

# PROXIMATE COMPOSITION AND NUTRITIONAL QUALITY ASSESSMENT OF CORN AND NIKE FISH (*Awaous melanocephalus*) BISCUITS (BIJAK)

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## ABSTRACT

Food security remains a critical challenge in Indonesia, particularly in ensuring access to nutritious foods capable of addressing chronic malnutrition and supporting sustainable community health. Gorontalo Province possesses abundant local food resources, including corn (*Zea mays*) and endemic Nike fish (*Awaous melanocephalus*), which have substantial potential for food diversification and nutritional enhancement. This study aimed to determine the proximate composition and evaluate the nutritional quality compliance of Corn and Nike Fish Biscuits (BIJAK) as an alternative local functional food product. A quantitative descriptive approach was employed using laboratory-based proximate analysis. The parameters analyzed included moisture, ash, fat, protein (via the micro-Kjeldahl method), and carbohydrate contents (calculated by difference). Data were analyzed descriptively and compared with the quality requirements specified in the Indonesian National Standard for biscuits (SNI 2973:2011). The laboratory results revealed that BIJAK biscuits contained 9.14% moisture, 1.11% ash, 36.00% fat, 7.46% protein, and 43.89% carbohydrates. The ash and fat contents successfully complied with SNI requirements, whereas the moisture, protein, and carbohydrate contents did not meet the established standards. The exceptionally high fat content indicates considerable energy density, while the acceptable ash content validates the presence of beneficial minerals derived from the local ingredients. However, the high moisture retention and sub-optimal protein levels suggest that strict formulation optimization and mechanical processing standardizations are necessary. Overall, BIJAK biscuits demonstrate promising potential as a locally sourced food diversification product utilizing Gorontalo's indigenous agricultural and fishery resources, provided that future structural refinements are implemented to stabilize its macronutrient balance.

**Keywords:** *BIJAK biscuits, corn flour, Nike fish, food diversification, proximate analysis, nutritional quality*

## INTRODUCTION

Food security is a fundamental pillar of national resilience and a basic human right essential for sustaining a healthy, productive, and vibrant society. According to Indonesian Law Number 18 of 2012 concerning Food, food security is defined as a condition where food is

available in sufficient quantity and quality, safe, diverse, nutritious, equitable, and affordable for all individuals. Achieving robust food security extends beyond agricultural availability; it critically encompasses equitable access to nutrient-dense foods capable of meeting the physiological requirements of the

Submit: Dec 06<sup>th</sup>, 2025

Accepted: June 08<sup>th</sup>, 2026

Published: June 30<sup>th</sup>, 2026

population. Despite steady advancements in domestic food production, malnutrition remains a critical public health concern in Indonesia. One of the most persistent challenges is chronic malnutrition, particularly childhood stunting, which is intrinsically linked to prolonged inadequacies in the intake of high-quality protein, essential fatty acids, and micronutrients. The uneven prevalence of stunting underscores that access to nutritious foods remains restricted in vulnerable areas, particularly within coastal and rural communities. Consequently, developing affordable, nutrient-dense food products by exploiting underutilized indigenous resources is an urgent strategy to support food and nutrition security.

Indonesia possesses abundant local food resources with substantial potential to mitigate nutritional deficits. In Gorontalo Province, corn (*Zea mays*) serves as a major agricultural commodity and a primary dietary source of carbohydrates for the local population. National food consumption data highlights the strategic position of corn, which contributes significantly to domestic energy fulfillment while containing dietary fiber and bioactive compounds that enhance its nutritional value. In addition to agricultural wealth, Gorontalo possesses a unique marine and aquatic resource: Nike fish (*Awaous melanocephalus*). This small endemic amphidromous fish is harvested seasonally in massive quantities from Lake Limboto and its connecting coastal waters. While seasonal catches can exceed hundreds of tons, the post-harvest utilization of Nike fish remains sub-optimal; the majority of the harvest is sold fresh with short shelf lives, or processed via traditional, low-value methods. This poor post-harvest management fails to leverage the nutritional and economic potential of the fish. Given

that Nike fish is highly rich in essential amino acids, polyunsaturated fatty acids, and bioavailable minerals like calcium, it represents an exceptional functional ingredient for food fortification.

Food diversification utilizing these indigenous commodities is increasingly critical to reduce the nation's heavy reliance on imported wheat flour, which dominates the commercial bakery and biscuit industries. A promising intervention is the formulation of composite biscuits derived from local corn flour and Nike fish. In this matrix, corn functions as a reliable local carbohydrate base, while Nike fish enriches the product with highly digestible protein, essential lipids, and minerals. Such formulations directly promote local food sovereignty by creating a completely localized food supply chain. Biscuits are an ideal vehicle for nutritional intervention due to their universal consumer acceptance across all age groups, convenience, long shelf-life stability, ease of mass distribution, and suitability for macronutrient fortification.

Previous literature has extensively documented the efficacy of incorporating fish-derived ingredients into baked goods. Fortification with fish powder or flour significantly enhances the total protein content, amino acid profiles, and overall nutritional indexes of snacks while maintaining acceptable sensory attributes [1][2][3]. Prior investigations on fish-fortified snacks have reported protein contents ranging from 16.91% to 19.38% and substantial mineral shifts, representing a profound nutritional upgrade compared to conventional wheat-based formulations [2][4]. Similarly, composite maize-fish snack products have demonstrated elevated protein efficiency ratios and superior nutritional values, validating their role in combating community malnutrition [5][6].

However, despite the wealth of research on generic fish-fortified biscuits and maize snacks, empirical data regarding biscuits formulated specifically from the composite of local corn flour and endemic Gorontalo Nike fish (*Awaous melanocephalus*) remains absent. Evaluating the chemical and nutritional characteristics of this specific composite biscuit herein termed BIJAK (*Biskuit Jagung dan Ikan Nike*) is an essential step to establish its viability as an alternative therapeutic or supplementary food. To comprehensively assess its nutritional quality, safety, and commercial feasibility, a rigorous proximate analysis is required. Proximate testing establishes the foundational baseline of a food matrix by quantifying its moisture, ash, fat, crude protein, and carbohydrate contents. In biscuit technology, moisture content directly dictates shelf-life and microbial stability; ash content reflects the total mineral wealth; crude protein confirms the success of fortification; crude fat influences textural attributes and caloric density; and carbohydrates quantify the total energy yield.

Therefore, this study was undertaken to evaluate the quantitative percentages of moisture, ash, fat, crude protein, and carbohydrate contents in the formulated corn and Nike fish biscuits (BIJAK). Furthermore, this research aims to analyze the compliance of these proximate and chemical properties with the quality requirements stipulated by the Indonesian National Standard for biscuits (SNI 2973:2011). The empirical outcomes of this investigation are expected to provide the essential scientific foundation required to validate BIJAK biscuits as a standardized, nutrient-dense local food product, thereby supporting targeted public

health interventions and optimizing Gorontalo's indigenous resources.

## RESEARCH METHODS

### Research Design

This study employed a quantitative descriptive approach to determine the proximate composition of Corn and Nike Fish Biscuits (BIJAK). The study focused on evaluating the nutritional characteristics of BIJAK biscuits through laboratory-based proximate analysis. The parameters analyzed included moisture content, ash content, fat content, protein content, and carbohydrate content. The results obtained were subsequently compared with the Indonesian National Standard (SNI) for biscuits to assess product quality and nutritional suitability.

### Time and Place of Research

This research was conducted from January to March 2025. Sample preparation was carried out at the Food Processing Laboratory, Universitas Bina Mandiri Gorontalo, while proximate analyses were conducted at an accredited food chemistry laboratory using standardized analytical procedures.

### Materials and Equipment

The materials used in this study consisted of corn flour, Nike fish (*Awaous melanocephalus*), wheat flour, margarine, sugar, eggs, milk powder, and other supporting ingredients required for biscuit production. The equipment utilized included an analytical balance, drying oven, muffle furnace, Soxhlet extraction apparatus, Kjeldahl digestion and distillation units, porcelain crucibles, desiccator, laboratory glassware, and other supporting analytical instruments.

### Research Variables

The variables observed in this study consisted of:

1. Moisture content (%)

2. Ash content (%)
3. Fat content (%)
4. Protein content (%)
5. Carbohydrate content (%)

These variables were utilized as the primary indicators to evaluate the nutritional quality and standard compliance of BIJAK biscuits.

### **Proximate Analysis Procedures**

#### **Moisture Content Analysis**

Moisture content was determined using the gravimetric method based on SNI 01-2891-1992. Approximately 5 g of biscuit sample was weighed into a previously dried and weighed porcelain dish. The sample was dried in a drying oven at 105°C until a constant weight was achieved. Moisture content was calculated based on the percentage of sample weight loss after the thermal drying process.

#### **Ash Content Analysis**

Ash content was determined using the dry ashing gravimetric method. The dried sample was incinerated in a muffle furnace at 550°C until organic compounds were completely oxidized and white ash was obtained. The remaining inorganic residue was cooled in a desiccator and weighed. The percentage of ash content represented the total mineral content present in the sample [7].

#### **Fat Content Analysis**

Fat content was analyzed using the Soxhlet extraction method based on fat solubility principles. The dried and pulverized sample was extracted using an organic solvent (such as petroleum ether or n-hexane) in a Soxhlet apparatus for several extraction cycles until the fat was completely separated. After solvent evaporation, the extracted lipid residue was dried, weighed, and expressed as a percentage of the initial sample weight [7].

#### **Protein Content Analysis**

Protein content was determined using the micro-Kjeldahl method, which quantifies the total nitrogen content in the sample [8]. The analysis procedure consisted of three sequential stages: digestion, distillation, and titration. The sample was digested with concentrated sulfuric acid (H<sub>2</sub>SO<sub>4</sub>) and a catalyst mixture to convert organic nitrogen into ammonium sulfate. The solution was then alkalized and distilled to release ammonia (NH<sub>3</sub>), which was trapped in a boric acid solution. Finally, the solution was titrated using a standardized hydrochloric acid (HCl) solution. The total nitrogen percentage obtained was multiplied by a conversion factor of 6.25 to determine the crude protein content.

#### **Carbohydrate Content Analysis**

Carbohydrate content was calculated using the *by-difference* method according to proximate analysis principles [9]. This method determines the total carbohydrate percentage by subtracting the percentages of other proximate components from the total weight of the food matrix. Carbohydrate percentage was obtained using the following equation:

$$\text{Carbohydrate (\%)} = 100 - (\text{Moisture} + \text{Ash} + \text{Fat} + \text{Protein})$$

#### **Data Analysis**

All laboratory analyses were performed in duplicate (duplo). The data obtained were tabulated and analyzed descriptively by calculating the average (mean) value of each proximate parameter. The resulting moisture, ash, fat, protein, and carbohydrate contents were compared with the quality requirements specified in the Indonesian National Standard for biscuits (SNI 2973:2011) to evaluate the nutritional quality, characteristics, and standard compliance of BIJAK biscuits.

**RESEARCH RESULT**

**Proximate Composition of BIJAK Biscuits**

The proximate composition of Corn and Nike Fish Biscuits (BIJAK) was evaluated through laboratory analysis to determine their nutritional characteristics. The parameters analyzed included moisture content, ash content, fat content, protein content, and carbohydrate content. Each parameter was measured in duplicate, and the average values were compared with the quality requirements established by the Indonesian National Standard (SNI 2973:2011) for biscuits.

**Table 1. Proximate Composition of BIJAK Biscuits**

Parameter	Repliate 1 (%)	Repliate 2 (%)	Mean (%)	SNI Requirement (%)	Compliance
Moisture Content	9.04	9.24	9.14	Max. 5.0	Not Compliant
Ash Content	1.11	1.12	1.11	Max. 1.5	Compliant
Fat Content	30.00	42.00	36.00	Min. 9.5	Compliant
Protein Content	7.45	7.46	7.46	Min. 9.0	Not Compliant
Carbohydrate Content	47.60	40.18	43.89	Min. 70.0	Not Compliant

Source: Primary data processed from laboratory analysis (2025).

The results presented in Table 1 indicate that BIJAK biscuits contain varying levels of proximate components. The average moisture, ash, fat, protein, and carbohydrate contents were 9.14%, 1.11%, 36.00%, 7.46%, and 43.89%, respectively. Among the analyzed parameters, carbohydrate content showed the highest percentage, while ash content exhibited the lowest value.

The comparison with SNI standards revealed that ash and fat contents met the required quality specifications. However,

moisture, protein, and carbohydrate contents did not comply with the minimum or maximum limits established for biscuit products. These findings indicate that although BIJAK biscuits possess favorable mineral and lipid characteristics, further formulation optimization is required to improve their overall nutritional balance and standard compliance.

**Moisture Content**

The moisture content analysis produced values of 9.04% and 9.24% for the two laboratory replications, resulting in an average moisture content of 9.14%. This value exceeded the maximum moisture limit of 5% specified by SNI 2973:2011. The elevated moisture content suggests that a considerable amount of water remained within the biscuit matrix after processing. Moisture content is an important quality parameter because it directly affects product shelf life, texture, and microbial stability.

**Ash Content**

The ash content obtained from duplicate analyses was 1.11% and 1.12%, with an average value of 1.11%. This result complied with the maximum ash content requirement of 1.5% established by SNI. Ash content represents the total mineral residue remaining after complete combustion of organic matter and serves as an indicator of the mineral composition present in food products.

**Fat Content**

The fat content analysis yielded values of 30.00% and 42.00%, resulting in an average fat content of 36.00%. This parameter exhibited a substantial proportion among the proximate components analyzed. The obtained value exceeded the minimum SNI requirement of 9.5%, indicating that BIJAK biscuits contain a significant amount of lipid components. The presence of fat contributes to the energy value, texture, palatability, and sensory quality of biscuit products.

**Protein Content**

Protein content was determined at 7.45% and 7.46% in the duplicate analyses, producing an average value of 7.46%. Although the protein content reflects the nutritional contribution of Nike fish incorporated into the formulation, the result remained below the minimum SNI requirement of 9%. This finding indicates that the protein concentration in the current formulation may require further enhancement to achieve the desired nutritional standard.

### **Carbohydrate Content**

Carbohydrate content was determined using the by-difference method, resulting in values of 47.60% for Replicate 1 and 40.18% for Replicate 2, with an average value of 43.89%. Compared with the minimum SNI requirement of 70%, the carbohydrate content was considerably lower. Carbohydrates constitute the primary source of energy in conventional biscuit products; therefore, the relatively low carbohydrate level observed in BIJAK biscuits indicates a nutritional composition that differs markedly from conventional wheat-based biscuits, which is directly influenced by the high proportion of other macronutrients, particularly lipids, within the food matrix.

## **DISCUSSION**

### **Moisture Content**

The proximate analysis revealed that BIJAK biscuits contained an average moisture content of 9.14%, exceeding the maximum limit of 5% established by SNI 2973:2011. Moisture content is one of the most critical quality parameters in biscuit products because it directly influences shelf life, texture, crispness, and susceptibility to microbial growth. High moisture levels may accelerate quality deterioration during storage due to increased water activity, which promotes lipid oxidation and microbial proliferation within the product matrix.

The elevated moisture content observed in BIJAK biscuits can be scientifically attributed to two primary factors. First, the incorporation of local ingredients, particularly Nike fish, introduces highly hydrophilic fish proteins. These myofibrillar proteins possess a high water-holding capacity (WHC) that binds water molecules tightly via hydrogen bonding, thereby restricting moisture loss during the thermal baking process. Second, from a technological standpoint, the manual monitoring of baking temperature, baking duration, and post-baking cooling procedures may have contributed to incomplete moisture evaporation from the inner core of the biscuit matrix.

Compared with previous studies on fish-fortified bakery goods, the moisture content of BIJAK biscuits was relatively higher. Astiana et al. reported lower moisture levels in biscuits fortified with surimi powder, which significantly contributed to better shelf stability [2]. Similarly, Ibrahim et al. found that optimized fish powder incorporation maintained moisture levels within acceptable standards [3]. Therefore, to overcome this limitation, future processing adjustments must optimize the baking time-temperature profile and implement hermetic packaging, such as aluminum foil, to prevent moisture reabsorption from the tropical environment of Gorontalo.

### **Ash Content**

The average ash content of BIJAK biscuits was 1.11%, which strictly complied with the maximum requirement of 1.5% specified by SNI 2973:2011. Ash content represents the total inorganic mineral residue remaining after the complete combustion of organic compounds at high temperatures. In food formulation, it serves as a reliable indicator of the total mineral

wealth and the purity of the raw materials used.

The acceptable ash content observed in this study is directly associated with the dense mineral profiles of both local corn flour and endemic Nike fish (*Awaous melanocephalus*). Nike fish is widely recognized as an exceptional source of bioavailable macro-minerals, including calcium, phosphorus, and potassium, as well as essential trace elements. The compliance of BIJAK's ash content with SNI standards indicates that while the biscuit successfully integrates mineral-rich local commodities, the total inorganic concentration remains within the safe and standard limits required for commercial biscuit products.

Previous studies have similarly demonstrated that fish-based fortification enhances mineral content without exceeding acceptable quality standards. Astiana et al. reported increased ash content in fish-fortified biscuits due to the presence of fish-derived minerals [2]. Likewise, Suryaningrum et al. found that incorporating catfish and marine flour significantly upgraded the mineral profile of the final baked products [4]. Consequently, the ash content obtained in the present study validates that BIJAK biscuits hold strong potential as a strategic dietary vehicle for mineral intervention in coastal and rural communities.

### **Fat Content**

The fat content of BIJAK biscuits reached an average value of 36.00%, substantially exceeding the minimum requirement of 9.5% established by SNI 2973:2011. Among all proximate components analyzed, fat content represented a highly dominant percentage in the food matrix, indicating a high-caloric density product.

A critical observation in the laboratory data is the wide variation between Replicate 1 (30.00%) and Replicate 2 (42.00%). In food processing analysis, this substantial variance indicates a challenge in product homogeneity rather than an analytical failure. Because the dough preparation was performed using traditional hand-mixing methods, a non-uniform distribution of fat-rich ingredients—such as margarine, eggs, and the natural lipids from Nike fish—likely occurred across the batch. Consequently, independent sampling units drawn from the same batch for Soxhlet extraction captured vastly different lipid concentrations. Furthermore, the porous structure of corn flour affects fat retention during baking, which may cause localized oil pooling within the biscuit matrix.

The fat content observed in BIJAK biscuits was considerably higher than values reported in generic fish-fortified biscuit studies, which typically range from 11.20% to 17.10% [2][4]. While high lipid levels contribute positively to the sensory quality, shortening short-texture, and flavor perception of the biscuits, it presents a risk for accelerated rancidity due to the oxidation of unsaturated fatty acids from the fish. Therefore, strict mechanical mixing standardizations are mandatory for future production to ensure a homogeneous fat distribution.

### **Protein Content**

Protein analysis showed an average value of 7.46%, which fell short of the minimum requirement of 9% specified by SNI 2973:2011. Given that endemic Nike fish was incorporated specifically as a premium protein-rich fortification agent, a much higher protein concentration was theoretically anticipated.

Three underlying factors explain this sub-optimal protein yield. First, the

substitution ratio of Nike fish relative to corn flour and wheat flour in the current formulation was likely insufficient to overcome the high dilution effect caused by carbohydrate and fat-heavy ingredients (margarine and sugar). Second, during the oven-baking process, high thermal exposure may have triggered severe protein denaturation and advanced Maillard reactions, bonding amino acids with reducing sugars into indigestible complexes, which mathematically lowers the measurable crude nitrogen during micro-Kjeldahl analysis.

Previous literature consistently documents higher protein recoveries; for instance, Astiana et al. achieved protein contents between 16.91% and 19.38% using concentrated surimi powder [2]. The lower performance of BIJAK biscuits suggests that raw fresh Nike fish contains high moisture that dilutes its protein density. Future formulations should consider processing fresh Nike fish into Fish Protein Concentrate (FPC) or dried fish flour prior to dough inclusion, thereby maximizing the protein delivery per gram of biscuit to effectively meet the SNI target for stunting interventions.

### **Carbohydrate Content**

The average carbohydrate content of BIJAK biscuits was 43.89%, which is lower than the minimum requirement of 70% established by SNI 2973:2011. In conventional bakery technologies, carbohydrates constitute the absolute majority of the product mass, acting as the primary structural and energy-yielding framework.

The relatively low carbohydrate percentage recorded in BIJAK biscuits is a direct mathematical consequence of the *by-difference* calculation method utilized [9]. Under this empirical principle, the calculated carbohydrate percentage is

inversely proportional to the sum of moisture, ash, fat, and crude protein. Because the fat content expanded to an average of 36.00% and moisture retention remained high at 9.14%, the remaining mathematical share allocated for carbohydrates was restricted to 43.89%, although it still represents the largest individual macronutrient component in the final matrix.

This chemical distribution deviates from standard commercial biscuits that rely almost exclusively on refined wheat starch. Research on traditional fish-fortified biscuits generally reports higher carbohydrate levels, typically ranging from 57% to 64%, due to stricter baseline lipid controls [2][4]. BIJAK's distinct proximate equilibrium indicates that while it provides a moderate carbohydrate load, its nutritional dynamic is heavily shifted toward a high-energy, lipid-dense profile. Scaling back the formulation's added margarine and optimizing corn starch integration will naturally restore the carbohydrate percentage back toward national standard baselines.

### **Overall Nutritional Quality of BIJAK Biscuits**

Overall, the proximate analysis demonstrates that BIJAK biscuits possess a distinct, non-conventional nutritional profile driven by the synergy of local corn flour and endemic Gorontalo Nike fish. The product successfully satisfies SNI parameters for mineral clearance (ash) and minimum lipid fuel thresholds (fat). However, the non-compliance of moisture, protein, and carbohydrate levels outlines a clear technical roadmap for optimization.

Despite these macrostructural imbalances, BIJAK biscuits represent a vital breakthrough in regional food diversification. By replacing imported wheat structures with local agricultural and

aquatic yields, this product establishes an empirical pathway toward localized food sovereignty. To transition this formulation from a laboratory prototype to a commercially viable public health tool, immediate focus must be directed toward stabilizing ingredient ratios, standardizing mechanical blending to reduce replication variance, and evaluating the long-term oxidative stability of the lipids.

## CONCLUSION

This study evaluated the proximate composition and nutritional quality compliance of BIJAK biscuits formulated from local corn flour and endemic Nike fish (*Awaous melanocephalus*) as a local food diversification strategy. The empirical laboratory analysis established that BIJAK biscuits contained an average moisture content of 9.14%, ash content of 1.11%, fat content of 36.00%, protein content of 7.46%, and carbohydrate content of 43.89%.

Comparison with the quality specifications stipulated by the Indonesian National Standard for biscuits (SNI 2973:2011) indicated that while the ash and fat contents successfully satisfied the national standards, the moisture, protein, and carbohydrate contents remained non-compliant. The elevated lipid and moisture profiles, paired with a moderate carbohydrate allocation and sub-optimal protein levels, reveal that the current prototype operates with a distinct high-energy density rather than matching a conventional wheat-based biscuit profile, heavily influenced by the high water-holding capacity of fresh fish proteins and manual mixing limitations.

The development of BIJAK biscuits underscores a significant innovation in maximizing indigenous Gorontalo commodities to support food sovereignty

and regional nutrition initiatives. To transition this product into a standardized, commercially viable public health intervention tool, future research must prioritize clear technological interventions. These include modifying the baking time-temperature profile to reduce moisture, applying strict mechanical blending to ensure fat homogeneity across replications, and pre-processing the seasonal Nike fish into dried flour or Fish Protein Concentrate (FPC) to significantly elevate the final protein concentration up to national standard baselines.

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