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Nutritional characterization of cookies with wheat (*Triticum spp*), maize (*Zea mays*), quinoa *(Chenopodium quinoa*), faba bean (*Vicia faba*) and chocho (*Lupinus mutabilis*) flour

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Abstract-* The double burden of malnutrition in Ecuador reflects two major nutritional problems: nutrient-deficient diets causing chronic malnutrition in children under five (23% prevalence), and excessive consumption of energy-dense processed foods leading to overweight in children aged 5–11 (35% prevalence). To address these issues, nutrient-enriched cookies were developed using flours from cereals and legumes. The study evaluated partial and complete substitution of wheat flour with mixtures of maize, quinoa, chocho, and faba bean flours to improve nutritional quality by increasing protein and fiber content. A completely randomized design was applied using seven formulations based on wheat flour, M1 flour (10% quinoa, 10% Licto maize, 60% chocho, and 20% whole faba bean), and M2 flour (10% quinoa, 10% Chazo maize, 60% chocho, and 20% peeled faba bean). Substitution levels of 100%, 50%, and 25% were tested. Nutritional analysis showed significant differences (p<0.05) in protein (7.25–17.63%), fiber (1.51–2.84%), and carbohydrates (45.86–56.95%). No significant differences (p>0.05) were observed in ash (1.21–2.19%), fat (23.84–25.16%), moisture (6.85–8.31%), water activity (0.368–0.397), pH (5.51–5.92), or acidity (0.22–0.40). Replacing wheat flour with cereal–legume blends reduced carbohydrate content and significantly increased protein and fiber levels, improving the nutritional profile of the cookies. These formulations represent a promising strategy to address malnutrition and promote healthier eating habits, while offering a nutritious alternative in the snack food market.

***Keywords-* cereal and legume cookies; functional foods; vegetable protein.**

I. INTRODUCTION

Global public health faces structural challenges related to food, such as malnutrition and various chronic diseases. In Ecuador, malnutrition is a critical issue that significantly impacts the country's social and economic development.

Since the initiation of the National Strategy "Ecuador Grows Without Malnutrition" in 2020, the three presidents who have taken office – Lenin Moreno, Guillermo Lasso, and Daniel Noboa– have continued the initiative, resulting in a reduction of the Chronic Childhood Malnutrition (CCM) rate from 23.6% in 2018 to 19.3% in 2024. Despite this progress, the Council reported that Ecuador still ranks fourth among Latin American countries for the highest CCM rates, following Guatemala, Haiti, and Honduras [1] [2].

Ecuador's CCM rate stands at 19.3%, the fourth highest in the region, following Honduras (19.9%), Haiti (20.4%), and Guatemala (42.8%) [3]. The provinces with the highest CCM rates are Chimborazo (35.1%), Bolívar (30.3%), and Santa Elena (29.8%). In contrast, the provinces with the lowest rates of CCM are El Oro (9.8%), Sucumbíos (13.4%), and Los Ríos (14.4%) [3].

It is worth noting that the prevalence of chronic malnutrition in Ecuador showed no significant changes compared to the first year of the survey (2022-2023), with rates of 19.3% in children under 2 years of age, 16.4% in children aged 2–5, and 17.5% in children under 5. The prevalence of overweight and obesity in children under 5 is estimated at 5.0% [4].

In addition to malnutrition, the coexistence of overweight and obesity constitutes a double burden of malnutrition. This evolving epidemiological profile has led to the development of governmental intervention programs, such as the distribution of fortified cookies in schools.

This product presents opportunities to be nutritionally optimized by incorporating high-quality proteins through a sustainable blend of legumes and cereals. This strategy would not only improve children's diets but also benefit the general population, while maintaining affordable costs. Furthermore, the appropriate combination of these flours would allow the elaboration of a great variety of food products, which could form the foundation of a balanced diet, providing essential components and a wide range of crucial nutrients for human health [5].

Flours derived from both traditional and non-traditional cereals such as quinoa, fava bean, wheat, and chocho are primary sources of carbohydrates. Wheat flour lacks lysine, an essential amino acid important for children's growth. Quinoa and chocho flour, on the other hand, stand out for their profile of essential amino acids such as lysine, leucine, valine, phenylalanine, methionine, isoleucine, and threonine, offering a plant-based alternative to animal proteins. These flours are also rich in vitamins and minerals, contributing significantly to a balanced diet [6].

Rice is widely consumed globally and is characterized by its high starch content, moderate protein levels, and low-fat content. Corn, another staple cereal, contains approximately 70-80 % carbohydrates, 7-9 % protein, and between 3-5 % fat, and is also rich in dietary fiber and antioxidants. Both wheat and oats stand out for their fiber content, B vitamins, and minerals such as iron and zinc [7]. These characteristics establish cereals as a fundamental base in many food cultures, providing essential nutrients for maintaining health and overall well-being [7].

Legumes are one of the most important botanical families from a nutritional standpoint, forming a significant part of the Mediterranean diet and essential diets of many developing countries. They are consumed as dry seeds, cleaned and separated from the pods. Among the grain legumes, dried beans (*Phaseolus vulgaris*), chickpeas (*Cicer arietinum*), and lentils (*Lens culinaris*) stand out. Peas (*Pisum sativum*), broad beans (*Vicia faba*), and *sweet lupin* (chocho), including *Lupinus mutabilis*, *L. albus, and L. luteus,* are also important [8].

Chocho (*Lupinus mutabilis*), known as Andean soybean, has been valued by Andean cultures since pre-Hispanic times due to its extraordinary nutritional properties. Its nutritional profile is comparable to that of soybeans, standing out for its high content of protein, unsaturated fats, and essential amino acids, making it a viable alternative for vegetarian diets. To complement the deficiency of certain amino acids, it is recommended to consume one serving of chocho with two servings of cereals, thus maximizing the nutritional benefits. Raw dehulled chocho has a remarkable protein content of up to 51% on a dry basis, while raw chocho with the hull has a higher caloric content and contains significant amounts of protein, fat, and carbohydrates, as well as essential micronutrients such as calcium, phosphorus, iron and zinc, and essential fatty acids [9].

Fava beans (*Vicia faba*) have a significant nutritional impact on the human diet, due to their high content of quality proteins, which favor the growth and development of the organism. They are also an important source of minerals such as iron, which is essential for hemoglobin synthesis and the prevention of anemia, as well as phosphorus and calcium, which contribute to improving cognitive functions. From a techno-functional perspective, the ability of fava bean flour to remain in a loose powder state and its ease of mixing with water have been investigated for different particle sizes (<200 and <45 μm) [10].

Cereals and legumes offer substantial health benefits in preventing heart disease and overweight; however, they are undervalued as proteins because of their low biological value, as they have limiting amino acids such as Tryptophan and Methionine [11].

The development of strategies to optimize protein quality through flour blends represents an approach that seeks to obtain a high nutritional and functional value that facilitates the incorporation of these blends in gastronomic preparations, such as cookies, cakes, purees, coladas, bars, and breads, among others.

In Ecuador, the cookie market has become one of the most dynamic in the food industry. Within this sector, a trend towards functional benefits has emerged, highlighting the importance of the consumption of cereals and legumes with low caloric content, but with a significant contribution of fiber and protein as well as essential amino acids [12].

This study proposes an innovative strategy to address the double burden of malnutrition through the formulation of cookies made with high nutritional value flours, such as corn, quinoa, beans and chocho, whose approach aims to meet caloric needs and provide an adequate protein profile that includes essential amino acids, vitamins and minerals essential in the daily diet. This is achieved by enhancing the nutritional characteristics of a mass-consumption product, such as cookies, made with a mixture of corn, chocho, broad bean, and quinoa flours.

In this context, the main objective of the study is to formulate nutritious cookies from these flour mixtures

II. MATERIALS AND METHODS

A. *Location of the study área*

The research was carried out in the laboratories of the Nutrition and Dietetics and Gastronomy careers of the Escuela Superior Politécnica de Chimborazo (ESPOCH), located in the city of Riobamba, Chimborazo, Ecuador (coordinates 1°39′29″S 78°40′35″O).

B. *Raw Material*

The Ministry of Agriculture, Livestock and Fisheries (MAGAP) of the province of Chimborazo, Ecuador, provided samples of Andean cereals and legumes, in the amount of 10 kg each, including quinoa (*Chenopodium quinoa*), fava bean (*Vicia faba*), chocho (*Lupinus mutabilis sweet*), and maize (*Zea mays L.*) from the communities of Chazo and Licto. The samples were evaluated according to food handling standards to ensure the safety and organoleptic quality of the raw materials. The wheat flour (*Triticum spp*.) and the inputs needed to make the cookies were purchased in a local market in the city of Riobamba-Ecuador.

The M1 and M2 flour mixtures were obtained according to Falconí et al[6], who optimized the protein content by strategically combining cereals and legumes, mixing corn, quinoa, chocho and bean flours in proportions that maximized nutritional synergy, taking advantage of the complementary qualities of each grain and legume, resulting in a flour with a high protein content.

C. Experimental design

The completely randomized design (CRD) was chosen for its simplicity and effectiveness in evaluating multiple formulations under controlled conditions. This design minimizes bias and allows a direct comparison between the different flour blends and their concentrations.

1) Factor 1: Type of flour

Wheat flour. Mixed flour 1 (M1): 10 % quinoa, 10 % Chazo maize, 60 % chocho and 20 % faba bean.

Flour mix 2 (M2): 10 % quinoa, 10 % Licto maize, 60 % chocho and 20 % faba beans.

2) *Factor 2:* Concentrations 25 %, 50 %, 100 %.

In the present study, seven cookie formulations were developed with the total and partial substitution of wheat flour by flour Mixture 1 (M1) or Mixture 2 (M2), as detailed in Table 1. The inclusion of wheat flour as a control (T1) allows establishing a basis for comparison to evaluate the impact of flour blends (M1 and M2) on cookie characteristics.

The concentrations of 25 %, 50 % and 100 % of the flours allow evaluating the effect of partial and total wheat flour substitution on the characteristics of the cookies.
By virtue of these results, formulations T2 and T3 evaluate the impact of total wheat flour substitution by M1 and M2, respectively.

Formulations T4, T5, T6, and T7 evaluate the impact of the partial substitution of wheat flour by M1 and M2 in different proportions, allowing for the identification of the optimal combination.

TABLE I
FORMULATIONS OF FLOUR MIXTURES FOR THE TREATMENTS IN COOKIE MAKING

Code	Flour blend	Wheat (%)	M1 (%)	M2 (%)
T1	Wheat	100	0	0
T2	M1	0	100	0
T3	M2	0	0	100
T4	Wheat:M1	75	25	0
T5	Wheat:M1	50	50	0
T6	Wheat:M2	75	0	25
T7	Wheat:M2	50	0	25

The standard formulation with the ingredients listed in Table II was used to prepare the cookies. This ensured that any variation in the cookies' characteristics was due to the types and concentrations of flour, not other factors.

TABLE II
STANDARD FORMULATION OF THE INGREDIENTS USED FOR THE PRODUCTION OF COOKIES

Ingredients[a]	%	Unit	Quantity
Pastry flour	44.01	grams	500
Unsalted butter	26.41	grams	300
Sugar, impalpable	17.61	grams	200
Eggs	0.09	units	1
Cornstarch	8.80	grams	100
Baking powder	0.88	grams	10
Triple Sec.	2.20	milliliters	25

[a]Ingredient that was substituted according to the treatments

D. Procedure for the elaboration of the cookies

The cookie preparation process took place in the Gastronomy-ESPOCH laboratories, following the process diagram shown in Figure 1. This diagram outlined the steps, which included weighing the ingredients, controlling the temperature, and applying the specified techniques. To ensure uniformity and minimize the potential for errors during cookie preparation, the ingredients needed to be measured and weighed accurately, as detailed in Table II.

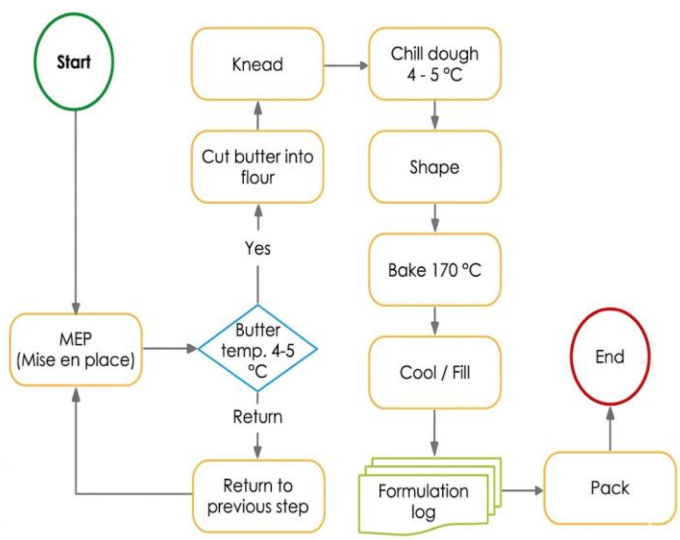

Fig. 1 Cookie preparation flowchart

In a bowl, place the cold butter cut into small cubes, and add the flour; mix quickly until the butter is integrated, forming coarse crumbs.

The mixture should have a texture similar to wet sand, with some pieces of butter still visible. This process is essential to achieve a light, flaky texture in the cookies. The dough was refrigerated at 4 °C for at least 30 minutes in order to make the dough more manageable and to keep the cookies' shape during baking. Subsequently, the dough was rolled and cut into a circular shape, then placed on a baking sheet [13].

The cookies were baked in a preheated oven at 180 °C for 10-12 minutes, until the edges were golden brown. Time and temperature are crucial to obtaining a perfect texture, crispy on the outside and soft on the inside. After this process, they were cooled at room temperature for approximately 10 minutes before being packed in polyethylene sleeves. Cooling is crucial, as it allows the cookies to settle and reach a suitable final texture [13].

E. Proximal composition analysis

The analyses performed on the cookies obtained in the seven treatments were: moisture, determined according to the standard procedure [15]. For ash determination, the Standard [16] was used. Protein content was determined by the Kjeldahl method, according to the indicator in standard [17]. The amount of fat was determined by continuous extraction using the Goldfish method according to Standard [18]. The determination of fiber and total carbohydrate content was performed as described by [14].

F. Analysis of physical characteristics

Water activity was measured with the ACUALAB 4TE equipment, which operates according to the vapor equilibrium principle (Aqualab), and hydrogen potential (pH) was determined according to NTE INEN 526 and Logroño[14].

G. Statistical analysis

The statistical package InfoStat, free version 2020, was used. An analysis of variance (ANOVA) followed by Duncan's multiple comparison test was applied, establishing a significance level of $\alpha = 0.05$ to determine the existence of significant differences among the samples of the seven treatments. The comparison of means was performed using the Duncan minimum significant difference, considering significant the differences with a value of $p < 0.05$.

III. RESULTS AND DISCUSSION

A. Proximal analysis

The results of the proximate analysis (Table 3) reveal significant differences in the nutritional composition of the cookies made with different flours. Particularly, the substantial increase in the protein content of T2 (17.63 g/100 g) and T3 (16.05 g/100 g) cookies, formulated with cereal and legume flours, compared to T1 (7.25 g/100 g) cookies, elaborated exclusively with wheat flour ($p<0.05$), stands out. This increase is of utmost importance, considering that wheat-based products are usually deficient in essential amino acids such as lysine [20]. These findings are consistent with previous studies. For example, Chirinos and Vargas reported a protein content of 15.7 % in cookies made with wheat flour and tapirama (Phaseolus lunatus), a value comparable to those obtained in the T2 and T3 formulations of the present investigation. The inclusion of protein-rich flours not only raises the nutritional value of the product, but also helps improve its amino acid profile, which is crucial for human health. [15].

The inclusion of protein-rich flours not only improves the nutritional value of the product but may also contribute to increased satiety, a key aspect in appetite control [16], all treatments in which wheat flour is substituted showed a significant increase in protein content.

Regarding carbohydrates, a significant decrease was observed in T2, T3, T4, T5 and T7 cookies compared to T1 ($p<0.0001$). This is due to the partial substitution of wheat flour by other flours with lower carbohydrate content and higher protein and fiber content. This reduction is favorable given that high carbohydrate intake is associated with various health problems, including type 2 diabetes [17]. The formulation of cookies with lower carbohydrate content may be an effective strategy to address these dietary concerns, as well as prevent obesity problems.

Total fiber content presented significant differences ($p<0.05$), with T5 cookies showing the highest levels (2.84 g/100 g). This finding is significant since dietary fiber is associated with multiple health benefits, including improved digestion and body weight control. [15] developed cookies based on wheat flour and tapirama, which presented a fiber content of 15.7%. [18] elaborated 11 cookie formulations with wheat flour, chia, and oil extracted from tarwi obtaining a fiber value of 5.07%. In this context it should be noted that the fiber content will depend on the nature of the raw materials used, as it is maintained in the process. Total fiber is very important for a healthy diet; moreover, it is considered that one of the best sources of fiber comes from legumes [19]. Although the formulations presented lower total fiber compared to previous studies, it should be considered that the flour used provides both soluble and insoluble fiber, which is beneficial for a balanced diet.

No significant differences were evidenced in the ash content; the percentages fluctuated between 2.19 % and 1.21 %, which are lower than those reported in other studies, such as that of Peñafiel, where 3.04 % was obtained. However, the values are within the acceptable parameters indicated by [20]. A low ash content can contribute to a higher whiteness of the product, which improves its visual acceptance among consumers [21].

The significant increase in the protein content of cookies made with cereal and legume flour, compared to wheat cookies, highlights the potential of these formulations to combat nutritional deficiencies, especially in essential amino acids such as lysine. Also, the variation in fiber content among formulations offers the opportunity to select those with higher dietary fiber intake, which translates into benefits for digestive health and chronic disease prevention. Taken together, these bromatological findings not only validate the effectiveness of the flour blends used but also provide valuable information for the formulation of cookies with an optimized nutritional profile, thus contributing to a healthier diet. Similarly, no significant differences in fat content were found between the formulations (p>0.05). Cookies are a convenient and easy-to-consume food, which makes them ideal for school and preschool children to improve height. Cookies formulated with local cereal and legume flour can provide a concentrated source of protein, fiber, vitamins, and minerals essential for children's growth and development; moreover, they can contribute to strengthening food security by diversifying the food supply and reducing dependence on imported products.

In the study conducted by García et al. [22], the substitution of wheat flour with lupin flour (*Lupinus albus*) was evaluated in proportions ranging from 10% to 30%.

Their findings demonstrated a linear increase in protein content, comparable to the results observed in T2 (17.63%). However, they reported that substitution levels exceeding 25% adversely affect dough stability due to gluten dilution. Regarding your study, upon reaching 100% substitution in T2, the primary technical limitation is not solely the observed analytical variability but rather the probable loss of structural cohesiveness—a common challenge when formulating with gluten-free flours. The utilization of M1 (containing Chazo maize) in T2 appears to be more efficient for nutrient retention compared to the blend with Licto maize (T3). The synergy between lupin and common bean serves as the primary driver for the protein increase, yielding a product that significantly surpasses the nutritional standards of commercial wheat-based cookies

Future distribution of these cookies in health centers and community kitchens could effectively reach vulnerable populations. Providing nutrition education is essential for parents and caregivers to understand the importance of reviewing the nutrients these cookies contain and to promote good nutrition.

TABLE III
PROXIMAL COMPOSITION OF COOKIES FORMULATED WITH WHEAT, CORN, QUINOA, BROAD BEAN, AND CHOCHO FLOUR EXPRESSED IN PERCENTAGE THERMS ± SD (STANDARD DEVIATION*)*

Treatment	Humidity	Ash	Protein	Fats	Carbohydrates	Fiber
T1	8.31 ± 0.39^{a}	2.19 ± 0.25^{a}	7.25 ± 0.42^{e}	23.36 ± 0,95^{a}	56.95 ± 1.07^{a}	1.51 ± 1.09^{d}
T2	7.11 ± 0.39^{a}	2.07 ± 0.25^{a}	17.63 ± 0.42^{a}	25.13 ± 0.95^{a}	45.93 ± 1.07^{c}	2.37 ± 1.09^{b}
T3	7.45 ± 0.39^{a,b}	2.05 ± 0.25^{a}	16.05 ± 0.42^{b}	24.94 ± 0.95^{a}	45.86 ± 1.07^{c}	2.06 ± 1.09^{c}
T4	8.28 ± 0.39^{a,b}	1.21 ± 0.25^{b}	12.05 ± 0.42^{d}	23.84 ± 0,95^{a}	51.29 ± 1.07^{b}	2.29 ± 1.09^{b}
T5	7.12 ± 0.39^{a,b}	1.61 ± 0.25^{a,b}	15.05 ± 0.42^{b}	24.51 ± 0,95^{a}	49.18 ± 1.07^{b}	2.84 ± 1.09^{a}
T6	7.32 ± 0.39^{a,b}	1.41 ± 0.25^{a,b}	13.75 ± 0.42^{c}	25.16 ± 0,95^{a}	50.37 ± 1.07^{b}	2.29 ± 1.09^{b}
T7	6.85 ± 0.39^{b}	1.45 ± 0.25$^{a, b}$	15.74 ± 0.42^{b}	25.04 ± 0,9^{a}	48.67 ± 1.07^{b,c}	2.15 ± 1.09^{b,c}
P-value	0.1100	0.0852	<0.0001	0.7542	<0.0001	<0.0001

Means with a common letter are not significantly different (p > 0.05

B. Physical analysis

The moisture content in the analyzed cookies varied between 6.85 % and 8.31 %, values that are within the limits established by the standard [20], which establishes a maximum of 10 %. Although no significant differences (p>0.05) were observed between the different treatments, these levels are fundamental to guaranteeing the texture and shelf life of the product. Adequate moisture content is crucial to prevent rancidity and microbial growth and to maintain sensory quality during storage. It should be noted that these values are higher than those reported by Martínez et al. [22], who found moistures in the range of 0.92 % to 1.58 % in cookies made with sorghum, bean, and wheat flour. Regarding water activity (aw), the results showed no significant differences between formulations ($p>0.05$), which is equally relevant for the microbiological stability of the product. Maintaining an adequate AW level is essential to prevent microbial growth and prolong the shelf life of the product.

Significant differences in pH were observed between formulations ($p<0.05$), ranging from 5.51 to 5.92. Variations in pH can influence product flavor and shelf life; most molds prefer slightly acidic environments and can grow in a wide pH range. Genera such as Penicillium and Aspergillus are common in bakery products and can cause visible spoilage, such as staining and off-flavors, and can affect the organoleptic properties of the food [24]. These results suggest that pH control during production is essential to ensure sensory and microbiological quality. Similarly, significant differences were evidenced in acidity ($p<0.05$); cookies with higher acidity could have implications in their acceptance by the consumer due to their influence on the flavor of the product. Proper acidity regulation is essential to ensure both food stability and palatability [17].

Bakery products, including cookies, are considered a mass-consumption food that can be a staple food, a favorite treat for children, and even a dietary food. Their acceptance is also due to their ease of transport and long shelf life [24]. Cookies are suitable products to be elaborated with flour mixtures; their characteristics make them ready to eat, and their prolonged shelf life due to their low moisture content and their consumption by all groups of people allow them to be considered a snack, which children, especially, usually consume at different meal times and places [25].

In Ecuador, the nutritional profile of legume consumption is very low, so the usefulness of these foods should be encouraged [26], and one way to achieve this would be to promote products made with mixtures of cereals and legumes.

TABLE IV
PHYSICAL PARAMETERS OF COOKIES FORMULATED WITH WHEAT, CORN, QUINOA, FAVA BEAN, AND CHOCHO FLOURS.

Code	Water activity (aw)	pH	Acidity[a]
T1	0.375 ± 0.02^{a}	5.71 ± 0.55^{b}	$0.28 \pm 0.03^{c,d}$
T2	0.378 ± 0.02^{a}	$5.58 \pm 0.55^{b,c}$	$0.38 \pm 0.03^{a,b}$
T3	0.393 ± 0.02^{a}	$5.51 \pm 0.55^{b,c}$	$0.27 \pm 0.03^{c,d}$
T4	0.378 ± 0.02^{a}	$5.63 \pm 0.55^{b,c}$	$0.28 \pm 0.03^{b,c,d}$
T5	0.368 ± 0.02^{a}	5.92 ± 0.55^{c}	0.22 ± 0.03^{d}
T6	0.397 ± 0.02^{a}	5.60 ± 0.55^{a}	0.40 ± 0.03^{a}
T7	0.374 ± 0.02^{a}	5.54 ± 0.55^{c}	$0.35 \pm 0.03^{a,b}$
P-value	0.4358	0.0007	0.0090

Means with a common letter are not significantly different ($p > 0.05$).
[a]Results are on a dry basis. meq NaOH/100g.

C. Nutritional analysis

The infant diet should adequately cover the energy and nutrient requirements at each stage to promote optimal growth and development, prevent or deal with any nutrient deficiency or excess disorder in a timely manner, and promote a healthy and varied dietary pattern that will last in later stages of life. Cereal-legume combinations offer high-quality proteins due to the compensation of their essential amino acids; the development of formulations based on mixtures of wheat flour (*Triticum*), quinoa (*Chenopodium quinoa*), chocho (*Lupinus mutabillis*), maize (*Zea mays L.*) and fava bean (*Vicia faba*) are a good alternative for optimal nutritional formulations [27].

A serving of 4 cookies (60 grams) plays an important role in the nutritional aspect due to its caloric intake (288.24), approaching the target of 300 kcal for an effective nutritional supplement, as well as its high value of protein (17.63 g/100 g and 10.578 g/serving), fat (25.13 g/100 g and 15.078 g/serving), and carbohydrates (45.93 g/100 g and 27.558 g/serving) within its composition. This balance of macronutrients makes them a viable alternative for people with high caloric and protein needs or difficulties in consuming conventional foods.

TABLE V
NUTRITIONAL ANALYSIS OF MACRONUTRIENTS PER COOKIE

Macronutrients (T2)	Nutritional Information / 100 grams	1 serving = 4 cookies, 15 grams each	Kcal/serving (per cookie)
Protein	17.63	10.578	42.312
Fat	25.13	15.078	135.702
Carbohydrates	45.93	27.558	110.232
Total			288.246

Formulations containing flour mixtures M1 and M2 showed a marked improvement in essential amino acid composition compared with the wheat control (T1). Treatments T2 and T3, corresponding to total wheat flour substitution, exhibited the highest estimated lysine content (6.3% and 6.1%, respectively), representing more than a two-fold increase relative to the control (2.7%). Additionally, branched-chain amino acids (leucine, isoleucine, and valine) were higher in formulations enriched with chocho and faba bean, indicating improved protein quality and greater nutritional functionality. The combination of cereals with Andean pseudocereals and legumes produced a complementary amino acid profile, particularly enhancing lysine, threonine, and aromatic amino acids, while maintaining adequate levels of sulfur-containing amino acids. Among all treatments, T2 demonstrated the most favorable estimated amino acid profile and the highest protein content, suggesting superior biological protein value.

TABLE VI
ESTIMATED ESSENTIAL AMINO ACID COMPOSITION OF COOKIE FORMULATIONS (% OF TOTAL PROTEIN)

Treatment	Protein (%)	Lysine	Leucine	Isoleucine	Valine	Methionine + Cysteine	Threonine	Phenylalanine + Tyrosine	Tryptophan	Nutritional interpretation
T1	7.25	2.7	6.6	3.4	4.2	2.5	2.8	6.8	1.1	Limiting in lysine; cereal-type protein profile
T2	17.63	6.3	7.5	4.4	5.0	1.8	3.8	7.2	1.2	Highest lysine and BCAA content; superior amino acid balance
T3	16.05	6.1	7.4	4.3	4.9	1.8	3.7	7.1	1.2	Comparable to T2; excellent protein complementation
T4	12.05	3.6	6.8	3.7	4.4	2.3	3.1	6.9	1.1	Improved lysine compared with control
T5	15.05	4.7	7.1	4.0	4.6	2.1	3.4	7.0	1.1	Balanced amino acid enhancement
T6	13.75	3.5	6.8	3.7	4.4	2.3	3.1	6.9	1.1	Moderate improvement in essential amino acids
T7	15.74	4.6	7.0	3.9	4.6	2.1	3.4	7.0	1.1	High-quality complementary protein profile

CONCLUSION

Cookies formulated with cereal and legume flours represent an effective strategy to address the double burden of malnutrition in Ecuador. By offering a product with higher protein and fiber content, it can contribute to improving children's nutrition and promoting healthier eating habits.

The substitution of wheat flour with blends of local cereal and legume flour represents an innovation in the snack market, offering a nutritious and healthy alternative that responds to the growing demand for products with a better nutritional profile.

The research opens new possibilities for the use of cereal and legume flours in the food industry, in particular the elaboration of cookies of good nutritional quality that benefit the health of consumers and contribute to diet diversification. In addition, there are benefits in terms of positive modification of the intestinal microbiome due to the quality and quantity of fiber.

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest in this work.

LIMITATION OF RESPONSIBILITY

The authors declare that the manuscript is the sole responsibility of the authors. Author contributions:

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REFERENCES

[1] UNICEF, "Desnutrición Crónica Infantil". Accessed: March1, 2025. [Online]. Available at: https://l1nq.com/zmaeypb

[2] C. Jijón, "Ecuador sigue 4to entre los países con mayor desnutrición". Accessed: March 1, 2025. [Online]. Available at: https://sl1nk.com/wm18rcq

[3] INEC, "Encuesta Nacional sobre Desnutrición Infantil. Principales resultados". [Online]. Available at: https://l1nq.com/alkn37x

[4] M. Herrera *et al.*, "Gestión de Estadísticas Permanentes a Hogares", p. 27, 2024.

[5] O. J. Q. Moreira, K. S. R. Arias, S. L. López, y L. E. F. Holguín, "Aceptabilidad de galletas con diferentes concentraciones de harinas de quinua, plátano, avena y endulzantes", *Revista Espamciencia ISSN 1390-8103*, vol. 11, n.º 1, Art. n.º 1, jun. 2020, doi: 10.51260/revista_espamciencia.v11i1.187

[6] P. R. P. Falconí, I. M. M. Parra, T. M. Z. Núñez, y M. R. V. Guevara, "Chocho, quinua, haba y maíz como materias primas para la elaboración de harinas", *Polo del Conocimiento*, vol. 9, n.º 2, Art. n.º 2, feb. 2024, doi: 10.23857/pc.v9i2.6515

[7] C. E. Gracas y M. S. Poliana, *Introduction to Cereals*. 2023. Accessed: December 10, 2024. [Online]. Available at: https://link.springer.com/chapter/10.1007/978-3-031-40308-8_1

[8] C. Delgado-Andrade, R. Olías, J. C. Jiménez-López, y A. Clemente, "Aspectos de las legumbres nutricionales y beneficiosos para la salud humana", *Arbor*, vol. 192, n.º 779, Art. n.º 779, jun. 2016, doi: 10.3989/arbor.2016.779n3003

[9] M. N. V. Cárdenas, M. E. R. Romero, Y. J. C. Salazar, H. C. E. Cevallos, y R. G. O. Ruiz, "Análisis comparativo de la composición nutricional del chocho, quinua y soya, y su aplicación en la elaboración de harinas", *La Ciencia al Servicio de la Salud y la Nutrición*, vol. 10, pp. 260-269, 2019.

[10] J. Villena Carrión, "Perfil nutricional de la vaina del haba (*vicia faba*) y propiedades tecnofuncionales de su harina", *Nutritional profile of vicia faba pod and the techno functional properties of its flour*, p. 23, oct. 2023.

[11] J. Flores-Fernández, R. Durán-Lugo, M. G. L.- Martínez, y J. G. Báez-González, "Cereales y legumbres: Alternativas a la Carne Roja desde la Perspectiva del Valor Biológico y la Salud", vol. 7, 2022.

[12] M. D. C. G. Romo, E. F. N. Herrera, E. D. M. León, y N. R. L. Aimacaña, "Actividades de innovación en el sector alimentos y bebidas de Ecuador: un modelo probabilístico", *Contaduría y Administración*, vol. 69, n.º 4, Art. n.º 4, 2024, doi: 10.22201/fca.24488410e.2024.5000.

[13] C. L. Blue, "Recetas Caseras Galletas y Pastas", Accessed: December10, 2024. [Online]. Available at: https://l1nq.com/jjtodd1

[14] M. Logroño, L. Vallejo, y L. Benítez, "Análisis Bromatológico, sensorial y aceptabilidad de galletas y bebida nutritiva a base de una mezcla de quinua, arveja, zanahoria y tocte", *Alimentos Hoy*, vol. 23, n.º 35, pp. 53-64, ago. 2015.

[15] W. de J. Chirinos Leal y N. Vargas Rincón, "Análisis proximal de galletas de harina de trigo (*triticum vulgare*): tapirama (*phaseolus lunatus*) de pueblo nuevo de Paraguaná", *Centro Azúcar*, vol. 44, n.º 2, pp. 10-17, jun. 2017.

[16] V. Quitral *et al.*, "Harina de cáscara de zanahorias como ingrediente en la elaboración de galletas", *Revista chilena de nutrición*, vol. 50, n.º 2, pp. 226-232, abr. 2023, doi: 10.4067/s0717-75182023000200226

[17] G. Din *et al.*, "Physicochemical, nutritional and organoleptic characteristics of cookies based on water chestnut (Trapa natans) and wheat", *Food Chemistry Advances*, abr. 2024, doi: 10.1016/j.focha.2024.100691

[18] Y. Salvatierra-Pajuelo, M. Azorza-Richarte, y L. Paucar-Menacho, "Optimización de las características nutricionales, texturales y sensoriales de cookies enriquecidas con chía (Salvia hispánica) y aceite extraído de tarwi (Lupinus mutabilis)", *Scientia Agropecuaria*, vol. 10, n.º 1, Art. n.º 1, abr. 2019, doi: 10.17268/sci.agropecu.2019.01.01

[19] M. M. Phillips, D. C. Dugdale, y B. Conaway, "Fibra soluble e insoluble", MedlinePlus: enciclopedia médica ilustración. Accessed: December 11, 2024. [Online]. Available at: https://medlineplus.gov/spanish/ency/esp_imagepages/19531.htm

[20] NTE INEN 2085, "Galletas. Requisitos", pdfcoffee.com. Accessed: December 20, 2024. [Online]. Available at: https://pdfcoffee.com/nte-inen-2085-4-pdf-free.html

[21] G. Espinoza-Córdova, R. Rojas, y F. Espinoza-Montesinos, "Análisis químico proximal de granos y harina de Pajuro (Erythrina edulis) para elaborar bebidas proteicas", *Alfa Revista de Investigación en Ciencias Agronómicas y Veterinaria*, vol. 5, n.º 14, pp. 297-318, ago. 2021, doi: 10.33996/revistaalfa.v5i14.119

[22] J. A. García, R. M. Martínez, y K. L. López, “Evaluación nutricional y sensorial de productos de panificación suplementados con harina de lupino (*Lupinus albus*),” *Rev. Chil. Nutr.*, vol. 49, n.º 1, pp. 112–120, feb. 2022.

[23] V. Y. C. INE, "Validación y Certificación INEN: Ensayos de laboratorio galletas", Validación y Certificación INEN. Accessed: December 11, 2024. [Online]. Available at: https://l1nq.com/iu4mem4

[24] M. E. Moreno Quintero, L. M. Crespo Zafra, y C. Curbelo Hernández, “Uso de harina de vainas secas de Moringa en la elaboración de galletas y tortas venezolanas. Parte II,” *Cen. Az.*, vol. 48, n.º 4, pp. 24–32, oct.-dic. 2021. [Online]. Available at: https://l1nq.com/u03h7w0

[25] A. Hussain *et al.*, "Development of nutritional biscuits for children, rich in Fe and Zn, by incorporation of pumpkin (Cucurbita maxima) seeds powder; a healthy pharma food in current post COVID 19 period", *Pure and Applied Biology*, vol. 12, pp. 392-403, mar. 2023, doi: 10.19045/bspab.2023.120042

[26] P. Caicedo, L. Arboleda, y C. Hidalgo, "Índice de producción de legumbres post Covid -19 en el cantón Píllaro", *Revista Científica Arbitrada Multidisciplinaria PENTACIENCIAS*, vol. 5, n.º 4, pp. 406-413, jun. 2023, doi: 10.59169/pentaciencias.v5i4.676

[27] P. Cerezal Mezquita, "Product development on the basis of cereal and leguminous flours to coeliac disease in children between 6 - 24 months; I: Formulation and acceptability", *Nutrición Hospitalaria*, n.º 1, pp. 0-0, ene. 2011, doi: 10.3305/nh.2011.26.1.4862