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Development and Sensory Acceptability of Protein-Enriched Squid Jerky Flakes Fortified With *Moringa Oleifera* Powder: A Value-Added Seafood Innovation For Sustainable Nutrition and Food Enterprise

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Abstract

This study developed and evaluated squid jerky flakes fortified with Moringa oleifera powder as a protein-enriched, value-added seafood product for sustainable nutrition and community-based enterprise. A developmental-experimental and descriptive-evaluative research design was employed. Four formulations were prepared: T0 with 0% moringa powder, T1 with 2%, T2 with 4%, and T3 with 6%. The products were evaluated on a 9-point hedonic scale for appearance, aroma, taste, texture, color, aftertaste, and overall acceptability. Results showed that all formulations were acceptable; however, T2, containing 4% moringa powder, obtained the highest grand mean of 8.17 and the highest overall acceptability rating of 8.28, both interpreted as very highly acceptable. One-way ANOVA revealed a significant difference in overall acceptability among formulations, $F(3,156) = 9.64$, $p < .05$, indicating that moringa concentration significantly influenced consumer preference. Proximate analysis of T2 showed 18.42% moisture, 42.65% crude protein, 5.84% crude fat, 7.26% ash, 2.18% crude fiber, and 23.65% estimated carbohydrate. Microbial findings indicated acceptable quality, with coliform, Escherichia coli, and Salmonella spp. not detected. Shelf-life observation indicated acceptability for up to 21 days at room temperature. Cost analysis showed a 60% return on investment, while consumer purchase intention was strongly favorable. Findings indicate that squid jerky flakes fortified with 4% moringa powder may serve as a nutritious, acceptable, marketable, and livelihood-oriented seafood innovation.

Keywords: *Squid jerky flakes; Moringa oleifera; sensory acceptability; value-added seafood product; food fortification*

Introduction

Seafood processing plays an important role in food security, postharvest loss reduction, nutrition improvement, and livelihood development, particularly in coastal and fisheries-based communities. Squid is a valuable aquatic food resource because of its protein content and potential for value-added processing. However, like many seafood commodities, squid is highly perishable due to moisture content, enzymatic activity, and microbial susceptibility. Converting squid into jerky flakes offers a practical strategy to extend shelf life, improve convenience, reduce waste, and create a marketable food product.

Value addition in squid processing is supported by studies showing that squid materials contain nutritionally useful components, including protein, lipids, ash, fatty acids, and essential elements. Aubourg et al. (2021) reported that Patagonian squid by-products contain food-relevant chemical constituents, indicating the broader potential of squid materials in food and value-added applications.

The incorporation of *Moringa oleifera* powder further enhances the nutritional and functional potential of squid jerky flakes. Moringa leaves are widely recognized as nutrient-dense plant materials containing protein, vitamins, minerals, and bioactive phytochemicals. Trigo et al. (2023) emphasized that moringa can be incorporated into various food matrices to improve nutrient profiles, particularly in protein, minerals, and fiber. Ariani et al. (2023) likewise described moringa leaf powder as a functional food ingredient due to its protein, vitamin, mineral, carotenoid, tocopherol, and phytochemical content.

Food fortification using moringa powder has been applied in various food products. Roni et al. (2021) developed cakes fortified with moringa leaf powder and ripe banana flour and reported that moringa fortification influenced nutritional composition and consumer acceptability. Olusanya et al. (2019) also found that moringa supplementation improved the nutritional composition of mahewu, particularly in protein, ash, and fiber content. These studies suggest that moringa can enhance food value, although sensory acceptability must be carefully evaluated, as it may affect taste, color, aroma, texture, and aftertaste.

Despite growing interest in functional foods, moringa fortification, and value-added seafood products, limited studies have examined squid jerky flakes fortified with moringa powder as a locally relevant seafood innovation. This study, therefore, aimed to develop and evaluate squid jerky flakes with varying levels of moringa powder in terms of formulation, sensory acceptability, proximate composition, microbial quality, shelf-life potential, production cost, market feasibility, and enterprise application.

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Methodology

Research Design

The study employed a developmental-experimental and descriptive-evaluative research design. The developmental component involved formulating and preparing squid jerky flakes fortified with varying levels of moringa powder. The experimental component compared four formulations to determine whether moringa powder concentration significantly influenced sensory acceptability. The descriptive-evaluative component assessed proximate composition, microbial quality, shelf-life potential, production cost, market feasibility, and possible enterprise model.

Product Formulation

Four formulations were developed. T0 served as the control formulation with 0% moringa powder. T1 contained 2% moringa powder, T2 contained 4%, and T3 contained 6%. The same squid-flake base, seasoning formulation, drying procedure, cooling method, and packaging preparation were applied across all treatments to ensure that the main variable was the level of moringa powder.

Fresh squid was cleaned, washed, blanched, flaked, seasoned, fortified with moringa powder at the specified treatment level, dried or dehydrated, cooled, packed, and coded with random identifiers to minimize evaluator bias. Participants with known allergy to squid, seafood, moringa, or seasoning ingredients were excluded from the sensory evaluation.

Sensory Evaluation

Sensory evaluation was conducted using a 9-point hedonic scale. Respondents evaluated each formulation in terms of appearance, aroma, taste, texture, color, aftertaste, and overall acceptability. The formulation with the highest grand mean and overall acceptability rating was identified as the most acceptable formulation.

Laboratory and Market Evaluation

The most acceptable formulation was subjected to proximate analysis for moisture content, crude protein, crude fat, ash, crude fiber, and estimated carbohydrate. Microbial quality was assessed through total plate count, yeast and mold count, coliform count, *E. coli*, and *Salmonella* spp. Shelf-life potential was observed during room-temperature storage. Production cost, suggested selling price, return on investment, packaging preference, market outlet preference, and consumer purchase intention were also evaluated.

Data Analysis

Weighted mean and standard deviation were used to describe sensory acceptability. One-way ANOVA was used to determine significant differences in overall acceptability

among formulations. When significant differences were found, post hoc analysis was used to identify the preferred formulation. Frequency, percentage, and weighted mean were used to analyze market feasibility and consumer purchase intention. The level of significance was set at 0.05.

Results

Developed Formulations of Squid Jerky Flakes with Moringa Powder

Four squid jerky flakes formulations were developed: T0 with 0% moringa powder, T1 with 2%, T2 with 4%, and T3 with 6%. The standardized process involved cleaning, blanching, flaking, seasoning, drying, cooling, and packaging. Among the four formulations, T2 with 4% moringa powder produced the most balanced product. It retained the savory squid flavor while providing mild moringa taste, acceptable color, good flake consistency, and desirable dryness. T3 with 6% moringa powder showed stronger green coloration and a more pronounced vegetal aftertaste.

Sensory Acceptability of the Formulations

Table 1. *Sensory Acceptability of Squid Jerky Flakes with Moringa Powder*

Sensory Attribute	T0 0% Moringa	T1 2% Moringa	T2 4% Moringa	T3 6% Moringa
Appearance	7.42	7.68	8.21	7.18
Aroma	7.36	7.55	8.05	6.92
Taste	7.51	7.84	8.32	6.75
Texture	7.63	7.91	8.18	7.10
Color	7.45	7.66	8.10	6.88
Aftertaste	7.38	7.70	8.06	6.60
Overall Acceptability	7.50	7.82	8.28	6.91
Grand Mean	**7.46**	**7.74**	**8.17**	**6.91**
Verbal Interpretation	Very Highly Acceptable	Very Highly Acceptable	Very Highly Acceptable	Highly Acceptable

The results show that all formulations were acceptable. However, T2 obtained the highest grand mean of 8.17, interpreted as very highly acceptable. It also received the highest

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ratings for taste, appearance, aroma, texture, color, aftertaste, and overall acceptability. T3 obtained the lowest grand mean, suggesting that 6% moringa powder may have exceeded the acceptable level for consumer preference.

Significant Difference in Overall Acceptability

Table 2. *ANOVA Result on Overall Acceptability of the Formulations*

Source of Variation	Sum of Squares	df	Mean Square	F-value	p-value	Decision
Between Groups	38.42	3	12.81	9.64	0.000	Significant
Within Groups	207.42	156	1.33	—	—	—
Total	245.84	159	—	—	—	—

The ANOVA result revealed a significant difference in overall acceptability among the four formulations, $F(3,156) = 9.64$, $p < .05$. This indicates that moringa powder concentration significantly influenced product acceptability. T2 emerged as the most acceptable formulation, while T3 was least preferred due to stronger vegetal notes, darker color, and more noticeable aftertaste.

Nutritional Composition of the Most Acceptable Formulation

Table 3. *Proximate Composition of T2: 4% Moringa Formulation*

Nutritional Component	Result
Moisture content	18.42%
Crude protein	42.65%
Crude fat	5.84%
Ash content	7.26%
Crude fiber	2.18%
Estimated carbohydrate	23.65%

The proximate composition shows that T2 is a protein-rich product, with 42.65% crude protein. The ash and fiber contents indicate the nutritional contribution of moringa powder. The moisture content of 18.42% suggests that the product underwent substantial dehydration, which is important for shelf stability and reduced spoilage risk.

Microbial Quality and Shelf-Life Potential

Table 4. *Microbial Quality of the Most Acceptable Formulation*

Microbial Parameter	Result	Interpretation
Total Plate Count	Within an acceptable limit	Acceptable
Yeast and Mold Count	Within an acceptable limit	Acceptable
Coliform Count	Not detected	Acceptable
Escherichia coli	Not detected	Acceptable
Salmonella spp.	Not detected	Acceptable

The microbial results indicate that the product was microbiologically acceptable at the time of testing. The absence of coliform, *E. coli*, and *Salmonella* spp. suggests that the product was prepared under sanitary conditions.

Table 5. *Shelf-Life Observation of T2 under Room Temperature Storage*

Storage Period	Appearance	Aroma	Texture	Visible Spoilage	General Observation
Day 1	Acceptable	Acceptable	Crisp-dry	None	Good quality
Day 7	Acceptable	Acceptable	Slightly less crisp	None	Still acceptable
Day 14	Acceptable	Mild aroma change	Slightly softer	None	Acceptable
Day 21	Slight color dullness	Slight aroma change	Less crisp	None	Acceptable but quality declining
Day 30	Noticeable quality decline	Slight fishy odor	Softer texture	None	Not recommended beyond this period without improved packaging

Shelf-life observation suggests that the product may remain acceptable for up to 21 days at room temperature. Quality declined by Day 30, indicating the need for improved packaging such as vacuum-sealed, laminated, or moisture-barrier packaging.

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Production Cost and Market Feasibility

Table 6. *Estimated Cost and Return Analysis*

Indicator	Value
Total production cost	₱1,000.00
Number of packs produced	40 packs
Cost per 50-g pack	₱25.00
Suggested selling price per pack	₱40.00
Gross sales	₱1,600.00
Net income	₱600.00
Return on investment	60%

The cost-and-return analysis indicates promising market feasibility. With a production cost of ₱25.00 per 50-g pack and a suggested selling price of ₱40.00, the product can generate a 60% return on investment.

Consumer Purchase Intention

Table 7. *Consumer Purchase Intention and Market Potential*

Indicator	Mean	Verbal Interpretation
I am willing to buy the product.	4.42	Strongly Agree
I would recommend the product to others.	4.35	Strongly Agree
The product has potential as a snack food.	4.48	Strongly Agree
The product has potential as a meal accompaniment.	4.56	Strongly Agree
The product has potential as a pasalubong item.	4.31	Strongly Agree
The product has potential for local market sales.	4.44	Strongly Agree
The product has potential for livelihood or enterprise.	4.52	Strongly Agree
Grand Mean	**4.44**	**Strongly Agree**

The respondents strongly agreed that the product has market potential. The highest rating was obtained for its potential as a meal accompaniment, followed by its potential for livelihood or enterprise.

Discussion

The results demonstrate that squid jerky flakes fortified with moringa powder can be developed as a nutritious, acceptable, and marketable value-added seafood product. The 4% moringa formulation emerged as the most acceptable treatment, indicating that moderate fortification provides an optimal balance between sensory quality and nutritional enhancement. This finding is consistent with food fortification studies showing that moringa can improve nutritional value but may affect sensory acceptability when added at excessive levels (Roni et al., 2021; Trigo et al., 2023).

The sensory results indicate that T2 achieved the best overall acceptability because it preserved the squid's natural savory flavor while adding mild moringa notes. In contrast, T3 with 6% moringa powder received lower ratings, particularly for taste, aroma, color, and aftertaste. This suggests that higher moringa concentration may introduce bitterness, stronger vegetal aroma, or darker coloration. Previous literature similarly emphasizes that the incorporation of moringa into food matrices should be optimized, as it may influence final sensory characteristics (Trigo et al., 2023).

The high crude protein content of T2 confirms the nutritional advantage of squid as the main ingredient. The ash and fiber contents suggest added nutritional contribution from moringa powder. Aubourg et al. (2021) emphasized that squid contains nutritionally relevant constituents, while Ariani et al. (2023) reported that moringa leaf powder contains proteins, vitamins, minerals, and phytonutrients. Thus, combining squid and moringa can produce a protein-rich, nutrient-enhanced product suitable for food innovation and community-based nutrition programs.

Microbial results further indicate that the most acceptable formulation was safe at the time of testing and contained no coliforms, E. coli, or Salmonella spp. detected. not detected. This finding suggests that proper cleaning, blanching, dehydration, cooling, and packaging can reduce microbial risks in seafood flakes. However, shelf-life observation showed that quality declined by Day 30, especially in aroma and texture. This indicates the need for improved packaging and more rigorous shelf-life testing, including water activity, pH, microbial count, lipid oxidation, histamine, and sensory stability under different storage conditions.

The product also showed promising enterprise feasibility. A 60% return on investment suggests that squid jerky flakes with moringa powder may be viable for coastal households, fisherfolk organizations, women’s associations, school-based livelihood units, and food-based microenterprises. Consumer purchase intention was strongly favorable, especially for use as a meal accompaniment, a snack, a pasalubong item, and a local market product. This supports the study’s enterprise-oriented objective and its alignment with sustainable consumption, value-added fisheries utilization, and local livelihood development.

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Overall, the study contributes to seafood processing and functional food product development by integrating squid as an animal-based protein source and moringa as a plant-based fortifying ingredient. It also supports sustainable food enterprises by promoting value addition, local resource utilization, nutritional enhancement, and the potential reduction of postharvest losses.

Conclusion

This study concludes that squid jerky flakes fortified with moringa powder can be successfully developed as a nutritious, acceptable, and marketable value-added seafood product. Among the four formulations, T2 with 4% moringa powder was the most acceptable, obtaining the highest grand mean and overall acceptability score. The level of moringa powder significantly influenced product acceptability, with excessive moringa concentration reducing preference due to stronger vegetal flavor, darker color, and more noticeable aftertaste.

The most acceptable formulation demonstrated promising nutritional quality, particularly high crude protein content, moderate ash content, and measurable crude fiber. Microbial findings showed acceptable quality, with coliform, *E. coli*, and *Salmonella* spp. not detected. Shelf-life observation indicated acceptability for up to 21 days at room temperature, although improved packaging is recommended to extend product stability.

The product also demonstrated market and enterprise potential, with favorable consumer purchase intention and an estimated 60% return on investment. Squid jerky flakes fortified with 4% moringa powder may therefore be promoted as a protein-rich snack, meal accompaniment, rice topping, pasalubong item, and community-based livelihood product. Future studies should conduct expanded sensory evaluation, laboratory-based nutritional profiling, water activity testing, histamine analysis, lipid oxidation testing, microbial shelf-life studies, packaging optimization, and commercial feasibility assessment.

AI Declaration Statement:
AI-supported tools helped with grammar and structure in creating this article. No AI tools were used to collect, analyze, or interpret data; all authors are credited for their academic contributions.

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