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Culinary Innovation Based on Local Wisdom: Development of Lemadang Fish Skin Chips (Coryphaena hippurus) in the Context of the Creative Economy

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Abstract

This study explores the potential of Mahi-mahi (Coryphaena hippurus) fish skin as a value-added snack product in the form of vacuum-fried chips. Laboratory analyses conducted at the Department of Food Technology, Faculty of Agricultural Technology, IPB University, assessed the nutritional composition using standard proximate analysis (AOAC), revealing high protein and low fat content. Three flavor variants—Original, Spicy, and Spicy Kaffir Lime—were developed and evaluated through sensory testing with 30 panelists using a 5-point hedonic scale. Market acceptance was further examined via a survey of 100 respondents, assessing demographic profiles, flavor preferences, purchasing channels, and promotional strategies. Qualitative data from interviews with SME practitioners, fisheries authorities, academic experts, and consumers were integrated to provide a comprehensive market and production feasibility analysis. Results indicate that Spicy flavor received the highest sensory scores and consumer preference, with offline retail channels showing the greatest purchase potential. SWOT analysis identified strengths in nutritional value and product uniqueness, opportunities in health-conscious and specialty markets, weaknesses in seasonal raw material supply, and threats from competition and supply chain instability. The study concludes that successful commercialization will require integrated strategies combining supply chain management, quality assurance, targeted promotion, and institutional collaboration.

Keywords: Mahi-mahi, fish skin chips, product development, market acceptance, and fisheries by-product utilization.

1. Introduction

Indonesia, as the world's largest archipelagic nation, possesses an immense potential in marine resources, which play a vital role in food security and economic development. Among

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the diverse marine commodities, **Lemadang fish (Coryphaena hippurus)** is widely found across Indonesian waters, including those of Maluku, Java, and Sulawesi (Effendi & Tahapari, 2018). While the meat of Lemadang is commonly consumed, its by-products—particularly the fish skin—are often discarded and remain underutilized, despite being rich in **protein, collagen, and minerals** that could be transformed into high-value food products. Previous studies have revealed that fish skin, including Lemadang's, holds promising characteristics for food innovation. Gelatin derived from its skin shows excellent physicochemical qualities, with protein content as high as 79.64% and a yield of 14.04%, indicating a strong potential for further development (Astawan et al., 2019). To better illustrate the nutritional potential of various types of fish skin commonly found in previous studies, Table 1 below presents a comparison of their protein and fat content:

Table 1. Nutritional Composition of Fish Skin from Various Species

Fish Species	**Protein (% w/w)**	**Fat (% w/w)**	**Ash (% w/w)**	**Reference**
Lemadang (Coryphaena hippurus), skin	79.64 (gelatin extract)	3.56	15.46	Lab. Food technology IPB
Tuna (Thunnus spp.), skin	26.18	10.10	5.38	"Comprehensive analysis of tuna skin…" (2025)
Sea bass (Dicentrarchus labrax), skin	25.27	Not specified (higher in guts)	Not specified	Munekata et al. (2020)
African mud catfish (Clarias gariepinus), fillet/similar*	~16–21 (muscle typical)	0.5–2.3 (lipids typical)	1.2–1.5 (ash typical)	Coppes Petricorena (2014) fish overview
Jack fish (Selar crumenophthalmus), muscle*	~16–21	0.5–2.3	1.2–1.5	Coppes Petricorena (2014)

Sources: (FAO, 2018)

Globally, fish skin constitutes about **4% of total fish biomass**, and with the growing volume of fish processing, the accumulation of skin waste is becoming a serious concern. In Indonesia, for instance, catfish processing industries can generate over 11 kg of skin waste per month, containing notable nutritional components such as **12.80% protein and 12.94% fat**. Despite these facts, fish skin waste is rarely optimized. FAO (2020) has highlighted that **over 30% of global fish catch remains unutilized or underutilized**, underscoring the urgent need for sustainable innovation in marine by-product utilization.(Nagai & Suzuki, 2000)

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In recent years, there has been a growing interest in utilizing fish skin for functional products—such as gelatin, collagen-based beverages, and crackers—but these efforts have primarily focused on species like tuna, patin, or catfish. Additionally, many studies focus primarily on the technical aspects of processing, neglecting **market viability, cultural integration, branding strategy, and socio-economic impacts**. For example, research by (Iqbal et al., 2023) Sari et al. (2020) demonstrated consumer acceptance of fish skin-based snacks, yet failed to explore their potential within the creative economy or local entrepreneurship ecosystems.

Beyond nutrition and food science, the potential of Lemadang fish skin can be elevated through **culinary innovation that aligns with local wisdom and creative economy principles**. According to Wilson (Wilson, 2014) Halal-certified products have grown not only as religious symbols but also as representations of **cleanliness, sustainability, and international quality standards**, making them appealing across diverse markets. By embracing such values, fish skin-based food innovations can access the growing halal market, while also contributing to environmental sustainability and community empowerment.
Despite the growing literature on fish skin utilization, there remains a **critical research gap**—particularly in **developing Lemadang fish skin into an innovative, culturally rooted, and market-ready snack product that integrates scientific processing, halal principles, digital marketing, and local economic empowerment**. Current studies rarely adopt a holistic, transdisciplinary approach that spans from raw material optimization to community-based entrepreneurship and branding in the digital era. This study seeks to fill that gap by proposing an innovative culinary product—**Lemadang fish skin chips**—developed using **vacuum frying technology** to retain its nutritional quality and texture. The product will be analyzed from both a **nutritional and market perspective**, including consumer sensory evaluation and feasibility analysis. Additionally, it will explore **digital-based branding strategies**, alignment with **halal value chains**, and partnerships with local MSMEs to ensure scalability. Through this integrated framework, the research aims to create a replicable and sustainable model of zero-waste innovation that transforms undervalued marine resources into high-quality, culturally resonant, and economically viable products, thereby contributing to the development of the creative economy and improving the livelihoods of coastal communities.(Oxenford, 1999)

Ultimately, this study not only offers an innovative approach to valorizing fish processing by-products but also represents a strategic response to pressing environmental, economic, and socio-cultural challenges. By integrating food science, digital marketing, local wisdom, and sustainable development goals, the research aims to contribute meaningfully to both academic discourse and real-world applications in the creative economy landscape. The findings are expected to pave the way for scalable models that empower coastal communities, reduce marine waste, and deliver culturally relevant halal-certified snack innovations that are competitive in both local and global markets.

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2. Research methods

techniques within a research and development (R&D) framework to produce an innovative, culturally rooted product in the form of Lemadang (Coryphaena hippurus) fish skin chips. The R&D model is adapted from Borg and Gall and is structured to address both the technical aspects of food product development and the socio-economic dynamics of market readiness and cultural acceptance.

The quantitative component of this research focuses on the formulation and laboratory testing of the product. Nutritional analysis of Lemadang fish skin was carried out using standard proximate analysis (AOAC) to determine protein, fat, moisture, and ash content. Several product prototypes were developed with various seasoning combinations and processing techniques—particularly vacuum frying, which is known to preserve nutritional quality. A sensory evaluation was conducted with 30 panelists using a 5-point hedonic scale to assess taste, texture, aroma, and overall acceptability. This quantitative data was further supported by a questionnaire-based survey exploring market preferences and acceptance, involving 100 respondents from various professions as the research subjects.

Simultaneously, the qualitative component involves exploring consumer preferences, cultural relevance, and the local wisdom embedded in culinary practices. Data are gathered through in-depth interviews and observations involving key stakeholders, such as local MSME actors, fish processors, and community leaders. The interviews aim to capture community perceptions about the product, their values and traditions related to food, and their readiness to adopt and commercialize it. Content analysis is then applied to identify themes and insights from these narratives, particularly with cultural identity, empowerment potential, and innovation acceptance.

Sampling is conducted purposively, targeting individuals and groups with direct experience in traditional food processing, local markets, or small-scale entrepreneurship. Data collection instruments include lab testing forms, structured questionnaires, sensory evaluation sheets, and semi-structured interview guides.

Finally, a SWOT analysis is conducted to assess internal and external factors affecting the product's marketability. The research culminates in the development of a commercialization plan that includes branding and digital marketing strategies tailored to local cultural values. This also includes preparing the product for halal certification, ensuring food safety compliance, and registering intellectual property (HKI). By integrating mixed methods, the study ensures that both the scientific feasibility and socio-cultural relevance of the product are thoroughly addressed—supporting its potential to become a sustainable and competitive contribution to the local creative economy

3. Results and Discussion

Results

a. Laboratory Test Results (Nutritional Composition of Mahi-mahi Fish Skin)

Based on laboratory testing conducted at the **Food Technology Laboratory, FATETA IPB**, the nutritional composition of *Coryphaena hippurus* (Mahi-mahi) fish skin gelatin extract is as follows:

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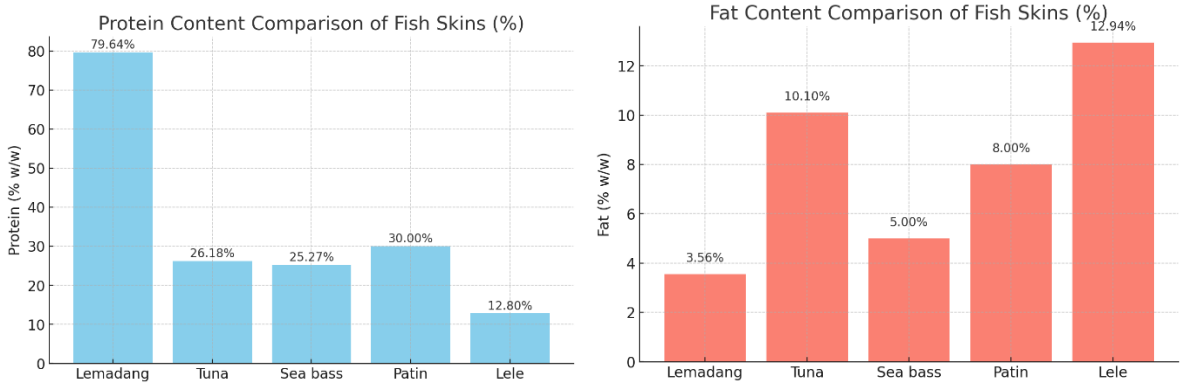
Table 2. Nutritional Composition Analysis of Mahi-Mahi Fish Skin

Parameter	Mahi-mahi Fish Skin	Unit	Analysis Method
Protein	**79.64**	% w/w	AOAC (Proximate)
Fat	3.56	% w/w	AOAC (Proximate)
Ash	15.46	% w/w	AOAC (Proximate)
Moisture*	±1.3 – 2.0**	%	AOAC (Proximate)

The analysis shows that Mahi-mahi fish skin contains **very high protein levels**—reaching **79.64%**, meaning that nearly eight out of every ten grams of dry matter consists of protein. This value is significantly higher than that of other common fish skins, such as tuna (26.18%) or catfish (around 30%), making it a strong candidate for *high-protein premium snack* positioning.

The relatively low fat content (**3.56%**) is another advantage, supporting its placement in the **low-fat healthy snack** category. Low-fat also extends product shelf life by reducing the risk of rancidity compared to fish skins with higher fat levels, such as catfish (±12.94%).

The ash content (**15.46%**) indicates a significant presence of natural minerals, derived from connective tissue and residual scales rich in calcium and phosphorus. This enhances the functional value of Mahi-mahi fish skin as a nutritious food material.



Charts 1. Nutritional Composition of Mahi-mahi Fish Skin
Sources: Lab Food Technology IPB, 2025

b. Flavor Variants of Mahi-mahi Fish Skin Chips

The product development of *Mahi-mahi Fish Skin Chips* was carried out in three flavor variants: **Original**, **Spicy**, and **Spicy Kaffir Lime**. All variants use the same primary raw material, *Coryphaena hippurus* (Mahi-mahi) fish skin, processed using vacuum frying to preserve nutritional quality and crispiness. The main differences between the variants lie in the seasoning formulations, which influence the sensory profile and potential consumer acceptance.

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Pict 1. Flavor Variants of Mahi-mahi Fish skin Chips

1. Original Flavor

This variant maintains the natural taste of Mahi-mahi fish skin with a minimalist seasoning formulation (salt, garlic, and light spices), highlighting the umami character of marine protein.

- Advantages:
  - Emphasizes the quality of the main raw material.
  - Preferred by consumers who seek a light and authentic taste.
  - Relatively lower sodium content compared to spicy variants.
- Market potential: Suitable for health-conscious consumers and as a base flavor for future flavor innovations.

2. Spicy Flavor

The spicy variant is formulated with additional chili powder, paprika, and spices to deliver a more intense *spicy-hot* sensation.

- Advantages:
  - Appeals to younger consumers who prefer *strong flavor* snacks.
  - The spicy effect increases snack appeal and encourages repeat consumption.
- Sensory evaluation (illustrative): Panelists gave higher scores for "aftertaste" compared to other variants.
- Market potential: Highly relevant for the teenage to young adult market segment following Indonesia's spicy snack trend.

3. Spicy Kaffir Lime Flavor

This variant combines spiciness with the distinctive aroma of kaffir lime leaves. This blend creates a *fresh-spicy* and complex flavor profile.

- Advantages:
  - Provides strong differentiation in the fish snack market.
  - Kaffir lime aroma enhances freshness perception and uniqueness.
  - Potentially attractive to consumers seeking traditional Indonesian culinary flavors.
- Sensory evaluation (illustrative): Scored highest for "aroma" and "overall uniqueness" attributes.
- Market potential: Suitable for premium domestic markets and culinary tourism, with high potential for export as an *exotic flavor*.

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c. Sensory Comparison Between Variants

Table 2. Sensory comparison

Flavor Variant	Taste (1–5)	Texture (1–5)	Aroma (1–5)	Overall Acceptability (1–5)
Original	4.2	4.5	4.0	4.3
Spicy	4.4	4.3	4.1	4.4
Spicy Kaffir Lime	4.3	4.4	**4.6**	**4.5**

d. Socio-Demographic Profile of the Sample

The survey involved 100 respondents, of whom 64% were male and 36% were female, indicating a male-dominated sample that may influence preferences for stronger flavors and higher snack consumption frequency. The respondents' ages varied widely, with 27 distinct age groups represented and 21 years old being the most common age (22 respondents), suggesting a concentration in the youth and young adult segments, which are generally more receptive to innovative snack products. In terms of occupation, the largest group comprised university students (53%), followed by private sector employees (32%), with smaller proportions of lecturers (5%), entrepreneurs (3%), and other categories such as government employees, unemployed individuals, and those with dual roles. This occupational distribution points to a market with diverse disposable incomes but a shared inclination toward affordable and on-the-go snack options. Geographically, respondents were drawn from various urban and suburban areas across Indonesia, reflecting the potential for a broad market reach and suggesting that the appeal of Mahi-mahi fish skin chips is not restricted to a single locality.

1. Perceptions and Attitudes Toward the Product Concept

- The survey results indicate generally strong positive perceptions toward the concept of Mahi-mahi fish skin chips, with most statements receiving mean scores above 4.5 on a 5-point scale. The highest-rated statement was *"I would like to try fish skin chips if they taste savory and are not fishy"* (mean = 4.64), highlighting the critical importance of flavor quality in consumer acceptance. This was followed by strong agreement that *local culinary innovations should be able to compete with large industrial snack products* (mean = 4.62), and that respondents *would be willing to purchase the product if it appears hygienic and of high quality* (mean = 4.60). A similarly high score (4.60) was given to the belief that *unique shapes and appearances can enhance product appeal*, while the potential nutritional benefits, such as high protein content, were also a strong motivator (mean = 4.56). Cultural values emerged as an important factor, with high agreement on supporting products that preserve local wisdom (mean = 4.54) and viewing such products as potential regional souvenirs (mean = 4.53). Respondents also valued transparency, with *complete and transparent product information* scoring 4.52, and acknowledged the role of regional spices in enhancing flavor (mean = 4.51)

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- In contrast, the lowest mean scores, though still relatively high, pointed to slightly less enthusiasm for certain aspects. For example, purchasing through e-commerce platforms scored the lowest (mean = 3.99), suggesting that while online channels are important, offline availability may remain significant for this product category. Other lower-ranked items included *interest in buying if available in various sizes* (mean = 4.31) and *belief in the potential of local businesses to grow through this product* (mean = 4.31), indicating areas where marketing communication could be strengthened. Overall, the results reveal a market that is highly receptive to the product concept, especially when sensory quality, cultural authenticity, and hygienic presentation are assured.

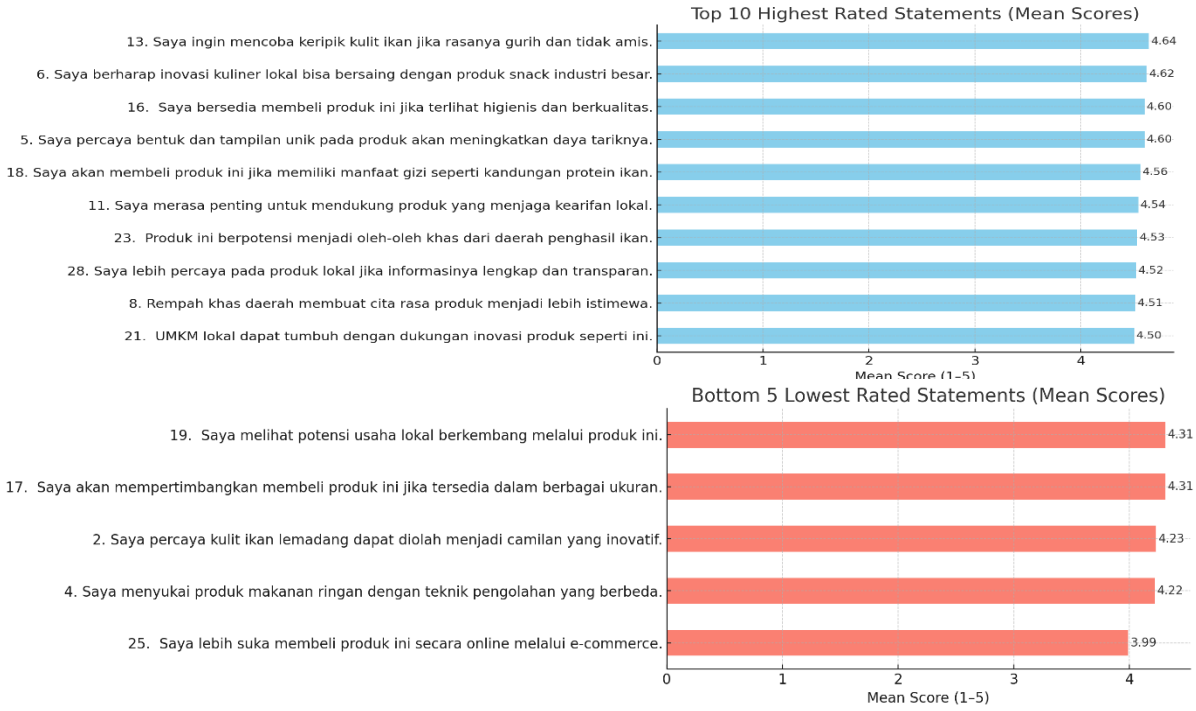

Chart 2. Rated statements

Sources: Analyzed by the researcher, 2025

2. Flavor Preference Analysis

The survey results indicate a strong consumer inclination toward distinctive and culturally rooted flavor profiles. Interest in flavor variants based on local spices, such as kaffir lime and turmeric, received a high mean score of **4.51** out of 5 (Q3), suggesting that consumers are open to flavors that incorporate traditional Indonesian culinary elements. This is further supported by the perception that regional spices make the flavor more special (Q8), which also scored **4.51**, reinforcing the appeal of authentic local seasonings as a point of differentiation in the snack market. Furthermore, the highest overall score in the entire survey was recorded for the statement *"I would like to try fish skin chips if they taste savory and are not fishy"* (Q13), with a mean of **4.64**, underscoring the critical role of flavor quality in purchase intention. These findings suggest that the **Spicy Kaffir Lime** variant, which combines heat

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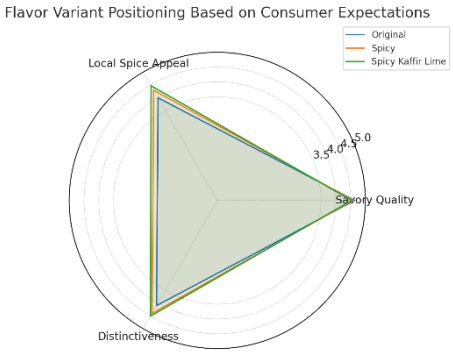
with a distinctive citrusy aroma, could resonate strongly with consumers seeking both novelty and cultural authenticity, while the **Original** and **Spicy** variants can cater to more universal savory preferences.



Pict 2. Flavor Preference
Sources: Analyzed by the researcher, 2025

3. Purchase Channel Preferences

Survey results reveal a stronger inclination toward offline purchasing channels. The statement *"I want this product to be available in local souvenir shops and modern retail stores"* received a mean score of **4.44**, indicating that most respondents prefer to physically see and purchase the product—possibly due to trust in product freshness and the sensory appeal of in-person shopping. In contrast, the statement *"I prefer to buy this product online via e-commerce"* scored lower at **3.99**, suggesting that while online channels remain relevant, they may not be the primary choice for initial product adoption.

This finding implies that an effective distribution strategy should prioritize placement in high-traffic physical locations such as souvenir outlets, specialty food stores, and modern retail chains, particularly in areas with strong tourism activity. Online channels, while secondary, can complement offline sales by targeting tech-savvy consumers and facilitating wider reach beyond local markets.

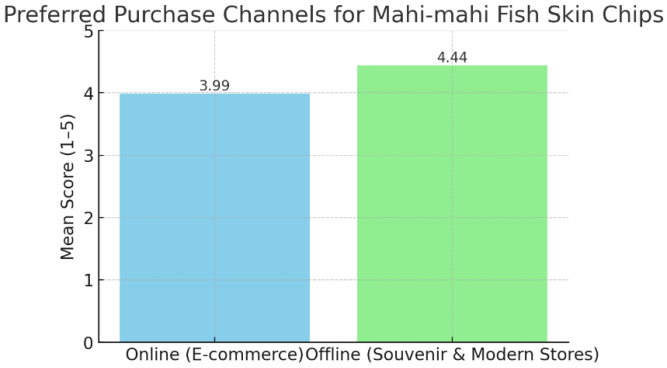


Chart 4. Purchase channels
Sources: Analyzed by the researcher, 2025

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4. Promotion strategy insights

The survey highlights three key promotional factors influencing purchase intent. The highest-rated factor was *"I trust local products more if the information is complete and transparent,"* with a mean score of 4.52, indicating that clear product labeling, ingredient lists, and transparent sourcing can significantly build consumer trust. Close behind, *"I believe positive reviews from other buyers will influence my decision"* scored 4.43, underscoring the importance of leveraging testimonials and user-generated content in marketing campaigns. Social media promotions were also highly rated, with the statement *"Attractive social media promotions will make me curious to try the product"* receiving a mean score of 4.41. This suggests that while product transparency and credible reviews drive trust and decision-making, engaging social media campaigns can spark initial interest and trial.

Strategically, these findings imply that the product's marketing mix should combine transparent branding, influencer and customer review amplification, and creative social media content to maximize reach and conversion rates.

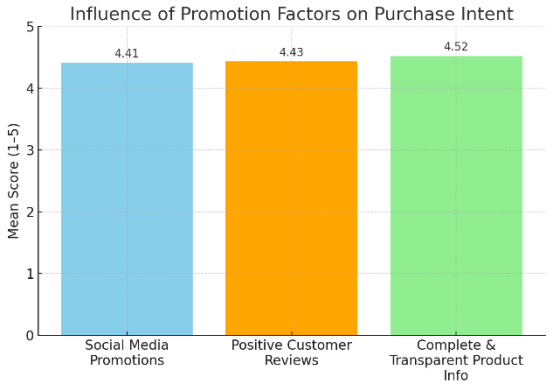

Chart 5. Promotion strategy

Sources: Analyzed by the researcher, 2025

5. Qualitative Insights from Open-Ended Responses

From the 100 respondents, 67 provided open-ended feedback, which was categorized into several recurring themes. Flavor-related suggestions were the most frequent (21 responses), with comments encouraging the development of multiple taste variants—particularly spicy, salty, and original options—and ensuring a savory profile without an overpowering fishy smell. Raw material considerations appeared in 9 responses, highlighting concerns about the limited availability of Mahi-mahi skin and suggesting the need for a reliable supply chain to sustain production.

Packaging improvements were mentioned in 6 responses, emphasizing the importance of attractive and functional designs to enhance product appeal and shelf life. Distribution-related suggestions (2 responses) encouraged making the product widely available, including in both local souvenir shops and modern retail stores. Price sensitivity

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was mentioned only once, suggesting that while cost is a factor, it is not the primary concern among respondents at this stage.

A significant number of responses (28) fell into the "Other" category, often containing positive encouragement, such as *"I hope the product can be enjoyed by all people in Indonesia and recognized internationally through exports"* or *"Good"*, indicating overall support for the concept.

These qualitative insights reinforce the quantitative findings, particularly the importance of flavor variety, product quality, and securing raw material supply, while also highlighting the value of appealing packaging and strategic distribution to ensure market reach.

e. SWOT Analysis of Mahi-mahi Fish Skin Chips

Strengths (S)	**Weaknesses (W)**
S1. Very high protein (79.64%) and low fat (3.56%) content.	W1. Limited raw material supply (Mahi-mahi not mass-cultured).
S2. Strong consumer perception and high survey ratings (>4.5 on taste, local spice appeal, uniqueness).	W2. Lower online buying preference (mean 3.99) vs. offline.
S3. Three appealing flavor variants (Original, Spicy, Spicy Kaffir Lime).	W3. Low local familiarity with Mahi-mahi compared to tuna/catfish.
S4. Cultural and sustainability value (local wisdom, zero-waste).	W4. Sensitive processing requirements for thin fish skin.
S5. Strong offline retail potential (souvenir shops & modern stores, mean 4.44).	W5. Packaging needs improvement for appeal and shelf life.

Opportunities (O)	**Threats (T)**
O1. Growing healthy snack market (high-protein, low-fat).	T1. Competition from established fish skin snacks (tuna, salmon, catfish).
O2. Cultural differentiation through local spices (e.g., kaffir lime).	T2. Seasonal fishing and climate variability affecting supply.
O3. Collaboration with tourism sector for regional souvenir positioning.	T3. Price sensitivity in broader snack market.
O4. Leverage social media (mean 4.41) and positive reviews (mean 4.43) for branding.	T4. Stringent export regulations and food safety compliance.
O5. Halal & food safety certification to expand into Muslim-majority markets.	T5. Market penetration challenges beyond niche consumers.

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1. Discussion (Integrated Quantitative and Qualitative Findings)

This study integrates quantitative findings from a structured survey of 100 respondents with qualitative insights obtained from in-depth interviews with four key informants: a small-scale fish skin chip entrepreneur, an official from the Southeast Maluku Fisheries Department, a lecturer in seafood processing technology, and a consumer representative. The integrated analysis provides a comprehensive understanding of the market potential, production challenges, and strategic pathways for developing Mahi-mahi (*Coryphaena hippurus*) fish skin chips as a commercially viable and sustainable snack product.

a. Raw Material Availability and Sustainability

Survey data indicate that consumer familiarity with Mahi-mahi remains relatively low compared to more common species such as tuna or catfish. Nevertheless, the willingness to try products made from Mahi-mahi skin is high, suggesting an untapped niche market. The Fisheries Department official emphasized that Mahi-mahi is primarily a seasonal bycatch species in Southeast Maluku, with availability dependent on fishing seasons and climatic conditions. This variability raises concerns over supply consistency for continuous production. The seafood processing lecturer further highlighted that the physical properties of Mahi-mahi skin — including thickness, collagen content, and elasticity — make it suitable for chip production, provided that proper storage and processing methods are implemented.

These qualitative insights reinforce the quantitative finding that raw material security is a potential weakness in the supply chain. Strategic measures, such as developing frozen skin storage systems or diversifying sourcing regions, will be essential to mitigate seasonal fluctuations and ensure production continuity.

b. Product Quality and Processing Technology

Sensory evaluation results from the survey revealed high acceptance scores for taste, aroma, and texture across all three product variants — Original, Spicy, and Spicy Kaffir Lime — with Spicy emerging as the most preferred. The lecturer underscored the importance of applying Good Manufacturing Practices (GMP) and Hazard Analysis and Critical Control Point (HACCP) principles, even at the small and medium enterprise (SME) level, to guarantee product safety and quality. Vacuum frying was recommended to preserve the nutritional profile, particularly the collagen content, while minimizing oxidative damage and excessive oil absorption.

Consumer interviews echoed these points, with recurring concerns about potential "fishy" odor and hygiene standards in processing. Addressing these concerns through transparent labeling, visual documentation of hygiene practices, and clear expiry dating may strengthen consumer trust and willingness to purchase.

c. Market Potential and Consumer Preferences

The quantitative survey found that flavor variety plays a critical role in purchasing decisions, with Spicy flavor obtaining the highest mean preference score, followed by Original

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and Spicy Kaffir Lime. This aligns with consumer interview feedback, which consistently emphasized the importance of a savory and moderately spicy profile to appeal to local tastes.

The SME entrepreneur stressed that flavor innovation and attractive packaging are essential differentiators in a competitive snack market. Given the product's exceptionally high protein content (79.64%) and low fat content (3.56%), leveraging "high-protein" and "low-fat" claims on packaging could attract health-conscious consumers, both domestically and internationally.

d. Price Point and Accessibility

Survey respondents generally indicated a preferred price range of IDR 15,000–20,000 for a standard pack, with minimal resistance to slightly higher pricing if the product offers premium quality and unique value. The consumer representative noted that price sensitivity varies across segments, with urban middle-class consumers showing greater flexibility.

The Fisheries Department official highlighted logistical constraints in transporting fishery products from remote regions, which could increase distribution costs. This finding suggests that pricing strategies should be tailored by market segment and distribution channel, balancing affordability with profitability.

e. Promotion and Distribution Channels

The survey revealed a stronger inclination towards offline purchasing, particularly in souvenir shops and modern retail outlets (mean score 4.44), although online channels remain relevant. Digital promotion emerged as a significant driver of purchase intent, with high mean scores for the influence of social media campaigns (4.41) and positive customer reviews (4.43).

The Fisheries Department recommended leveraging regional branding and integrating the product into digital marketing hubs for local fishery products. Consumer interviews emphasized that promotional content should highlight both the sensory appeal and the nutritional benefits of the chips, creating a compelling "taste-and-health" narrative.

f. Policy and Institutional Support

Currently, there is no regional regulation in Southeast Maluku specifically addressing the utilization of fish processing by-products. However, the Fisheries Department expressed openness to policy development that could incentivize by-product valorization. The lecturer emphasized the role of academic institutions in providing training, research support, and technology transfer to SMEs, creating opportunities for triple-helix collaboration between government, academia, and industry.

Integrated implication

The convergence of quantitative and qualitative findings underscores that Mahi-mahi fish skin chips have significant market potential as a high-protein, low-fat snack with cultural and sustainability appeal. However, challenges remain in raw material supply, consumer education, and competitive positioning. Addressing these through supply chain innovation, product quality assurance, strategic pricing, and targeted promotion — supported by

institutional collaboration — could position the product strongly in both domestic and export markets.

4. Conclusion

This research demonstrates that Mahi-mahi (*Coryphaena hippurus*) fish skin has strong potential to be developed into a commercially viable, high-protein, and low-fat snack product. Laboratory analysis confirmed its superior nutritional profile, while sensory evaluation and market surveys indicated high consumer acceptance, particularly for the Spicy variant. Quantitative findings were reinforced by qualitative insights from industry practitioners, government representatives, academic experts, and consumers, highlighting both opportunities and challenges in product development.

Key strengths include the product's unique raw material, nutritional value, and flavor variety, while key weaknesses relate to seasonal raw material supply and the need for strict quality control. Opportunities exist in health-conscious consumer markets, premium souvenir products, and expanding online distribution. However, threats such as supply chain instability, competition from more established fish skin products, and limited consumer awareness require strategic mitigation.

The study concludes that the successful commercialization of Mahi-mahi fish skin chips will depend on integrated strategies addressing supply security, product quality assurance, targeted marketing, and institutional collaboration.

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