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SENSORY, NUTRITIONAL, AND PHYSICOCHEMICAL EVALUATION OF GLUTEN-FREE CORNMEAL NILE TILAPIA (OREOCHROMIS-NILOTICUS)-BASED SNACK PRODUCTS

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ABSTRACT

This study developed and evaluated three gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based snack products—(F1) chips, (F2) cookies, and (F3) crackers—using cornmeal and tilapia powder as primary ingredients. A quasi-experimental research design was employed in the Third Congressional District of Bohol during the School Year 2026–2027. A total of 100 respondents, comprising 40 Food Technology teachers, 35 senior high school students, and 25 local food processors, were selected through purposive sampling and evaluated the products using a validated four-point hedonic scale. Data were analyzed using mean, standard deviation, Friedman test, and Durbin–Conover pairwise comparisons. Results revealed that cookies obtained the highest overall preference mean (3.78), followed by chips (3.31) and crackers (2.79). Significant differences were found among the three products ($\chi^2 = 174$, $df = 2$, $p < 0.001$), with all pairwise comparisons showing statistically significant differences. Shelf-life observations indicated that cookies maintained their observable sensory quality throughout the 60-day room-temperature storage period, while chips and crackers exhibited textural deterioration beginning in Week 6. Laboratory analysis of the most preferred product, cookies, revealed 22.40 g/100 g protein, 55.30 g/100 g carbohydrates, 11.80 g/100 g fat, and 3.63 g/100 g dietary fiber. Physicochemical analysis recorded 7.85 g/100 g moisture, a pH of 6.24, and water activity of 0.517. A proposed technology guide was also developed to support school-based food processing and potential livelihood activities. The study concluded that cornmeal and Nile tilapia powder demonstrated potential as ingredients for developing acceptable, value-added snack products, although further microbiological testing and shelf-life validation were recommended before commercialization.

Keywords: *gluten-free cornmeal, Nile tilapia, snack product development, sensory evaluation, nutritional analysis, physicochemical properties, consumer preference*

INTRODUCTION

The increasing demand for nutritious, convenient, and gluten-free food products has encouraged the development of alternative snacks using agricultural and fisheries resources. Food product innovation has increasingly emphasized the incorporation of nutrient-rich ingredients into commonly consumed products while maintaining desirable sensory characteristics. Gluten-free snack development presents particular challenges because replacing conventional wheat-based ingredients may influence product structure, texture, flavor, and nutritional composition. Olaimat et al. (2023) demonstrated that corn-based gluten-free biscuits could be nutritionally enhanced through the incorporation of supplementary ingredients, although changes in formulation also affected their physicochemical and sensory properties. These findings highlight the importance of developing gluten-free food products that provide nutritional value without compromising consumer acceptability.

Nile tilapia (*Oreochromis niloticus*) is a widely cultivated freshwater fish with considerable potential for value-added food processing. Its nutritional characteristics, accessibility, and suitability for various processing applications make it a promising ingredient for the development of protein-enriched food products. El-Sayed (2019) emphasized the importance of tilapia in global aquaculture and its contribution to food production, processing, and economic development. Beyond its conventional consumption as fresh fish, tilapia can be processed into protein concentrate or powder for incorporation into various food formulations. This approach provides opportunities to diversify the utilization of fishery resources while developing products with additional nutritional value. In the Philippine context, where aquaculture contributes to local food production and livelihoods, exploring alternative uses of tilapia may support food innovation and value-added processing.

Previous investigations have demonstrated the potential of tilapia-derived ingredients to improve the nutritional characteristics of processed snack products. Sivaraman et al. (2023) examined cookies supplemented with tilapia fish protein concentrate and seaweed and reported improvements in selected nutritional characteristics, particularly protein and mineral composition. Their findings also demonstrated the importance of evaluating physical and sensory attributes when incorporating fish-derived ingredients into conventional bakery products. Similarly, Kaur et al. (2024) developed nutrition bars enriched with carp fish protein powder and observed that protein content increased from 13.79% in the control formulation to 27.70% in the formulation containing 12.5% fish protein powder. However, the incorporation of fish protein also influenced product hardness and color, with the formulation containing 7.5% fish protein powder receiving the highest sensory acceptance. These findings suggest that fish-based ingredients may improve nutritional composition, but their incorporation must be carefully considered to maintain desirable product characteristics.

Corn (*Zea mays* L.) is another agricultural resource with potential for developing alternative snack products because of its carbohydrate content, processing versatility, and naturally gluten-free characteristics. Cornmeal can serve as a cereal base in food formulations, providing structural properties and contributing to the texture and consistency of finished products. The suitability of corn for gluten-free food production was demonstrated by Olaimat et al. (2023), who developed biscuits using corn-based flour supplemented with walnuts and peanuts. Their investigation revealed improvements in protein, fat, crude fiber, and ash contents following ingredient supplementation. Sensory evaluation also indicated that the quality and acceptability of the developed biscuits varied according to ingredient composition. These findings provide a scientific basis for considering cornmeal as a suitable ingredient for nutrient-enriched gluten-free snack products.

Combining cornmeal with tilapia powder offers an opportunity to integrate the nutritional and functional characteristics of agricultural and aquatic ingredients. Cornmeal primarily contributes carbohydrates and product structure, while tilapia powder provides an additional source of protein. This complementary relationship may be useful in developing snack products that offer nutritional variety while maintaining desirable sensory properties. Cookies, crackers, and chips are particularly suitable for investigation because they represent different snack formats with distinct preparation methods, structural characteristics, and texture requirements. However, the incorporation of fish-derived ingredients may influence their appearance, aroma, taste, and texture. Consequently, evaluating these characteristics is necessary to determine whether the developed products meet consumer expectations.

Sensory evaluation is essential in determining the acceptability of newly developed food products. Hirschman and Holbrook (1982) explained that consumption involves sensory, emotional, and experiential dimensions, suggesting that consumer responses are influenced by more than the functional characteristics of products. In food product development, appearance, aroma, taste, and texture are important considerations because these attributes influence consumer preference and acceptance. Lawless and Heymann (2010) likewise emphasized the importance of systematic sensory evaluation in measuring and interpreting human responses to food characteristics. Through sensory testing, researchers can assess product quality, identify desirable attributes, and determine whether differences in product composition influence consumer evaluations. These principles are particularly relevant to fish-enriched snack products because the inclusion of fish powder may introduce changes in flavor, aroma, color, and texture that affect consumer preference.

The importance of balancing nutritional improvement and sensory quality was demonstrated by Sivaraman et al. (2023), whose investigation of tilapia-enriched cookies considered nutritional, physical, and sensory characteristics. Similarly, Kaur et al. (2024) found that increasing the concentration of fish protein powder influenced the physical characteristics and sensory acceptance of nutrition bars. These studies indicate that improving nutrient composition does not necessarily result in greater consumer preference. The most nutritionally enriched formulation may differ from the formulation

receiving the highest sensory rating. Therefore, evaluating the appearance, aroma, taste, and texture of gluten-free cornmeal and Nile tilapia-based snack products is necessary to identify their relative acceptability and determine which product is most preferred by evaluators.

In addition to sensory evaluation, nutritional analysis provides essential information about the composition and potential dietary contribution of developed food products. Important nutritional parameters include protein, carbohydrates, fat, caloric value, dietary fiber, and selected vitamins and fatty acids. Sivaraman et al. (2023) demonstrated that incorporating tilapia fish protein concentrate could influence the nutritional composition of cookies, while Kaur et al. (2024) established that fish protein supplementation increased the protein content of snack bars. These findings support the importance of laboratory analysis in determining the actual nutritional composition of fish-enriched food products rather than relying solely on the presumed nutritional benefits of their raw ingredients.

Physicochemical properties must also be considered because they provide important information regarding food quality, processing characteristics, and storage stability. Moisture content, ash, pH, and water activity are relevant parameters in evaluating processed snack products, particularly those containing fish-derived ingredients. Olaimat et al. (2023) demonstrated that ingredient supplementation influenced the physicochemical characteristics of gluten-free corn-based biscuits, while Kaur et al. (2024) reported changes in the textural and physical properties of fish-protein-enriched snacks. These findings indicate that modifications in food formulations can affect both nutritional composition and product quality. Accordingly, examining the physicochemical properties of the developed products is necessary to provide objective information about their composition and characteristics.

Shelf-life evaluation is another important consideration in food product development because the quality of processed foods may change during storage. Changes in appearance, aroma, taste, and texture may indicate deterioration and influence consumer acceptability. Lawless and Heymann (2010) recognized quality control and shelf-life testing as important applications of sensory evaluation in food science. For fish-based products, appropriate handling, processing, packaging, and storage are especially important because the characteristics of fish-derived ingredients may influence product stability. In the Philippines, Republic Act No. 10611, otherwise known as the Food Safety Act of 2013, established a regulatory framework intended to protect consumers from unsafe food products and strengthen food safety practices throughout the food supply chain. This legal framework highlights the importance of proper food preparation, processing, and storage when developing alternative snack products. Observations of physical and sensory changes during storage may provide preliminary information about product stability, although microbiological testing is necessary to establish microbial safety.

The development of gluten-free cornmeal and Nile tilapia-based snack products also has implications for agricultural and fisheries development. Republic Act No. 8435,

or the Agriculture and Fisheries Modernization Act of 1997, promotes the modernization of the Philippine agricultural and fisheries sectors and supports improvements in productivity, profitability, and value-added processing. Transforming locally available agricultural and fisheries commodities into alternative food products is consistent with the objective of increasing their economic usefulness. In Bohol, the utilization of corn and tilapia in food innovation may provide opportunities for product diversification, local entrepreneurship, and small-scale food processing. Developing practical preparation procedures and documenting production costs may further support the potential adoption of these products by individuals and community-based food enterprises.

Despite existing investigations on fish-enriched food products and gluten-free corn-based snacks, the reviewed literature indicates a need for further research integrating these ingredients across different snack formats. Sivaraman et al. (2023) focused on cookies containing tilapia fish protein concentrate and seaweed, while Kaur et al. (2024) investigated fish-protein-enriched nutrition bars. Meanwhile, Olaimat et al. (2023) examined gluten-free corn-based biscuits supplemented with plant-derived ingredients. Although these investigations established the potential of nutritional supplementation in processed foods, they did not directly examine the combined utilization of cornmeal and Nile tilapia powder in chips, cookies, and crackers within a single comparative evaluation. Moreover, the sensory characteristics, product preferences, nutritional composition, physicochemical properties, and storage-related characteristics of these specific products require further investigation in the local context.

Addressing this gap is particularly relevant to the Third Congressional District of Bohol, where agricultural and fisheries resources provide opportunities for developing alternative food products. The combined utilization of cornmeal and Nile tilapia powder may contribute to the diversification of locally produced snacks while supporting the development of value-added food products. However, the feasibility of these products depends on several considerations, including ingredient requirements, production costs, preparation procedures, sensory characteristics, and laboratory-determined composition. A comprehensive product development approach is therefore necessary to evaluate their potential for further improvement, utilization, and small-scale production.

In response to these considerations, the present study aimed to develop and evaluate three gluten-free cornmeal and Nile tilapia (*Oreochromis niloticus*)-based snack products, namely chips, cookies, and crackers, in the Third Congressional District of Bohol during the School Year 2026–2027. Specifically, the study sought to describe the products in terms of ingredients and cost, tools and equipment, preparation procedures, shelf-life characteristics, nutritional content, and physicochemical properties. It also evaluated their sensory attributes in terms of appearance, aroma, taste, and texture; determined respondents' levels of preference; and examined significant differences in preference among the three developed products. Furthermore, the study aimed to develop a technology guide based on its findings to document product formulations, preparation procedures, and relevant production information. Through these objectives, the research sought to contribute to gluten-free food product innovation, promote the value-added utilization of locally available agricultural and fisheries resources, and

provide a basis for further product development and potential small-scale enterprise initiatives.

Research Questions

This study sought to evaluate the sensory, nutritional and physicochemical properties of Gluten-free Cornmeal Nile Tilapia (*Oreochromis niloticus*)-based snack products in the Congressional District 3 of Bohol for the School Year 2026-2027.

Specifically, it sought to answer the following aspects of the problem:

1. What are the descriptions of Gluten-free Cornmeal Nile Tilapia-based snack products in terms of:
   1.1 ingredients and cost;
   1.2 tools and equipment used;
   1.3 procedure;
   1.4 shelf life;
   1.5 nutritional content and physicochemical properties.
2. What are the sensory attributes of Gluten-free Cornmeal Nile Tilapia-based snack products in three formulation in terms of:
   2.1 appearance;
   2.2 aroma;
   2.3 taste;
   2.4 texture?
3. What is the respondents' preference level for the developed Gluten-free Cornmeal Nile Tilapia-based snack products?
4. Is there a significant difference of the respondents' preference level of the Gluten-free Cornmeal Nile Tilapia-based snack products?
5. What technology guide may be developed based on the findings and outputs of the study?

METHODOLOGY

Research Design

The study employed a quasi-experimental research design to develop and evaluate gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based snack products. Three snack products were developed, namely chips, cookies, and crackers, using cornmeal and Nile tilapia powder as the primary ingredients. The design involved variations in ingredient formulations and preparation procedures to produce the three snack products and evaluate their sensory characteristics and consumer preferences.

Descriptive research techniques were also employed to assess the sensory attributes of the developed products in terms of appearance, aroma, taste, and texture. A structured sensory evaluation questionnaire using a four-point hedonic scale was administered to determine the respondents' levels of preference. Additionally, shelf-life

observations were conducted over a one-month period to monitor changes in the products' sensory characteristics during storage. Nutritional and physicochemical analyses were performed on the most preferred product to determine its composition and quality characteristics. This approach allowed for the systematic development, evaluation, and comparison of the three gluten-free cornmeal Nile tilapia-based snack products.

Research Environment

The study was conducted in selected municipalities within the Third Congressional District of Bohol, Philippines, specifically Alicia, Anda, Candijay, Guindulman, and Mabini. These municipalities were selected because of their agricultural and fisheries resources, particularly corn and tilapia, which served as the primary raw materials for the developed gluten-free snack products. The study was conducted in selected public schools and local food-processing establishments within these municipalities, where the sensory evaluation and data collection were undertaken.

The preparation, processing, and production of the three gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based snack products, namely chips, cookies, and crackers, were carried out in Mabini, Bohol. The location was selected because of its accessibility to the researcher and the availability of the necessary facilities, tools, and equipment for product development. Conducting the preparation and production activities in this location facilitated the consistent implementation of the established formulations, processing procedures, and proper handling of ingredients throughout the study.

Research Participants

The study involved 100 respondents from selected municipalities in the Third Congressional District of Bohol, Philippines, specifically Alicia, Anda, Candijay, Guindulman, and Mabini. The participants consisted of 40 Food Technology teachers, 35 senior high school students, and 25 local food processors. These groups were selected based on their relevant knowledge, experience, and potential involvement in food preparation, product development, and sensory evaluation.

Purposive sampling was employed to select respondents who could provide meaningful evaluations of the developed gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based snack products. Food Technology teachers were included because of their knowledge and experience in food processing, product innovation, and quality assessment. Senior high school students represented potential consumers of the developed products, particularly if introduced in school canteens. Local food processors were also included because of their practical experience in food preparation and production. Their participation provided relevant perspectives in evaluating the sensory characteristics and preference levels of the three snack products.

Distribution of Research Participants

Group of Participants	Number of Participants
Food Technology Teachers	40
Senior High School Students	35
Local Food Processors	25
Total	**100**

Research Instrument

The study utilized a modified sensory evaluation questionnaire as the primary data-gathering instrument to assess the sensory attributes and respondents' preference levels for the three developed gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based snack products, namely chips, cookies, and crackers. The questionnaire employed a four-point hedonic scale, guided by the principles of sensory evaluation and consumer preference testing discussed by Gatchalian (1981) and Lawless and Heymann (2010). It measured four sensory attributes: appearance, aroma, taste, and texture. Respondents evaluated each product using the prescribed rating scale, ranging from 4, representing the highest level of sensory preference, to 1, representing the lowest level.

The research instrument underwent expert validation to ensure the relevance, clarity, and appropriateness of its items. Before actual data collection, the questionnaire was pilot-tested with at least 10 respondents through a mock sensory evaluation. The pilot-test responses were analyzed using Cronbach's alpha to determine internal consistency. The instrument obtained a reported reliability coefficient of 0.89, indicating good internal consistency. The validated questionnaire was subsequently administered to assess the sensory characteristics and respondents' preference levels for the developed snack products.

Research Procedure

The study followed seven systematic phases involving research approval, preparation of ingredients and equipment, product formulation, sensory evaluation, shelf-life observation, laboratory testing, and development of a technology guide.

Phase I. Approval of the Study. The researcher secured the necessary permissions from the Dean, Campus Director, College President, and Schools Division Superintendent of Bohol. Approval from the research adviser and concerned authorities was obtained before proceeding with product development, sensory evaluation, and data collection.

Phase II. Preparation of Ingredients, Materials, Tools, and Equipment. Fresh Nile tilapia (*Oreochromis niloticus*) was obtained from a local aquaculture supplier in Mabini, Bohol. The fish was thoroughly cleaned, steamed, deboned, and filleted before being dehydrated and ground into fine tilapia powder. Yellow corn was obtained from a local milling station, inspected for quality, ground into fine cornmeal, sifted, and stored in clean,

dry, airtight containers. The necessary ingredients, materials, tools, and equipment were subsequently prepared for product development.

Phase III. Formulation of Gluten-Free Cornmeal Nile Tilapia-Based Snack Products. Three snack products, namely chips, cookies, and crackers, were developed using cornmeal and tilapia powder as the primary ingredients. Preliminary trials were conducted using different ingredient proportions and preparation procedures to achieve the desired product characteristics. The finalized formulations were subsequently used to prepare the samples for sensory evaluation.

Phase IV. Distribution of Questionnaires and Sensory Testing. Sensory evaluation was conducted in selected public schools and local food-processing establishments within the Third Congressional District of Bohol. Before testing, respondents were oriented on the evaluation procedures and instructed to assess the appearance, aroma, taste, and texture of each product using a four-point hedonic scale. Samples of chips, cookies, and crackers were distributed together with drinking water for palate cleansing between evaluations. The accomplished questionnaires were collected, checked for completeness, and organized for statistical analysis.

Phase V. Shelf-Life Observation. The three developed snack products underwent shelf-life observation over a one-month period. Each product was individually packed in a ziplock pouch and stored under the designated conditions. Changes in appearance, aroma, taste, and texture were monitored and recorded using a shelf-life observation sheet to assess observable changes in product quality during storage.

Phase VI. Laboratory Testing. Following the sensory evaluation, cookies were identified as the most preferred product and were selected for nutritional and physicochemical analyses. A one-kilogram sample of the finalized cookie formulation was submitted to First Analytical Services and Technical Cooperative (F.A.S.T.) in Mandaue City, Cebu. Laboratory analyses were conducted to determine moisture content, ash content, crude protein, crude fat, carbohydrates, caloric value, pH, water activity, omega-3 fatty acid content, dietary fiber, and vitamin B3 (niacin) content.

Phase VII. Development of the Technology Guide. Based on the findings and outputs of the study, a technology guide was developed to document the formulations and preparation procedures of the gluten-free cornmeal Nile tilapia-based snack products. The guide included ingredients and cost, required tools and equipment, processing techniques, and relevant nutritional information. It was intended to facilitate knowledge transfer, encourage the utilization of locally available agricultural and fisheries resources, and provide practical guidance for potential small-scale production and commercialization.

Data Analysis

The data gathered from the sensory evaluation of the gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based snack products were organized, tabulated, and analyzed using descriptive and inferential statistical techniques. The mean and standard deviation were employed to determine the sensory attributes and respondents' preference levels for the three developed products, namely chips, cookies, and crackers. The Friedman test and Durbin–Conover pairwise comparisons were used to determine significant differences in respondents' preference levels among the three products.

The mean was computed to determine the average sensory evaluation ratings of each product in terms of appearance, aroma, taste, and texture. Meanwhile, the standard deviation was used to measure the variability of respondents' ratings and determine the consistency of their evaluations.

Descriptive Rating Scale for Sensory Attributes

Scale	Numerical Range	Appearance	Aroma	Taste	Texture
4	3.25–4.00	Very Appealing	Very Pleasant	Very Palatable	Very Crisp and Crunchy
3	2.50–3.24	Appealing	Pleasant	Palatable	Crisp and Crunchy
2	1.75–2.49	Moderately Appealing	Moderately Pleasant	Moderately Palatable	Moderately Crisp and Crunchy
1	1.00–1.74	Not Appealing	Not Pleasant	Not Palatable	Not Crisp and Crunchy

The respondents' overall preference levels were determined using the mean ratings obtained from the sensory evaluation.

Descriptive Rating Scale for Respondents' Preference Levels

Scale	Numerical Range	Descriptive Rating
4	3.25–4.00	Most Preferred
3	2.50–3.24	Preferred
2	1.75–2.49	Slightly Preferred
1	1.00–1.74	Not Preferred

To determine whether significant differences existed in the respondents' preference levels among the three developed snack products, the Friedman test was employed. This nonparametric statistical test was appropriate for comparing three related samples because the same respondents evaluated all three products. The test was used to determine whether the respondents' preference ratings differed significantly among chips, cookies, and crackers.

When a statistically significant difference was identified, Durbin–Conover pairwise comparisons were employed as a post hoc procedure to determine which specific pairs of products differed significantly. The comparisons included chips and cookies, chips and crackers, and cookies and crackers. Statistical significance was evaluated at the 0.05 level, with p-values below 0.05 interpreted as indicating significant differences.

The results of the descriptive and inferential analyses served as the basis for determining the sensory characteristics, respondents' preference levels, and significant differences among the developed Nile tilapia-based gluten-free cornmeal snack products.

RESULTS

This section presents the findings on the development and evaluation of three gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based snack products, namely chips, cookies, and crackers. The results include product descriptions, sensory attributes, respondents' preference levels, significant differences in preferences, and the development of a technology guide.

Table 1.1
Ingredients and Cost of Gluten-Free Cornmeal Nile Tilapia-Based Snack Products

Cost Component	F1 Chips	F2 Cookies	F3 Crackers
Total Cost of Ingredients and Materials	₱61.85	₱88.99	₱84.89
Operating Expenses (20%)	₱12.37	₱17.80	₱16.98
Mark-Up Cost (30%)	₱18.56	₱26.70	₱25.47
Total Cost of Production (as reported)	₱92.78	₱133.49	₱127.34
Total Serving Packs/Yield	20	25	22
Price per Pack	₱4.64	₱5.34	₱5.79

Table 1.1 presents the cost analysis of the three developed gluten-free cornmeal Nile tilapia-based snack products. Among the products, chips (F1) recorded the lowest ingredient and material cost of ₱61.85, followed by crackers (F3) at ₱84.89, while cookies (F2) incurred the highest cost of ₱88.99. The variations were attributed to differences in the ingredients, quantities, and packaging materials used in each formulation.

After incorporating the reported 20% operating expenses and 30% mark-up, the computed totals were ₱92.78 for chips, ₱133.49 for cookies, and ₱127.34 for crackers. The corresponding production yields were 20, 25, and 22 packs, respectively. Based on these figures, chips had the lowest reported price per pack at ₱4.64, followed by cookies at ₱5.34 and crackers at ₱5.79.

The findings indicated that the three snack products required different production expenditures despite sharing cornmeal and tilapia as their primary ingredients. Chips were the least expensive to produce based on the reported costing, whereas cookies required the highest total expenditure. The results provided baseline cost information for

evaluating the potential small-scale production and pricing of the developed snack products.

Table 1.2
Tools and Equipment Used in the Production of Gluten-Free Cornmeal Nile Tilapia-Based Snack Products

Tools	Functions
Mixing Bowl	Used for combining and mixing ingredients for the three snack products.
Sifter	Used for removing lumps and ensuring uniformity of dry ingredients.
Spatula	Used for mixing, folding, scraping, and transferring mixtures.
Measuring Cup	Used for accurately measuring liquid and dry ingredients.
Measuring Spoon	Used for measuring small quantities of ingredients.
Wooden Ladle	Used for stirring and mixing ingredients during preparation and cooking.
Can Opener	Used for opening canned ingredients required in the formulations.
Food Gloves	Used for maintaining hygiene and minimizing direct hand contact with ingredients and products.
Saucepan	Used for heating and cooking ingredients during preparation.
Baking Pan	Used for baking the formulated snack products.
Cookie Cutter	Used for shaping dough into uniform pieces.
Rolling Pin	Used for flattening and shaping cornmeal-tilapia dough.
Rolling Mat	Used as a clean surface for rolling and shaping dough.
Frying Pan	Used for frying the gluten-free cornmeal Nile tilapia chips.
Strainer	Used for draining excess oil from fried chips.
Frying Ladle	Used for stirring, turning, and handling ingredients during frying.
Wire Whisk	Used for blending and incorporating ingredients evenly.
Pastry Brush	Used for applying oil or other coatings to products and baking surfaces.
Cooling Rack	Used for cooling finished products and allowing air circulation to minimize moisture accumulation.
Parchment Paper	Used for lining baking pans and sheets.
Ziplock Pouch	Used for packaging and storing the finished snack products.
Weighing Scale	Used for measuring finished products to ensure consistent pack weights.
Equipment	**Functions**
Dehydrator Machine	Used for removing moisture from processed tilapia before pulverization.
Steamer	Used for steaming tilapia before deboning and further processing.
Electric Pulverizer	Used for grinding dehydrated tilapia into fine powder.
Oven	Used for baking gluten-free cornmeal Nile tilapia cookies and crackers.
Gas Stove	Used as a heat source for steaming, frying, and other cooking processes.

Table 1.2 presents the tools and equipment utilized in developing the three gluten-free cornmeal Nile tilapia-based snack products, namely chips, cookies, and crackers. The researcher employed standard food-processing and kitchen tools for ingredient measurement, mixing, shaping, cooking, cooling, and packaging. Measuring instruments, mixing bowls, sifters, and other preparation tools facilitated the consistent implementation of the established formulations. Meanwhile, the dehydrator, steamer, and electric pulverizer were used to process Nile tilapia into powder, which served as a primary ingredient in the developed products.

The oven and gas stove provided the necessary heat for the different cooking processes, while cooling racks and packaging materials were used during the final stages of production. The selection and proper utilization of these tools and equipment supported consistency, efficiency, and hygienic handling throughout product development. These practices were consistent with the *General Principles of Food Hygiene* established by the Codex Alimentarius Commission (2023), which emphasized the importance of suitable equipment, proper maintenance, and controlled processing conditions in maintaining food quality and safety.

Table 1.3.1
Procedures in Preparing Nile Tilapia Powder and Cornmeal

A. Nile Tilapia Powder	
Step	**Procedure**
1	Washed the fresh tilapia thoroughly, removed the scales, and removed the viscera.
2	Steamed the cleaned tilapia until the meat was adequately cooked.
3	Allowed the steamed tilapia to cool before removing the bones.
4	Arranged the deboned tilapia meat evenly in the dehydrator and dried it.
5	Pulverized the dehydrated tilapia meat into fine powder.
6	Transferred the tilapia powder into a clean, dry, airtight container and stored it properly until use.
B. Cornmeal	
Step	**Procedure**
1	Inspected the corn, removed visible impurities, and ground it until fine, uniform cornmeal was obtained.
2	Transferred the cornmeal into a clean, dry, airtight container and stored it properly until use.

Table 1.3.1 presents the procedures used to prepare Nile tilapia powder and cornmeal, which served as the primary ingredients of the developed snack products. Tilapia underwent cleaning, steaming, deboning, dehydration, and pulverization to obtain a powdered ingredient suitable for incorporation into the formulations. Meanwhile, corn was inspected, ground, and stored in airtight containers to maintain its quality. These procedures established the preparation methods used for the primary ingredients before producing the three snack products.

Table 1.3.2
Procedures in Preparing Gluten-Free Cornmeal Nile Tilapia Chips

Step	**Procedure**
1	Prepared, washed, and dried all tools and equipment required for production.
2	Sifted the tilapia powder and cornmeal to remove lumps and measured all ingredients according to the formulation.
3	Combined cornmeal, tilapia powder, baking powder, salt, onion powder, black pepper powder, and garlic powder in a mixing bowl.

4	Gradually added lukewarm water while mixing until a workable dough was formed.
5	Kneaded the dough until a uniform consistency was achieved.
6	Placed the dough on a rolling surface and flattened it evenly to the desired thickness.
7	Cut the flattened dough into the desired sizes and shapes.
8	Pricked each piece using a fork.
9	Heated the cooking oil and fried the prepared pieces until golden brown and crisp.
10	Removed the fried chips, drained the excess oil, and allowed them to cool before packaging and storage.

Table 1.3.2 presents the preparation procedures for gluten-free cornmeal Nile tilapia chips. The process involved combining the dry ingredients, gradually adding water to form dough, and kneading and flattening the mixture before cutting it into uniform pieces. The prepared pieces were fried until golden brown and crisp, drained, and cooled before packaging. The procedure was intended to produce chips with consistent appearance, flavor, and crunchy texture.

Table 1.3.3
Procedures in Preparing Gluten-Free Cornmeal Nile Tilapia Cookies

Step	Procedure
1	Prepared, washed, and dried all tools and equipment needed for production.
2	Sifted the tilapia powder and cornmeal to remove lumps and measured all ingredients according to the formulation.
3	Combined the egg, sugar, and vanilla in a mixing bowl and whisked until the sugar dissolved and the mixture became pale yellow.
4	Added melted butter to the egg mixture and whisked thoroughly until incorporated.
5	Added cornmeal, tilapia powder, and baking powder to the wet mixture and whisked until smooth and free from lumps.
6	Piped uniform portions of cookie batter onto a baking pan lined with parchment paper.
7	Baked the cookies in a preheated oven at 180°C for 15 minutes or until done.
8	Allowed the cookies to cool completely before packaging and storage.

Table 1.3.3 presents the procedures followed in preparing gluten-free cornmeal Nile tilapia cookies. The process involved mixing the wet ingredients, incorporating the dry ingredients, and preparing a uniform batter before baking. The cookies were baked at 180°C for approximately 15 minutes and cooled completely before packaging. These procedures facilitated the preparation of consistently shaped cookies with the desired sensory characteristics.

Table 1.3.4
Procedures in Preparing Gluten-Free Cornmeal Nile Tilapia Crackers

Step	Procedure
1	Prepared, washed, and dried all tools and equipment required for production.
2	Sifted the tilapia powder and cornmeal to remove lumps and measured the ingredients according to the formulation.
3	Combined cornmeal, tilapia powder, baking powder, sugar, salt, and cinnamon powder in a mixing bowl.
4	Added the measured lard to the dry mixture and mixed until incorporated.
5	Heated the evaporated milk in a saucepan until lukewarm.
6	Added the dry mixture to the lukewarm evaporated milk, stirred thoroughly, and turned off the heat once combined.
7	Allowed the mixture to rest for approximately 10 minutes.
8	Transferred the mixture into a bowl, allowed it to cool, and kneaded until a uniform, workable dough was formed.
9	Sprinkled sesame seeds over the dough and flattened it evenly using a rolling pin.
10	Cut the flattened dough into the desired shapes using a cookie cutter.
11	Arranged the crackers on a baking pan lined with parchment paper and baked them in a preheated oven at 170°C for 20–25 minutes or until done.
12	Allowed the crackers to cool completely before packaging and storage.

Table 1.3.4 presents the procedures used to produce gluten-free cornmeal Nile tilapia crackers. The process involved combining the dry ingredients with lard, incorporating the mixture into lukewarm evaporated milk, and allowing it to rest before kneading and shaping. Sesame seeds were added before the dough was flattened, cut, and baked at 170°C for approximately 20–25 minutes. The baked crackers were cooled before packaging to preserve their desired physical and sensory characteristics.

Overall, the preparation procedures demonstrated the different processing techniques employed in producing the three gluten-free cornmeal Nile tilapia-based snack products. Chips underwent frying, while cookies and crackers were baked using their respective formulations and processing conditions. The standardized preparation methods provided a practical basis for documenting the production processes and developing the technology guide proposed in the study.

Table 1.4
Shelf-Life Observation of Gluten-Free Cornmeal Nile Tilapia-Based Snack Products at Room Temperature

Observation Period	Product	Appearance	Aroma	Taste	Texture
Days 1–7	Chips	No changes	No changes	No changes	No changes
	Cookies	No changes	No changes	No changes	No changes

	Crackers	No changes	No changes	No changes	No changes
Days 8–14	Chips	No changes	No changes	No changes	No changes
	Cookies	No changes	No changes	No changes	No changes
	Crackers	No changes	No changes	No changes	No changes
Days 15–21	Chips	No changes	No changes	No changes	No changes
	Cookies	No changes	No changes	No changes	No changes
	Crackers	No changes	No changes	No changes	No changes
Days 22–28	Chips	No changes	No changes	No changes	No changes
	Cookies	No changes	No changes	No changes	No changes
	Crackers	No changes	No changes	No changes	No changes
Days 29–35	Chips	No changes	No changes	No changes	No changes
	Cookies	No changes	No changes	No changes	No changes
	Crackers	No changes	No changes	No changes	No changes
Days 36–42	Chips	No changes	No changes	No changes	Slight loss of crispness and crunchiness
	Cookies	No changes	No changes	No changes	No changes
	Crackers	No changes	No changes	No changes	Slight loss of crispness and crunchiness
Days 43–49	Chips	No changes	No changes	No changes	Slight loss of crispness and crunchiness
	Cookies	No changes	No changes	No changes	No changes
	Crackers	No changes	No changes	No changes	Slight reduction in crispness and crunchiness
Days 50–56	Chips	No changes	No changes	No changes	Noticeably less crisp and crunchy
	Cookies	No changes	No changes	No changes	No changes
	Crackers	No changes	No changes	No changes	Noticeably less crisp and crunchy

Days 57–60	Chips	No changes	No changes	No changes	Soft and soggy
	Cookies	No changes	No changes	No changes	No changes
	Crackers	No changes	No changes	No changes	Soft and soggy

Table 1.4 presents the observed changes in the sensory characteristics of the three developed snack products during 60 days of room-temperature storage. During the first 35 days, chips, cookies, and crackers maintained their original appearance, aroma, taste, and texture, with no noticeable changes recorded. These findings indicated that the three products retained their initial observable quality throughout the early storage period.

Beginning on Days 36–42, changes in texture were observed in the chips and crackers, particularly a slight reduction in crispness and crunchiness. These changes continued during Days 43–49 and became more noticeable during Days 50–56. By Days 57–60, both products had developed soft and soggy textures, indicating a considerable decline in their desirable physical characteristics. However, their appearance, aroma, and taste remained unchanged according to the recorded observations.

In contrast, the gluten-free cornmeal Nile tilapia cookies maintained their original appearance, aroma, taste, and crisp texture throughout the 60-day observation period. No observable changes were recorded in any of the four sensory attributes. Among the three products, the cookies therefore demonstrated the greatest stability in observable sensory quality under the reported storage conditions.

Overall, the findings showed that the three snack products maintained their initial sensory characteristics for approximately 35 days. The chips and crackers subsequently experienced progressive textural deterioration, whereas the cookies maintained their observed quality throughout the 60-day period. No visible mold growth was reported in any of the products. However, these observations established only changes in sensory and physical quality and did not independently confirm microbiological safety or a validated safe shelf life.

Table 1.5
Nutritional Content and Physicochemical Properties of Gluten-Free Cornmeal Nile Tilapia-Based Cookies

Parameters	Unit	Result	Test Method
Nutritional Content			
Ash	g/100 g	2.63	AOAC 923.03, Ignition
Fat	g/100 g	11.8	Mojonnier with Acid Hydrolysis
Protein (N × 6.25)	g/100 g	22.4	Kjeldahl Method
Carbohydrates	g/100 g	55.3	By Computation

Calories	Cal/100 g	417	By Computation
Omega-3 Fatty Acid	%	0.0660	Gas Chromatography (FID)
Dietary Fiber	g/100 g	3.63	Enzymatic–Gravimetry (Modified)
Vitamin B3 (Niacin)	mg/100 g	1.55	HPLC
Physicochemical Properties			
Moisture	g/100 g	7.85	Air Oven
pH	—	6.24 at 22.9°C	Electrometry
Water Activity	aw	0.517 at 25.1°C	Water Activity Analyzer

Table 1.5 presents the nutritional composition and physicochemical characteristics of the gluten-free cornmeal Nile tilapia-based cookies. Laboratory analysis revealed that carbohydrates constituted the largest macronutrient component at 55.30 g/100 g, followed by protein at 22.40 g/100 g and fat at 11.80 g/100 g. The product provided a reported energy value of 417 calories per 100 g. The relatively high protein content suggested that Nile tilapia powder contributed to the nutritional composition of the cookies, although its specific contribution could not be determined without a control formulation.

The analysis further revealed an ash content of 2.63 g/100 g and dietary fiber content of 3.63 g/100 g. The ash value represented the inorganic mineral residue remaining after combustion, while the dietary fiber result indicated the presence of fiber in the finished product. Additionally, the cookies contained 0.0660% omega-3 fatty acids and 1.55 mg/100 g vitamin B3 (niacin). These findings demonstrated that the developed cookies contained measurable amounts of selected nutrients beyond their major macronutrients.

Regarding physicochemical properties, the cookies recorded a moisture content of 7.85 g/100 g, indicating relatively low moisture in the finished product. This characteristic was consistent with the dehydration of tilapia and subsequent baking processes. The recorded pH of 6.24 at 22.9°C indicated slightly acidic conditions and provided baseline information about the product's chemical characteristics.

The water activity was recorded at 0.517 at 25.1°C, indicating limited water availability for microbial growth. This value was below the commonly recognized threshold of 0.60, under which microbial growth is generally inhibited. The U.S. Food and Drug Administration (1984) emphasized that water activity influenced microbial growth and food stability. Similarly, the Commonwealth Scientific and Industrial Research Organisation (1995) distinguished water activity from total moisture content and highlighted its importance in food preservation. These findings suggested that the cookies

possessed favorable low-moisture characteristics, although microbiological safety could not be established from water activity alone.

Overall, the laboratory findings demonstrated that the gluten-free cornmeal Nile tilapia-based cookies contained protein, carbohydrates, fat, dietary fiber, omega-3 fatty acids, and niacin. Their relatively low moisture content and water activity provided preliminary information regarding product stability. However, these laboratory results applied only to the cookies, and further nutritional, physicochemical, and microbiological analyses were necessary to establish the characteristics, safety, and validated shelf life of all three developed snack products.

Table 2.
Sensory Attributes of Gluten-Free Cornmeal Nile Tilapia-Based Snack Products

Product	Sensory Attribute	Mean	Description
Chips (F1)	Appearance	3.26	Very Appealing
	Aroma	3.28	Very Pleasant
	Taste	3.41	Very Palatable
	Texture	3.28	Very Crisp and Crunchy
Cookies (F2)	Appearance	3.82	Very Appealing
	Aroma	3.77	Very Pleasant
	Taste	3.81	Very Palatable
	Texture	3.83	Very Crisp and Crunchy
Crackers (F3)	Appearance	3.11	Appealing
	Aroma	2.75	Pleasant
	Taste	2.70	Palatable
	Texture	2.51	Crunchy

Table 2 presents the sensory evaluation results of the three gluten-free cornmeal Nile tilapia-based snack products. The findings revealed that cookies (F2) obtained the highest mean ratings across all four sensory attributes, with 3.82 for appearance, 3.77 for aroma, 3.81 for taste, and 3.83 for texture. All attributes received the highest descriptive classifications, indicating that the respondents evaluated the cookies most favorably. Texture obtained the highest mean score, suggesting that the cookies' crispness and crunchiness were particularly appreciated by the respondents.

The chips (F1) also received favorable sensory evaluations, recording mean scores of 3.26 for appearance, 3.28 for aroma, 3.41 for taste, and 3.28 for texture. All four attributes were classified within the highest descriptive categories, with taste obtaining the highest rating. This finding indicated that the flavor of the chips was their most highly evaluated sensory characteristic. Although their ratings were lower than those of the cookies, the chips demonstrated favorable sensory acceptability across all evaluated attributes.

In contrast, the crackers (F3) obtained the lowest mean scores, with 3.11 for appearance, 2.75 for aroma, 2.70 for taste, and 2.51 for texture. Appearance received

the highest rating, while texture obtained the lowest. Although all four attributes remained within the positive descriptive categories, the comparatively lower texture rating suggested that the crackers required further improvement in crispness and crunchiness to enhance their sensory quality.

The findings were consistent with the principles of sensory evaluation discussed by Lawless and Heymann (2010), who emphasized the importance of appearance, aroma, taste, and texture in determining consumer responses to food products. Similarly, Sivaraman et al. (2023) demonstrated that cookies supplemented with tilapia fish protein concentrate and seaweed could achieve favorable sensory acceptance while incorporating ingredients intended to improve nutritional composition. Their findings supported the potential of tilapia-derived ingredients in developing acceptable snack products, although sensory outcomes depended on the specific formulation and processing conditions.

Overall, the sensory evaluation demonstrated that the cookies received the highest ratings across all attributes, followed by the chips and crackers. The consistently favorable evaluations of the cookies supported their identification as the most preferred product and their subsequent selection for nutritional and physicochemical laboratory analyses. Meanwhile, the lower sensory ratings of the crackers indicated opportunities for further refinement of their formulation and preparation procedures to improve overall acceptability.

Table 3
Respondents' Preference Levels of Gluten-Free Cornmeal Nile Tilapia-Based Snack Products

Questions/Indicators	Mean	Standard Deviation	Description
Chips (F1)			
1	3.30	0.522	Most Preferred
2	3.26	0.505	Most Preferred
3	3.07	0.498	Preferred
4	3.30	0.577	Most Preferred
5	3.25	0.657	Most Preferred
6	3.50	0.541	Most Preferred
7	3.40	0.512	Most Preferred
8	3.37	0.544	Most Preferred
9	3.29	0.591	Most Preferred
10	3.24	0.497	Preferred
Cookies (F2)			
1	3.80	0.402	Most Preferred
2	3.79	0.456	Most Preferred
3	3.73	0.489	Most Preferred
4	3.77	0.510	Most Preferred
5	3.85	0.359	Most Preferred

6	3.81	0.394	Most Preferred
7	3.75	0.435	Most Preferred
8	3.80	0.402	Most Preferred
9	3.66	0.555	Most Preferred
10	3.87	0.338	Most Preferred
Crackers (F3)			
1	2.90	0.482	Preferred
2	2.74	0.441	Preferred
3	2.72	0.494	Preferred
4	2.65	0.520	Preferred
5	2.65	0.520	Preferred
6	3.02	0.651	Preferred
7	2.81	0.662	Preferred
8	2.76	0.638	Preferred
9	2.83	0.682	Preferred
10	2.82	0.672	Preferred

Table 3 presents the respondents' preference levels for the three developed gluten-free cornmeal Nile tilapia-based snack products. The findings revealed that cookies (F2) consistently obtained the highest ratings, with mean scores ranging from 3.66 to 3.87. All ten indicators were classified as Most Preferred, with standard deviations ranging from 0.338 to 0.555. Indicator 10 recorded the highest mean of 3.87, while Indicator 9 obtained the lowest mean of 3.66. The relatively low standard deviations indicated that respondents' evaluations were generally consistent, demonstrating favorable preference for the developed cookies.

The chips (F1) also received positive evaluations, with mean scores ranging from 3.07 to 3.50. Eight indicators were classified as Most Preferred, while two were rated Preferred. Indicator 6 obtained the highest mean of 3.50, whereas Indicator 3 received the lowest mean of 3.07. The standard deviations ranged from 0.497 to 0.657, indicating some variation in respondents' ratings. Although the chips obtained lower ratings than the cookies, their results demonstrated favorable preference among the respondents.

In comparison, the crackers (F3) recorded the lowest preference ratings, with mean scores ranging from 2.65 to 3.02. All ten indicators were classified as Preferred. Indicator 6 obtained the highest mean of 3.02, while Indicators 4 and 5 recorded the lowest mean of 2.65. The standard deviations ranged from 0.441 to 0.682, reflecting variations in respondents' evaluations. These findings suggested that the crackers remained acceptable to respondents but required further improvement to achieve preference levels comparable to those of the cookies and chips.

The findings supported the importance of sensory acceptability in food product development. Lawless and Heymann (2010) emphasized that consumer preference was influenced by sensory characteristics, including appearance, aroma, taste, and texture. Similarly, Sivaraman et al. (2023) investigated tilapia fish protein concentrate in cookies and demonstrated that fish-derived ingredients could be incorporated into snack products

while maintaining favorable sensory characteristics. These studies provided relevant support for evaluating consumer preference alongside the nutritional and physical qualities of food products.

Overall, the results established that cookies received the highest preference ratings, followed by chips and crackers. The consistently favorable evaluations of the cookies supported their selection for nutritional and physicochemical laboratory analyses. Meanwhile, the lower preference ratings of the crackers indicated opportunities for improving their formulation and processing procedures to enhance consumer acceptability.

Table 4
Significant Differences in Respondents' Preference Levels for Gluten-Free Cornmeal Nile Tilapia-Based Snack Products

Friedman X^2	df	p-value	Decision	Interpretation
174	2	<0.001	Reject null hypothesis	Significant
Pairwise Comparisons				
Formulation	**Test Statistic**	**p-value**	**Decision**	**Interpretation**
F1 vs F2	17.5	<0.001	Reject null hypothesis	Significant
F1 vs F3	19.3	<0.001	Reject null hypothesis	Significant
F2 vs F3	36.8	<0.001	Reject null hypothesis	Significant

Note. F1 = Chips; F2 = Cookies; F3 = Crackers. The level of significance was set at 0.05.

Table 4 presents the significant differences in the respondents' preference levels for the three developed gluten-free cornmeal Nile tilapia-based snack products. The Friedman test yielded a chi-square value of 174 with two degrees of freedom and a p-value of less than 0.001. Since the p-value was below the 0.05 level of significance, the null hypothesis was rejected. This indicated that statistically significant differences existed in the respondents' preference levels among the three products.

Following the significant Friedman test result, Durbin–Conover pairwise comparisons were conducted to identify which products differed significantly. The comparison between chips (F1) and cookies (F2) yielded a test statistic of 17.5 and a p-value of less than 0.001, indicating a significant difference in respondents' preferences. Similarly, the comparison between chips (F1) and crackers (F3) produced a test statistic of 19.3 and a p-value of less than 0.001. The comparison between cookies (F2) and crackers (F3) also revealed a significant difference, with a test statistic of 36.8 and a p-value of less than 0.001.

The pairwise results demonstrated that all three product comparisons were statistically significant. When considered alongside the descriptive findings, the results showed that cookies (F2) received the highest preference ratings, followed by chips (F1),

while crackers (F3) obtained the lowest ratings. These findings indicated that respondents expressed different levels of preference for the three developed snack products.

Overall, the Friedman test and subsequent pairwise comparisons provided statistical evidence that respondents' preference levels differed significantly among the gluten-free cornmeal Nile tilapia-based chips, cookies, and crackers. The results supported the identification of cookies as the most preferred product and provided a basis for considering improvements to the formulations with lower preference ratings.

DISCUSSION

The study employed a quasi-experimental research design to develop and evaluate three gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based snack products: chips, cookies, and crackers. It involved 100 respondents from the Third Congressional District of Bohol, selected through purposive sampling. Data were gathered using a validated four-point hedonic scale and analyzed using mean, standard deviation, Friedman test, and Durbin–Conover pairwise comparisons. Results revealed that cookies were the most preferred product, followed by chips and crackers, with significant differences in respondents' preference levels. Nutritional and physicochemical analyses were conducted on the cookies, and a proposed technology guide was developed based on the study findings.

Findings

Based on the data gathered, analyzed, and interpreted, the study revealed the following findings:

1. **Product Development.** Three gluten-free cornmeal Nile tilapia-based snack products, namely chips, cookies, and crackers, were successfully developed using locally available ingredients and standardized preparation procedures. Chips incurred the lowest ingredient and material cost of ₱61.85, followed by crackers at ₱84.89 and cookies at ₱88.99. The computed prices per pack ranged from ₱4.64 to ₱5.79, reflecting differences in production requirements and yields. Common kitchen tools and food-processing equipment, including a dehydrator, steamer, pulverizer, and oven, were utilized in preparing the products.

2. **Shelf Life, Nutritional Content, and Physicochemical Properties.** All three products maintained their original sensory characteristics during the first 35 days of room-temperature storage. Cookies showed no observable changes throughout the 60-day period, while chips and crackers exhibited gradual textural deterioration beginning in Week 6. Laboratory analysis of the cookies revealed 22.40 g/100 g protein, 55.30 g/100 g carbohydrates, 11.80 g/100 g fat, 3.63 g/100 g dietary fiber, and 2.63 g/100 g ash. The product also contained 0.0660% omega-3 fatty acids and 1.55 mg/100 g vitamin B3 (niacin). Physicochemical analysis recorded 7.85 g/100 g moisture, a pH of 6.24, and a water activity of 0.517. These findings

provided baseline information on the nutritional composition and storage-related characteristics of the developed cookies.

3. **Sensory Attributes.** Cookies obtained the highest sensory ratings in appearance, aroma, taste, and texture, with mean scores ranging from 3.77 to 3.83. Chips also received favorable evaluations, with mean scores ranging from 3.26 to 3.41. Meanwhile, crackers recorded comparatively lower ratings of 2.51 to 3.11, particularly in texture. The findings indicated that cookies demonstrated the most favorable sensory characteristics, while the crackers' lower texture rating suggested opportunities for further improvement in formulation and processing.

4. **Respondents' Preference Levels.** The overall mean ratings established the following order of preference: cookies (3.78), chips (3.31), and crackers (2.79). Cookies and chips were classified as Most Preferred, while crackers were classified as Preferred. These results demonstrated that all three products received favorable evaluations, although respondents expressed varying degrees of preference.

5. **Significant Differences in Preference Levels.** The Friedman test revealed a statistically significant difference in respondents' preference levels among the three products ($\chi^2 = 174$, $df = 2$, $p < 0.001$), resulting in the rejection of the null hypothesis. Subsequent Durbin–Conover pairwise comparisons showed significant differences between all product pairs, with p-values below 0.001. These findings established that respondents' preference levels differed significantly among the developed snack products.

6. **Proposed Technology Guide.** A technology guide was developed based on the findings and outputs of the study. It incorporated product descriptions, objectives, ingredient requirements, preparation and processing procedures, packaging and handling considerations, and a proposed six-month school-based implementation mechanism. The guide provided a practical framework for food-processing instruction, skills development, livelihood activities, and potential small-scale enterprise adoption using locally available cornmeal and Nile tilapia.

Conclusions

Based on the findings of the study, it was concluded that gluten-free cornmeal Nile tilapia (*Oreochromis niloticus*)-based chips, cookies, and crackers were successfully developed using locally available ingredients and standardized food-processing procedures. The differences in production costs and processing requirements demonstrated the feasibility of preparing the products using commonly available tools and equipment, providing a basis for potential small-scale food production.

The sensory and preference evaluations established that cookies were the most preferred product, followed by chips and crackers. The significant differences in respondents' preference levels indicated that the three products varied in their overall

acceptability. The comparatively lower ratings of crackers, particularly in texture, highlighted the need for further formulation and processing improvements.

The nutritional and physicochemical analyses confirmed that the developed cookies contained measurable amounts of protein, carbohydrates, fat, dietary fiber, omega-3 fatty acids, and vitamin B3. Shelf-life observations further revealed that cookies maintained their observable sensory quality throughout the 60-day storage period, whereas chips and crackers experienced textural deterioration during prolonged storage. However, additional microbiological testing was necessary to establish product safety and validated shelf life.

Finally, the proposed technology guide consolidated the study's findings into a practical resource for food-processing instruction, product development, and potential livelihood activities. Overall, the study demonstrated the potential of combining cornmeal and Nile tilapia powder in developing acceptable, value-added snack products while providing a foundation for further product improvement, food safety evaluation, and possible small-scale commercialization.

Recommendations

Based on the findings and conclusions of the study, the following recommendations were proposed:

1. **Product Formulation and Improvement.** Food technologists, researchers, and food processors should further refine the formulations of the three gluten-free cornmeal Nile tilapia-based snack products, particularly the crackers, to improve their sensory attributes while maintaining nutritional quality and consumer acceptability.

2. **Processing Optimization.** Food processors and researchers should improve dehydration, frying, and baking techniques to achieve consistent product quality, preserve nutritional components, and maintain desirable appearance, aroma, taste, and texture.
3. **Shelf-Life and Food Safety Evaluation.** Further microbiological and physicochemical testing should be conducted to establish product safety, determine appropriate storage conditions, and validate shelf life. Improved packaging materials should also be explored to minimize moisture absorption and maintain product crispness.

4. **Product Diversification.** Food entrepreneurs and product developers should explore alternative flavors, seasonings, shapes, and sizes to accommodate different consumer preferences. The potential incorporation of tilapia powder into other food products, such as bread, noodles, snack bars, nuggets, and patties, should also be investigated.

5. **Market Assessment and Commercialization.** Entrepreneurs and food processors should conduct market feasibility studies focusing on consumer demand, production costs, pricing, packaging, and purchasing intentions before pursuing larger-scale production.

6. **Sustainable Raw Material Utilization.** Local farmers, tilapia producers, and concerned government agencies should strengthen agricultural and fisheries production initiatives to ensure a consistent supply of quality corn and tilapia for value-added food processing.

7. **Technology Transfer and School-Based Adoption.** Educational institutions, particularly those offering Technology and Livelihood Education (TLE) and Technical-Vocational-Livelihood (TVL) programs, should consider adopting the proposed technology guide for food-processing instruction, practical skills development, and livelihood activities. Collaboration with local government units, the Department of Agriculture, and the Bureau of Fisheries and Aquatic Resources should also be encouraged to support community-based training and potential enterprise development.

8. **Intellectual Property Protection.** The researcher, in coordination with the concerned institution and the Intellectual Property Office of the Philippines (IPOPHL), should assess the eligibility of the developed formulations, processing methods, and technology guide for appropriate intellectual property protection before potential commercialization.

9. **Further Research.** Future researchers should conduct additional studies involving improved formulations, nutritional and physicochemical analyses of all three products, microbiological safety, packaging technologies, consumer acceptability, and economic feasibility to strengthen the scientific and commercial potential of gluten-free cornmeal Nile tilapia-based snack products.

Proposed Technology Guide Of Gluten-Free Cornmeal Nile Tilapia-Based Snack Products: Chips, Cookies And Crackers

Introduction

The TechnoGuide for Gluten-Free Cornmeal Nile Tilapia-Based Snack Products presents the development and potential utilization of locally available tilapia (Oreochromis niloticus) and cornmeal as alternative ingredients for nutritious, innovative, and value-added snack products. It features three gluten-free cornmeal Nile tilapia-based products: chips, cookies, and crackers which were developed and evaluated based on their sensory attributes, nutritional composition and physicochemical properties.

The guide was developed to provide practical and systematic information on product formulation, preparation, processing, and handling, making it a useful reference

for teachers, food processors, aspiring entrepreneurs, and other potential users interested in developing similar products. It also highlights opportunities for value addition, enterprise development, and commercialization by utilizing locally available tilapia and corn resources, thereby supporting local food innovation and livelihood opportunities.

Product Description

The proposed product line consists of Gluten-free Cornmeal Nile Tilapia (*Oreochromis niloticus)*-based snack products developed as innovative, nutritious, and value-added food products using locally available tilapia. The product line includes gluten-free cornmeal Nile tilapia chips, cookies, and crackers, which incorporate processed tilapia powder as a key ingredient and are formulated with gluten-free components such as cornmeal. These products are designed to provide consumers with convenient and palatable snack options while offering the nutritional benefits associated with tilapia.

The gluten-free cornmeal Nile tilapia chips are golden brown andcrisp looking snack products characterized by a savory flavor and crisp and crunchy texture. They are intended to provide a convenient alternative to conventional snack chips while utilizing tilapia as a value-added ingredient.

The gluten-free cornmeal Nile tilapia cookies are baked snack products with a characteristic golden-brown appearance, pleasant aroma, plesantly sweet taste, and crisp and crunchy texture. The incorporation of tilapia powder provides an innovative nutritional component while maintaining the familiar form and acceptability of a cookie.

The gluten-free cornmeal Nile tilapia crackers are baked, crisp snack products characterized by a milky golden brown appearance, pleasant aroma, balanced salty-sweet taste, and crunchy texture. They are developed as a convenient snack option that combines the familiar characteristics of crackers with the added value of tilapia.

Objectives

The TechnoGuide aims to facilitate the school adoption of gluten-free cornmeal Nile tilapia-based snack products as an innovative and value-adding food processing activity. Specifically, it aims to:

- Provide practical guidance on the proper preparation, formulation, processing, packaging, and handling of gluten-free cornmeal Nile tilapia-based chips, cookies, and crackers.

- Promote the utilization of locally available tilapia and cornmeal as alternative and value-added ingredients for food product development.

- Support school-based learning and livelihood activities by providing opportunities for learners, teachers, and school organizations to acquire practical skills in food processing, entrepreneurship, and product development.

- Encourage community participation and enterprise development through the adoption of the technology by local food processors, community groups, cooperatives, and aspiring entrepreneurs.

- Provide a basis for small-scale production by presenting information on basic tools and equipment, raw materials, production procedures, costing, packaging, and potential marketing activities.

Implementation Mechanism

The school-based implementation will be carried out over six months, beginning with preparation and coordination, followed by orientation and skills training. Learners will then participate in hands-on production of the gluten-free cornmeal Nile tilapia-based snack products under the guidance of TLE/TVL teachers. Product evaluation will be conducted to identify areas for improvement, after which the technology may be integrated into appropriate TLE/TVL, entrepreneurship, livelihood, or school-based activities. Monitoring and sustainability planning will help ensure the continued and appropriate use of the TechnoGuide in the school.

Proposed Technology Guide for Implementation Mechanism of The Production of Gluten-Free Cornmeal Nile Tilapia-Based Snack Products

Key Activity	Objectives	Strategies	Persons Involved	Budget	Time Frame	Expected Output
Preparation and Coordination	To secure school approval; identify participants; and prepare tools, equipment, and raw materials.	Coordinate with school administrators; prepare an implementation plan; assess available facilities and equipment; and procure necessary ingredients and supplies.	Reseracher, School Head, TLE/TVL Coordinator, TLE Teachers, School Research/Innovation Coordinator	₱2,000	Month 1	Approved implementation plan; identified participants; and prepared facilities, equipment, and materials
Technology Transfer, Orientation and Training	To orient teachers, stakeholders and learners on the TechnoGuide, food safety, sanitation, and proper	Conduct orientation and hands-on training on ingredient measurement, tilapia powder preparation, mixing, shaping,	Reseracher, TLE/TVL Teachers, Stakeholders, School Health Personnel, Learners	₱5,000	Month 2	Trained teachers and learners; improved knowledge and skills in preparing the snack products

	processing procedures.	cooking, cooling, packaging, and sanitation.				
Product Evaluation and Improvement	To evaluate product quality,packaging, presentation, and acceptability and identify areas for improvement.	Conduct product demonstrations and sensory evaluation; gather feedback; assess texture, appearance, aroma, taste, and packaging; and revise procedures when necessary.	TLE/TVL Teachers, Learners, School Canteen Personnel, School Research/Innovation Coordinator	₱2,000	Month 3	Evaluated snack products; documented feedback; and recommended product improvements
School-Based Application and Market Testing	To apply the technology through TLE/TVL activities, entrepreneurship projects, school livelihood programs, or other appropriate school-based activities.	Apply the technology through TLE/TVL activities, entrepreneurship projects, school livelihood programs, or other appropriate school-based activities.	School Head, TLE/TVL Teachers, Learners, School Canteen Personnel, relevant School Organizations	₱5,000	Month 4	Prepared and packaged snack products; costing and pricing records; and documented market-testing results
Monitoring and Sustainability	To integrate product preparation into practical lessons and entrepreneurship activities; develop product labels and costing; and conduct appropriate market testing or promotional activities, subject to school approval.	Integrate product preparation into practical lessons and entrepreneurship activities; develop product labels and costing; and conduct appropriate market testing or promotional activities, subject to school approval.	School Head, TLE/TVL Coordinator, TLE/TVL Teachers, School Research/Innovation Coordinator	₱2,000	Month 5-6	Monitoring and evaluation report; sustainability plan; and recommendations for continued technology utilizatio

Compliance with Ethical Standards

The study adhered to ethical principles in conducting research involving human participants. Prior to data collection, the researcher secured the necessary permissions from the concerned institutional and educational authorities. The respondents were informed of the study's objectives, procedures, and nature of participation. Their participation was voluntary, and they were assured that their responses would be treated confidentially and used solely for academic and research purposes. The researcher maintained the anonymity of respondents during data collection, analysis, and reporting. Appropriate food preparation, sanitation, and handling practices were observed during the development and sensory evaluation of the gluten-free cornmeal Nile tilapia-based snack products. The ingredients and preparation procedures were carefully managed to minimize potential risks to participants. Furthermore, the researcher upheld honesty, accuracy, and integrity in recording, analyzing, and presenting the research findings. The data were reported without fabrication or manipulation, and relevant sources were properly acknowledged to respect intellectual property rights and maintain academic integrity.

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