

Development of a vegetable drink based on coconut milk (*Cocos nucifera*), pistachio (*Pistacia vera*) and maple syrup (*Acer saccharum*) as a source of fiber, protein and calcium

Desarrollo de una bebida vegetal a base de leche de coco (*Cocos nucifera*), pistacho (*Pistacia vera*) y sirope de arce (*Acer saccharum*) como aporte de fibra, proteína y calcio

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Abstract: This experimental work developed a vegetable drink from coconut milk, pistachios and maple syrup to take advantage of the nutritional benefits contained in each ingredient. A completely randomized design (CRD) was used, employing an Analysis of Variance and Tukey's test, three beverage treatments (B1, B2 and B3) with four replicates, modifying the amounts of coconut milk, pistachios and maple syrup. Calcium content was determined by atomic absorption spectrophotometry. The treatment that obtained the highest calcium content was B3, with a statistical mean of 638.43 ± 15.10 mg/kg, followed by B2 with a mean of 538.87 ± 24.14 mg/kg, and finally B1 with a mean of 430.48 ± 28.34 mg/kg. The results of the protein and fiber content analysis for the treatment with the highest calcium content (B3) were 3.95% and 2.75%, respectively. Microbiological analyses were also performed on B3. INEN Standard 2337 was used as a reference for the determination of the microbiological characteristics of juices, pulps, concentrates, nectars, fruit and vegetable drinks. All parameters evaluated in the vegetable drink met the requirements established by the reference standard, indicating that the product was produced under adequate hygienic conditions and is suitable for human consumption.

Keywords: bromatological analysis, lactose free, Kjeldahl, technical standard, technical norm

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Resumen El presente trabajo experimental desarrolló una bebida vegetal a partir de leche de coco, pistachos y sirope de arce para aprovechar los beneficios nutricionales que contiene cada ingrediente. Se utilizó un diseño completamente al azar (DCA), empleando un Análisis de Varianza y prueba de Tukey, se constituyeron tres tratamientos de bebida (B1, B2 y B3) con cuatro repeticiones, modificando las cantidades de leche de coco, pistachos y sirope de arce. La determinación del contenido de calcio se realizó mediante espectrofotometría de absorción atómica. El tratamiento que obtuvo mayor contenido de calcio fue B3, con una media estadística de 638.43 ± 15.10 mg/kg, seguido por B2 con una media de 538.87 ± 24.14 mg/kg, y por último B1 con una media de 430.48 ± 28.34 mg/kg. Los resultados de los análisis del contenido de proteína y fibra al tratamiento de mayor presencia de calcio (B3) fueron 3.95% y 2.75%, respectivamente. Así mismo se realizaron análisis microbiológicos a B3. Se utilizó como referencia la Norma INEN 2337 para la determinación de las características microbiológicas de jugos, pulpas, concentrados, néctares, bebidas de frutas y vegetales. Todos los parámetros evaluados en la bebida vegetal cumplieron con los requisitos establecidos por la normativa de referencia, lo que indica que el producto se elaboró con las condiciones higiénicas adecuadas y es apto para el consumo humano.

Palabras clave: análisis bromatológicos, libre de lactosa, Kjeldahl, norma técnica

Introduction

The growing demand for functional foods has led to the development of innovative and nutritious beverages that offer not only hydration but also additional health benefits. Consumers are looking for beverages that go beyond traditional options, provide essential nutrients, and promote overall wellness. In response to this demand, the present study focuses on the development of a plant-based beverage that combines the goodness of coconut milk, pistachios and maple syrup to provide a rich source of fiber, protein and calcium.

Coconut milk (*Cocos nucifera*) has gained popularity as a plant-based alternative to cow's milk due to its creamy texture and distinctive flavor. It is naturally lactose-free, making it suitable for people with lactose intolerance (Edem and Elijah, 2016). Coconut milk is also known for its high fiber content, which aids in digestion and promotes satiety (Priya, 2016). In addition, it contains essential minerals such as calcium, magnesium, and phosphorus, which contribute to bone health (Debmandal and Mandal, 2011). The unique combination of nutrients in coconut milk makes it a valuable ingredient for the development of functional beverages.

Pistachios (*Pistacia vera*) are a highly valued raw material for their nutritional profile and potential health benefits. They are an excellent source of plant-based protein, due to the fact that they contain all the essential amino acids required by the human body (Mandalari et al., 2021). Pistachios are also rich in dietary fiber, contributing to digestive health and promoting satiety (Syrine et al., 2019). Furthermore, pistachios are a natural source of several vitamins and minerals, including calcium, which is crucial for maintaining bone strength and preventing osteoporosis (D'Evoli et al., 2015). Additionally, therapeutic potential has been evidenced by evaluating the antioxidant activity and anti-inflammatory properties of polyphenols present in pistachio (Paterniti et al., 2017). The incorporation of this nut in a vegetable beverage can improve its protein and fiber content while providing additional health-promoting properties.

Maple syrup (*Acer saccharum*) is a natural sweetener derived from the sap of maple trees. Aside from its distinctive flavor profile, maple syrup offers potential health benefits as a source of essential nutrients. It contains several antioxidants that possess anti-inflammatory properties (Ramadan, Gad and Farag, 2021). Maple syrup also contains minerals such as calcium, potassium and magnesium, which play vital roles in several physiological processes, including nerve function and muscle contraction (Mohammed, Sibley, Guillaume, Abdulwali, Abdulwali, 2022). Including maple syrup in the formulation of the vegetable beverage not only improves its taste, but also contributes to the overall nutritional composition.

The combination of coconut milk, pistachios and maple syrup in a plant-based beverage has the potential to provide a balanced blend of fiber, protein and calcium. Fiber is known for its role in promoting digestive health, regulating blood sugar levels, and supporting weight management (Aleixandre and Miguel, 2016). Protein is essential for muscle development, tissue repair, and overall body growth and maintenance (Landi et al, 2016). Calcium is a critical mineral necessary for strong bones and teeth, as well as for proper nerve and muscle function (Owen et al, 2016).

By incorporating these natural and nutrient-rich ingredients, the vegetable beverage developed aims to provide consumers with a refreshing and nutritious beverage option. This study seeks to evaluate

the calcium content of three formulations of the beverage, and the treatment that presented the highest calcium content was analyzed for fiber and protein content, in addition to microbiological analysis according to the requirements of the NTE INEN 2338:2008 standard.

Materials and methods

Formulation of the beverage

Table 1 shows the composition of the proposed beverage. Three formulations were devised, varying the contents of coconut milk (*Cocos nucifera*), pistachio (*Pistacia vera*) and maple syrup (*Acer saccharum*) with the intention of finding the composition with the highest calcium content. Subsequent to this treatment, protein, fiber and microbiological requirements were analyzed.

Table 1. *Vegetable drink formulations*

Component	Formulations		
	B1 (%)	B2 (%)	B3 (%)
Coconut milk	56,67	61,33	58,34
Pistachio (powdered)	19,67	21,67	30
Maple syrup	23,33	16,67	11,33
Sodium benzoate	0,33	0,33	0,33
Total	100	100	100

The beverage production process began with the selection of the raw materials, which were in optimum condition, i.e., free of evident signs of deterioration and disease, as well as residues or pests. Next, they were washed with abundant potable water in order to discard the physical, chemical and microbiological residues adhered to the surface. This was followed by a disinfection stage using a 5000 ppm solution of sodium hypochlorite, and rinsed with abundant potable water. The pistachios were then soaked at room temperature for 12 hours, achieving a hydration of over 90%. After the soaking time, the hydrated pistachios were removed and washed with abundant water. All the ingredients (except the preservative) were placed in an industrial blender, this operation was carried out until the product had a uniform and homogeneous appearance, at the end of which the preservative (sodium benzoate) was added. A sieving stage was carried out using sieves with particle sizes of 1500 μm and 900 μm , with the intention of

separating particles of a larger size. A pasteurization stage was carried out with the following conditions: 85°C for 16 seconds, followed by a sudden drop in temperature or thermal shock until reaching a temperature of 35°C. Immediately, the beverage was packaged in 300 mL transparent glass bottles, which were previously sanitized and sterilized by steam for 90 seconds, and finally hermetically sealed using stainless steel crown caps. The bottles were kept refrigerated (4°C) until further use.

For the analysis of calcium, fiber and protein content, the official methods of the *Association of Official Agricultural Chemists* (AOAC) were used, as described below: Calcium content according to AOAC 965.09, crude protein by the AOAC 984.13 method, fiber using the AOAC 978.1 gravimetric method.

Microbiological analysis

For microbiological analyses, the methods described in INEN standards were considered as follows: Coliform count according to NTE INEN 1529-6, Fecal coliform count according to NTE INEN 1529-8, Determination of mesophilic aerobes according to NTE INEN 1529-15, Mold and yeast count according to NTE INEN 1529-10.

The data obtained were tabulated using Infostat v.2020 statistical software, using one-way analysis of variance (ANOVA), followed by Tukey's test at 5% significance.

Result

Table 2 shows the results of calcium content, the B3 formulation containing the highest amount of pistachio had the highest values, reaching an average of 638.43 mg/kg, followed by the B2 treatment with an average value of 538.87 mg/kg and the beverage with the lowest content was B1 with an average of 430.48 mg/kg of calcium. The calcium content in a vegetable beverage is a crucial aspect due to the potential health benefits associated with this essential mineral. Calcium plays a vital role in maintaining bone health, supporting muscle function and participating in various enzymatic reactions in the body (Silva and Neira, 2020). Several studies have investigated the calcium content of plant-based beverages and their potential as alternative sources of this mineral. In this regard, Marina and NurulAzizah (2014) found that coconut milk contains a moderate amount of calcium, which

contributes to the total calcium content of a plant-based beverage but also has a high sensory acceptability, making it an attractive alternative. In addition, *Pistacia vera* (pistachios) has been recognized as a remarkable source of calcium and other minerals in several studies (Bai et al., 2019; Fabani et al., 2013).

Table 2. Results of the calcium content of the three beverage formulations.

Formulation	Mean (mg/kg)
B1	430.48±28.34a
B2	538.87±24.14b
B3	638.43±15.10c

Means of three replicates ± standard deviation. Different letters in the same column denote significant statistical difference according to Tukey (p<0.05).

Table 3 shows the results of the fiber and protein content of the beverage with the highest calcium content, corresponding to 2.75 % and 3.95 %, respectively. The total fiber and protein content of a vegetable beverage based on coconut milk, pistachios (*Pistacia vera*) and maple syrup are important factors contributing to its nutritional value. Fiber is an essential component of a healthy diet, promotes digestive health and provides a feeling of satiety. The incorporation of plant-based ingredients in the vegetable drink can enhance its fiber content. Previous studies have indicated that coconut milk contains dietary fiber, which contributes to the overall fiber content of the beverage (Patil and Benjakul, 2018). In addition, *Pistacia vera* (pistachios) is known for its relatively high fiber content, which can further improve the fiber profile of the beverage (Kola et al., 2018).

In terms of protein, coconut milk provides a modest amount of this macronutrient, which contributes to the total protein content of the plant-based beverage (Patil and Benjakul, 2018). While *Pistacia vera* being a major source of plant-based protein (Bailey and Stein, 2020) is the main contributor of this macronutrient. The combination of these ingredients, along with the added maple syrup, can provide a diverse amino acid profile. Protein is essential for several biological processes, including muscle growth and repair. The incorporation of protein-rich plant-based ingredients in the vegetable drink can provide a valuable source of protein for people following a vegetarian or plant-based diet.

Table 3. Fiber and protein content results for the beverage with the highest calcium content.

Parameter	Result	RDI (%)
Fiber (%)	2.75±0.34	11
Protein (%)	3.95±0.14	13

Means of three replicates ± standard deviation. RDI for adults based on a 2000 Kcal diet.

Microbiological analysis results

Table 4 shows the microbiological requirements of the beverage with the highest calcium content, taking NTE INEN 2337 as a reference. It can be seen that all the parameters evaluated comply with the requirements of the standard in question.

Complying with the microbiological requirements of food standards is of utmost importance to ensure the safety and quality of food products. Microorganisms, including bacteria, yeasts and molds, can contaminate food and pose a risk to human health if consumed (Zwietering et al., 2015). Foodborne illnesses caused by microbial pathogens can have serious health consequences, such as gastrointestinal infections, poisoning, and even death (Fung, Wang, & Menon, 2018). Consequently, complying with microbiological standards helps prevent the proliferation of harmful microorganisms and minimizes the risk of foodborne illness.

Table 4. Results of microbiological requirements for the beverage with the highest calcium content

Parameter	Unit	Result	Requirement
Coliforms	NMP/mL	<3	<3
Fecal coliforms	NMP/mL	<3	<3
Mesophilic aerobes	CFU/mL	<10	<10
Molds and yeasts	UP/mL	<10	<10

*Requirements come from NTE INEN 2337 for juices, pulps, concentrates, nectars, fruit and vegetable drinks.

Conclusions

Overall, this study successfully developed a vegetable beverage formulation (T3) with favorable calcium content, satisfactory protein and fiber levels, and met microbiological standards. The findings support the potential of using coconut milk, pistachio and maple syrup as ingredients to produce a nutritious and safe beverage option. Further research could focus on sensory analysis and shelf-life evaluations to improve the understanding and commercial viability of this plant-based beverage product.

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