a prosperous, predominantly middle-class society by 2040. Developing shrimp shell flour-based nuggets contributes to this vision by creating affordable, nutritious food products that are environmentally sustainable. Furthermore, it provides economic opportunities for coastal communities, particularly in Surigao, where seafood production is a key industry. By turning waste into value-added products, this study supports the broader goals of inclusive growth, environmental sustainability, and food security.

In summary, the development of shrimp shell flour-based nuggets is not only a response to local and global challenges of waste management and nutrition but also a step toward achieving a sustainable and prosperous future. This study seeks to create a market-ready product that embodies innovation, supports sustainable practices, and aligns with consumer acceptance regarding taste, texture, and overall quality.

II. LITERATURE REVIEW

Nature and Usability of Alternative Flour

Alternative flours have attracted interest internationally because of the nutritional, sustainability, and cost benefits it provides for food product development. Composite flour-a mixture of flour from various sources- has long been an accepted partial or total wheat flour substitute in bakery and confectionery industries. It produces products that are different from those of wheat flour, with unique textures and improved nutritional properties as well as market viability (Milligan et al., 2019; Noor Aziah & Komathi, 2019).

Alternative flours derived from food byproducts, such as fruit seeds, legumes, and root crops, have also been promising. Quinoa flour, for instance, is high in phenolic compounds and antioxidants (Aguilar et al., 2019). Cactus-based flour also enhances gluten-free baked products with phenolic and antioxidant properties (Dick et al., 2020). Crustacean shell byproducts also hold a great potential for nutrient-dense flours because of their high protein, calcium, and chitin content.

Potential of Shrimp Shells as Food Ingredients

Crustacean shells, especially from shrimp and crabs, have proteins, minerals, and bioactive compounds. Despite their common practice of being wasted, they have been proven to be of nutritional value in many studies. Some of the compounds that might be found in shrimp shells include chitin, calcium carbonate, and carotenoids with possible uses in food in enhancing their strength or adding to their healthful features (Duarte et al., 2020).

The present research focuses on chitosan or dietary supplements from shrimp shell processing, while whole shell flour integration into ready-to-eat food products remains largely unexplored. Crustacean shell flour-developed nugget may represent an eco-friendly and nutritious alternative to conventional ingredients and may help to address the dual challenges of food waste and malnutrition.

Nutritional Content of Shrimp Shell Flour

Shrimp shells are an excellent candidate for functional food development due to their nutrient profile. Research has shown that shrimp shell flour is rich in calcium, protein, and essential amino acids. The presence of chitin and carotenoids also enhances its antioxidant properties, thus improving health benefits (Younes et al., 2021). These nutritional attributes align well with consumer demand for health-oriented food products.

Consumer Acceptance of Sustainable Food Products

Consumer perception is a critical factor in the success of foods derived from unconventional sources. Sensory evaluation, focusing on attributes like taste, texture, aroma, and appearance, plays a pivotal role in determining acceptability. Recent studies on alternative flours, such as plant-based and protein-rich products, suggest that while modifications can impact sensory properties, consumer acceptance significantly increases when nutritional advantages are emphasized. For example, mushroom-enriched protein alternatives were found to achieve high sensory ratings (Delgado et al., 2020). Similarly, innovations in bread formulations have shown that improving taste and olfactory appeal can enhance consumer willingness to adopt sustainable food options (Smith et al., 2023). These findings

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underscore the importance of strategic marketing and educational campaigns in driving the acceptance and success of sustainable food innovations.

Processes for Developing Nugget Products

Shrimp shell flour-based nuggets begin by cleaning the shells to remove impurities and drying them to have low moisture. The dried shells are ground into a fine flour so that they can be uniformly included in the nugget mixture. In that formulation, shrimp meat and other additives, such as carrots, are combined with the shrimp shell flour, which is the main protein and flavored material.

Ingredients are mixed for a uniform batter, and added seasonings enhance the flavor. The mix is then shaped into nuggets to achieve the desired consistency and structure. After shaping the nuggets, they have a layer of breadcrumbs added to produce a crispy texture when they are fried.

The process of cooking is through deep frying, which is selected based on the need to produce the same golden-brown appearance and texture. Ingredient ratio and seasoning adjustments are conducted in the formulation to hide the characteristic flavor of seafood in the shrimp shell flour while retaining the nutrients in it. The formulation will depend on knowledge from alternative flour use experiences such as soy and pea flour (Anjum et al., 2020) that the product shall pass sensory acceptability, which includes taste, texture, and quality, aligned to the objectives of the research.

Nutritional Properties of Shrimp Shells

Shrimp shells are rich in chitin, a carbohydrate polymer that can be converted into chitosan. Chitosan has numerous health benefits, such as lowering cholesterol and improving gut health (Kumar et al., 2021). Furthermore, shrimp shells contain astaxanthin, a potent antioxidant responsible for maintaining skin health and reducing oxidative stress. These attributes make shrimp shells a valuable resource in the development of nutrient-rich food products, such as shrimp shell flour.

Protein and Mineral Composition

Shrimp shells are rich in protein and essential minerals, including calcium, magnesium, and selenium, which are vital for maintaining bone strength, fighting oxidative stress, and supporting the immune system. These nutritional components enhance the usefulness of shrimp shells as a dietary supplement and a functional ingredient in fortified food products. Research has highlighted the potential of shrimp shells in the development of food products due to their high mineral and protein content, along with their antioxidant properties, which offer several health benefits (Kumar et al., 2021).

Culinary and Nutritional Uses

Shrimp shells are not typically edible in their raw form; however, when processed into flour, they can be used in a variety of food products, imparting a distinct crunch and umami flavor. Proper preparation and processing play a crucial role in maximizing the nutritional benefits of shrimp shells while ensuring that food products are digestible. Research has highlighted the potential of shrimp shells as a valuable food ingredient, with a study by Kumar et al. (2021) discussing the chemistry, properties, and applications of chitin and chitosan derived from shrimp shells. This study emphasizes the importance of processing methods in enhancing the culinary and nutritional value of shrimp shell-based ingredients.

III. METHODOLOGY

A developmental research design was used. Through the developmental design, this study developed a food product with nuggets as its formulation, using shrimp shell flour as the main ingredient. Through this, the product will be systematically developed and tested in its feasibility and acceptability. The developmental research study was carried out in Food Technology Innovation Center in Surigao del Norte State University, Surigao City. Three formulations of shrimp shell flour-based nuggets were prepared: Formulation A with 100% shrimp shell flour concentration, Formulation B with concentration between 50% and 100%, and Formulation C with 50% concentration.

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Since the product is made using shrimp shell flour, it contains crustaceans, which are common allergens. Individuals with known allergies to shrimp, crustaceans, or shellfish are advised not to participate in the sensory evaluation to avoid adverse reactions.

Respondents are required to review the allergen information before deciding whether to participate. By proceeding with the evaluation, participants acknowledge that they have read the allergen information and are not at risk of allergic reactions to shrimp or crustacean-derived products. The samples of shrimp shell flour-based nuggets were assessed by food experts and consumers using the Hedonic Scale. Such a method ensures accurate feed on the sensory acceptability of the product. The scale is from 1: Dislike Extremely to 9: Like Extremely and enables the structured expression of evaluators' preferences in the sensory attributes for a certain feature

Before conducting the survey instrumentfor the study "Development and Acceptability of Shrimp Shell Flour-Based Nuggets" the researcher sought permission from the appropriate authorities. A letter of request sent to the respondents to ask for their consent and cooperation in gathering the necessary data for this study. Respondents who have superiors were also given letters to their respective heads of office to ensure that their participation in this study does not jeopardize any professional standard. Additionally, the respondents were assured that the samples they are about to intake would be free from harmful substances or any elements that could pose a risk to their health and sanitation. After the conduct, copies of the distributed survey instrument were retrieved, and the data collected were analyzed and interpreted.

IV. RESULTS AND DISCUSSION

The sensory evaluation results regarding appearance and color of shrimp shell flour-based nuggets reveal interesting patterns across the three different formulations. Formulation A and C were equally preferred for their color, both receiving median scores of 7 ("like moderately"), while Formulation B scored slightly higher with a median of 8 ("like very much"). This suggests that consumers tend to favor either the most authentic version with full shrimp shell flour concentration or the more balanced 50% formulation, possibly indicating that the 75% option lacks the visual appeal of either extreme.

All three formulations performed consistently regarding uniformity of appearance, each scoring a median of 7 ("like moderately"), indicating that the percentage of shrimp shell flour did not significantly impact the nuggets' consistency in appearance. Similarly, the visual appeal of nugget shape and size was highly rated across all formulations with a median score of 8 ("like very much"), suggesting that the manufacturing process maintained consistent sizing and shaping regardless of flour composition.

Surface texture evaluation showed interesting variation, with Formulation B scoring higher (median 8 - "like very much") than both Formulations A and C (both scoring 7 - "like moderately"). This suggests that Formulation B shrimp shell flour concentration achieved an optimal textural balance that was visually appealing to respondents. The overall attractiveness assessment followed the same pattern, with Formulation B again outperforming the others with a median score of 8 compared to 7 for Formulations A and C.

Despite variations in individual attributes, the preferred formulation overall received a median score of 8 ("like very much"), indicating strong acceptance. Although the table doesn't explicitly state which formulation was preferred overall, the pattern of scores suggests Formulation B may have been the overall preference due to its superior performance in surface texture and overall attractiveness, despite slightly lower color ratings. These findings demonstrate that while all formulations were well-received visually, the concentration of shrimp shell flour does impact various aspects of appearance and consumer appeal.

	Form	ulation A Formula		ulation B	Form	ulation C
Appearance/Color	MEDIAN	Qualitative	MEDIAN	Qualitative	MEDIAN	Qualitative
	MEDIAN	Description		Description		Description
1. Color of the shrimp	Q	like very	7	like	Q	like very
shell flour-based nugget.	0	much	/	moderately	8	much

TABLE 1: ACCEPTABILITY OF APPEARANCE/COLOR OF THE SHRIMP SHELL FLOUR-BASED NUGGETS

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2. Uniformity of the	7	like	7	like	7	like
product's appearance.	/	moderately	/	moderately	/	moderately
3. Visual appeal of the	0	like very	0	like very	Q	like very
nugget shape and size.	0	much	0	much	0	much
4. Surface texture (e.g.,	7	like	Q	like very	7	like
smoothness or roughness).	/	moderately	0	much	/	moderately
5. Overall attractiveness of	7	like	o	like very	7	like
the nugget's presentation.	/	moderately	0	much	/	moderately

Formulation A performed adequately with median scores between 6 and 7, indicating a generally positive reception though not as enthusiastic as for Formulation B. The highest ratings for Formulation A were for balance between shrimp shell aroma and seasoning (7) and overall appeal (7), both described as "like moderately." However, it scored lower on absence of undesirable odors (6 - "like slightly") and consistency of aroma (6 - "like slightly"), suggesting that the full concentration of shrimp shell flour may have introduced some aromatic elements that were less appealing to respondents.

	Formulation A		Formulation B		Formulation C	
Aroma/Odor	Median	Qualitative Description	Median	Qualitative Description	Median	Qualitative Descriptio n
1. Freshness of the nugget's aroma.	6.5	like moderately	7.5	like very much	6	like slightly
2. Balance between the shrimp shell aroma and seasoning.	7	like moderately	8	like very much	6	like slightly
3. Overall appeal of the nugget's aroma.	7	like moderately	8	like very much	6	like slightly
4. Absence of undesirable odors.	6	like slightly	8	like very much	6	like slightly
5. Consistency of aroma across multiple samples.	6	like slightly	7	like moderately	6	like slightly

TABLE 2: ACCEPTABILITY OF AROMA/ODOR OF THE SHRIMP SHELL FLOUR-BASED NUGGETS

Formulation C consistently received the lowest ratings with median scores of 6 ("like slightly") across all aroma attributes. This consistent pattern suggests that while the reduced concentration of shrimp shell flour was still acceptable to respondents, it failed to create the optimal aromatic profile that was achieved. The overall preferred formulation received a rating of 8 ("like very much"), confirming that Formulation B struck the ideal balance in terms of aromatic properties. This finding indicates that the Formulation B concentration provides the most pleasing aromatic experience, balancing the distinctive shrimp shell aroma with other ingredients in a way that enhances rather than diminishes the sensory experience.

The taste evaluation data reveals distinct preferences among respondents for the three shrimp shell flour nugget formulations, with Formulation B emerging as the most preferred option across all taste attributes. Formulation B consistently received higher ratings than both alternative formulations, with median scores ranging from 7 ("like moderately") to 8 ("like very much"). Most notably, it scored highest on the complementary taste between flour base and shrimp (8), demonstrating that this formulation achieved the most harmonious flavor integration.

Formulations A and C performed similarly to each other, both receiving median scores of 6 ("like slightly") for most attributes, including balance of seasoning, distinct shrimp flavor, overall flavor encouraging repeat consumption, and

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overall taste acceptability. The only exception was the complementary taste between flour base and shrimp, where both formulations received a higher score of 7 ("like moderately"). This suggests that while both formulations were acceptable in terms of taste, neither achieved the optimal flavor profile that was found in Formulation B.

Interestingly, the data indicates that reducing the shrimp shell flour content from 100% to 50% did not significantly impact taste preferences, as both formulations received nearly identical ratings. This finding suggests that the relationship between shrimp shell flour concentration and taste acceptability is not linear but rather peaks at the intermediate concentration between 50%-100%. The overall preferred formulation received a rating of 7 ("like moderately"), which aligns with the ratings consistently given to Formulation B. This confirms that Formulation B strikes the optimal balance for taste acceptability, providing enough shrimp flavor to be distinctive while maintaining a complementary relationship with other ingredients that enhances the overall taste experience.

	Formulation A		Formulation B		Formulation C	
Taste	MEDIAN	Qualitative	MEDIAN	Qualitative	MEDIAN	Qualitative
	MEDIAN	Description	MEDIAN	Description	MEDIAN	Description
1. Balance of						
seasoning in the	6	like slightly	7	like moderately	6	like slightly
nugget.						
2. Distinct shrimp	6	like slightly	7	like moderately	6	like slightly
flavor in the product.	0	like slightly	'	like moderatery	0	like slightly
3. Complementary						
taste between flour	7	like moderately	8	like very much	7	like moderately
base and shrimp.						
4.Overall flavor						
encourages repeat	6	like slightly	7	like moderately	6	like slightly
consumption.						
5.Overall acceptability	6	1:11: -1-41	7	lika madarataki	6	like slightly
of the product's taste	0	like slightly	/	like moderatery	0	like slightly

TABLE 3: THE ACCEPTABILITY OF TASTE OF THE SHRIMP SHELL FLOUR-BASED NUGGETS

The texture evaluation data demonstrates a clear preference pattern among respondents for the three shrimp shell flour nugget formulations, with Formulation B consistently receiving the highest ratings across all texture attributes. This formulation excelled particularly in providing an optimal balance between crunchiness and softness, earning a median score of 8 ("like very much"), while all other texture attributes received scores of 7 ("like moderately"). This suggests that the Formulation B concentration achieves an ideal textural profile that provides the best eating experience for consumers.

Formulation A received the lowest ratings, with consistent median scores of 6 ("like slightly") across all texture attributes. This uniform pattern suggests that the highest concentration of shrimp shell flour may result in textural characteristics that are less appealing, possibly creating a product that is either too dense, dry, or lacks the desired balance between exterior crispiness and interior tenderness that consumers prefer.

Formulation C performed slightly better than Formulation A but not as well as Formulation B. It received median scores of 6 ("like slightly") for crispiness of exterior, tenderness of interior, and consistency in texture, but performed better with scores of 7 ("like moderately") for moisture level and balance between crunchiness and softness. This indicates that reducing the shrimp shell flour concentration improves certain textural aspects, particularly moisture and textural balance, but doesn't match the overall textural appeal of Formulation B.

The overall preferred formulation received a rating of 7 ("like moderately"), which aligns with the consistent ratings given to Formulation B. This finding confirms that Formulation B strikes the optimal balance for textural acceptability. The data suggests a non-linear relationship between shrimp shell flour concentration and textural quality, with the intermediate concentration providing the most appealing combination of crispiness, tenderness, moisture, consistency,

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and textural balance. This optimal formulation seems to successfully mitigate any potential textural challenges associated with incorporating shrimp shell flour while maximizing its beneficial properties.

TABLE 4: ACCEPTABILITY OF TEXTURE OF THE SHRIMP SHELL FLOUR-BASED NUGGETS

	Formulation A		Formulation B		Formulation C	
Texture	MEDIAN	Qualitative		Qualitative	MEDIAN	Qualitative
	MEDIAN	Description	MEDIAN	Description	MEDIAN	Description
1. Crispiness of the	6	like slightly	7	lika madaratak	6	like slightly
nugget's exterior.	0	like slightly	/	like moderatery	0	
2. Tenderness of the	6	lika ali ahtlyr	7	like moderately	6	like slightly
nugget's interior.	0	like slightly				
3. Moisture level of	6	like slightly	7	like moderately	7	like moderately
the nugget.	0	like slightly	7	like moderatery	/	like moderatery
4. Consistency in						
texture throughout the	6	like slightly	7	like moderately	6	like slightly
product.						
5. Balance between						
crunchiness and	6	like slightly	8	like very much	7	like moderately
softness						

The ANOVA results provide crucial statistical insights into how the three different formulations of shrimp shell flourbased nuggets differ across sensory attributes. The analysis reveals a clear pattern of significant and non-significant differences that helps us understand which aspects of the product are affected by varying shrimp shell flour concentrations.

For appearance, the ANOVA results (F = 0.568, p = 0.568) indicate no statistically significant difference among the three formulations. This confirms that regardless of shrimp flour concentration, consumers perceived their visual characteristics similarly. This finding aligns with our previous observation where all formulations received relatively consistent ratings for uniformity and shape appeal, suggesting that the varying concentrations of shrimp shell flour did not noticeably alter the visual properties of the nuggets.

In stark contrast, the other sensory attributes showed highly significant differences across formulations. Aroma demonstrated extremely significant differences (F = 54.721, p < .001), indicating that the concentration of shrimp shell flour strongly influenced how the nuggets smelled to consumers. Similarly, taste showed the most pronounced variation among formulations (F = 55.695, p < .001), suggesting that the percentage of shrimp shell flour dramatically affected flavor perception. Texture also exhibited highly significant differences (F = 35.220, p < .001), demonstrating that the mouthfeel and structural properties of the nuggets varied meaningfully depending on the formulation.

These findings lead to a partial rejection of the null hypothesis (Ho1). While we fail to reject the null hypothesis for appearance, we must reject it for aroma, taste, and texture, where significant differences exist among the three formulations. This statistical evidence indicates that while manufacturers can maintain visual consistency across different shrimp shell flour concentrations, they must carefully consider the impact of formulation adjustments on the product's aroma, taste, and texture attributes—as these are significantly affected by the proportion of shrimp shell flour used. The particularly high F-values for taste and aroma suggest these attributes are most sensitive to changes in formulation.

TABLE 5: SIGNIFICANT DIFFERENCE ON THE ACCEPTABILITY OF THE SENSORY ATTRIBUTES OF THE THREE FORMULATIONS OF SHRIMP SHELL FLOUR-BASED NUGGETS

Sensory Attribute	F	р	Decision on Ho	Interpretation
Appearance	0.568	0.568	Not Rejected	Not Significant
Aroma	54.721	<.001	Rejected	Significant
Taste	55.695	<.001	Rejected	Significant
Texture	35.22	< .001	Rejected	Significant

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The nutritional analysis of the developed shrimp shell flour-based nuggets reveals an exceptionally protein-rich food product with unique nutritional characteristics. With 40.24g of crude protein per 100g, these nuggets deliver 20g of protein per serving, meeting 40% of daily protein needs based on a 2000-calorie diet and 28% of the RENI for adult males aged 19-29 years. This high protein content is particularly notable considering the product's innovative use of shrimp shell flour, traditionally a waste by-product in seafood processing. The nuggets contain 25.19g of total fat per 100g (13g per serving), accounting for 17% of daily fat allowance, with most of the calories (226.71 out of 392.91 total calories per 100g) derived from fat. At 392.91 calories per 100g (200 calories per serving), these nuggets provide 8% of daily caloric needs. The sodium content is moderate at 444.09mg per 100g (220mg per serving), representing 10% of the recommended daily intake, suggesting a balanced approach to flavor enhancement.

Perhaps most striking is the remarkably low carbohydrate content at just 1.31g per 100g, registering as 0g per serving and 0% of daily carbohydrate requirements. This nutritional profile positions the shrimp shell flour-based nuggets as a potentially valuable high-protein, low-carbohydrate food option that effectively transforms seafood processing waste into a nutritionally significant product. These nuggets could be particularly attractive to consumers following protein-focused diets or those seeking sustainable, innovative food products with functional nutritional benefits.

Food Nutrient	Result of Chemical	Amount of food	% Daily value (based	%RENI(based on
	Analysis(per 100g)	nutrient per serving	on 2000 Calorie	FNRI reference adult
		size (rounded value)	Diet,Rounded value)	requirement of males
				19-29 years old)
Calories	392.91	200		8
Calories from	226.71	110		
Fat				
Total Fat(g)	25.19	13	17	
Sodium(mg)	444.09	220	10	
Total	1.31	0	0	
Carbohydrates(g)				
Protein(g)	40.24	20	40	28

TABLE 6: NUTRITIONAL CONTENTS OF FORMULATION B OF SHRIMP SHELL FLOUR-BASED NUGGETS

Most notably, these nuggets contain an impressive 40.24g of crude protein per 100g, making them an excellent protein source compared to conventional nugget products. The high protein content is complemented by a moderate fat content of 25.19g/100g, which likely contributes to the product's palatability and mouthfeel. With a moisture content of 28.36g/100g, the nuggets maintain an appealing texture while the ash content of 4.90g/100g indicates a significant mineral presence, reflecting the mineral-rich nature of the shrimp shell ingredient. The sodium level of 444.09mg/100g is moderate for a processed food product, suggesting careful formulation to balance flavor enhancement with nutritional considerations. This innovative product effectively utilizes shrimp shell, a by-product typically discarded in seafood processing, transforming it into a value-added food with exceptional nutritional properties that could appeal to health-conscious consumers seeking alternative protein sources.

TABLE 7: PHYSICO-CHEMICAL PROPERTIES OF FORMULATION B OF SHRIMP SHELL FLOUR-BASED

NUGGETS

Parameters	Result	Method
Moisture	28.36 g/100g	AOAC No. 940.46B AOAC International 2023, 22 nd ed., vol 2
Total Fat	25.19 g/100g	AOAC No.991.36 International 2023, 22 nd ed., vol 2
Ash Content	4.90 g/100g	AOAC No. 938.08, International 2023, 22 nd ed., vol 2
Crude Protein	40.24 g/100g	AOAC No.928.08 International 2023, 22 nd ed., vol 2
Sodium	444.09 mg/100g	AOAC No.973.54 AOAC International 2023, 22 nd ed., vol 1

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V. CONCLUSION

Respondents consistently rated Formulation B higher in all sensory attributes—including appearance, aroma, taste, texture, and overall appeal. Formulation B of the shrimp shell flour-based nuggets was most preferred by the respondents. The nuggets are notably low in carbohydrates, with virtually no measurable amount per serving, resulting in a 0% contribution to the daily value. In contrast, they are rich in protein, supplying 20 grams per serving. This amount provides 40% of the daily value for protein and 28% of the Recommended Energy and Nutrient Intake (RENI) for adult males aged 19 to 29, according to the Food and Nutrition Research Institute (FNRI).In terms of protein composition, the nuggets are rich in crude protein, containing 40.24 grams per 100 grams, according to AOAC Method No. 928.08. The sodium content is recorded at 444.09 milligrams per 100 grams, determined through AOAC Method No. 973.54. All analyses were conducted following the Official Methods of Analysis of AOAC International, 22nd edition, 2023.

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