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BROMATOLOGICAL AND SENSORY ANALYSES OF A SNACK BASED CORN FLOUR AND CASSAVA ROOT FORTIFIED WITH MORINGA TO COMBAT THE MALNUTRITION

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Abstract

This research details an effort to develop a nutritious snack that can alleviate, and combat problems associated with undernourishment product was developed using corn, cassava, and moringa (or teberinto). Two samples of the product were made, with 1 and 2% moringa, along with corn (60%) and cassava (39%) and were tested through a sensory analysis with 15 panelists. The better product was determined by applying the ANOVA to the results of the sensory analysis. The selected sample was the one containing 1% moringa. The product was subjected to microbiological tests for quality and bromatological tests and to ascertain its chemical composition. Results from both tests met the requirement of established standards. Three physicochemical determination (protein, moisture and ash) also provided favorable results. Thus combining these foods into a snack may contribute to mitigation of undernourishment.

Introduction

Malnutrition is defined as "an abnormal physiological condition caused by insufficient, unbalanced or excessive consumption of the macronutrients that provide food energy (carbohydrates, proteins and fats) and micronutrients (vitamins and minerals) essential for growth, as well as physical and cognitive development" (FAO 2007). In addition, undernourishment is defined as "the food intake that is insufficient to meet the needs of food energy" (Satil *et al*. 2013).

In El Salvador, the problem of undernourishment has led to the controversy regarding whether malnutrition in areas where high rates are found is really being addressed. This has prompted the question of whether it is possible to prepare a nutritious snack. Corn flour base (*Zea mays*) and cassava root (*Manihot esculenta*) fortified with teberinto (*Moringa oleifera*) are considered as a potential means to combat undernourishment in El Salvador. Table 1 presents allowed limit of food additives in the snack. *Moringa oleifera* or teberinto is known as a tree that can grow rapidly in dry conditions, including sandy point in Indian areas, Indonesia, Sri Lanka and in recent years African countries and countries which have joined Central Americans (Carrillo and Saavedra 2013; Caceres and Diaz 2005). In El Salvador, teberinto is not known for being a cutting-edge cultivation plant, as is the case for bean, corn or sorghum, since its main use is the perimeter barrier. It consumes none of its parts. In addition, there are no plantations or technical guides for crop cultivation, which hinders its use (Bruhns 2011).

Currently, in El Salvador, the first steps in the eradication of malnutrition are being taken. However, the cases of undernourishment, according to the FAO (Food and Agriculture Organization of the United Nations) have increased from 12% in 2009 to 13% in 2014 (FAO 2007, Chandrakar and Keshavkant 2018, Villatoro 2015). These figures indicate that strategies aimed at eradicating malnutrition in El Salvador have not yielded desired results. To make the

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Table 1. Allowed limit of food additives in the preparation of snacks.

Additive	Admitted limit (mg/kg)
Acesulfame potassium	350
Adipates (adipic acid, potassium adipate, adipato de sodio, adipato de ammonio)	13000
Propylene glycol alginate	3000
Quinolein yellow	200
Sunset yellow FCF	200
Aspartame	500
Bright blue FCF	200
Benzoates (benzoic acid, potassium benzoate, sodium benzoate, calcium benzoate)	1000
Betacyclodextrin	500
Antioxidant BHA	200
Antioxidant BHT	200
Carmines	200
Carotenoids	400
Carotenes vegetables	400
Carnauba wax	200
Caramel color class II	10,000
Curcumin	200
Sodium diacetate	500
Estearoil-2-lactilatos	5,000
Ascorbyl esters	200
Diacetyltartaric esters and fatty acids of glycerol	20,000
Extracts of bija, bixina, norbixina and annato	GMP
Propyl gallate	200
Glycosides of esteviol	170
Hydroxybenzoates	1,000
Indigotine	300
Brown HT	200
Brilliant black PN	200
Neotamo	32
Iron oxides	500
Ponceau 4R	200
Propylene glycol	300
Riboflavin	1,000
Red allura AC	200
Saccharin	100
Aluminum and sodium silicate	30,000
Calcium and aluminum silicate (Kaolin) (Synthetic)	30,000
Magnesium silicate (Synthetic)	30,000
Sorbates	1,000
Sucralose	1,000
Aluminum ammonium sulfate	500
Sulfites	50
Tartrazine	300
Tartrates	2,000

Source: Mineco *et al*. 2009.

snack, dehydrate the teberinto leaves by exposing them to sunlight and the product was developed in a conventional electric stove. The investigation was carried out because no healthy snack that has high protein content is currently available in the market (Cook 1989, Söğüt and Öztürk 2018). However, there is abundance of fried foods that have high carbohydrate and saturated fat content, which is detrimental to health. For these reasons, in the present investigation an attempt was taken to develop a healthy snack that contains teberinto (*Moringa oleifera*) that, when combined with the carbohydrates from corn flour (*Zea mays*) and cassava root (*Manihot esculenta*), can be viewed as a food with a high nutritional value. It can thus help to combat undernourishment, since teberinto can provide a high protein content, while also helping in the treatment of various diseases, such as asthma, goiter, diabetes, and anemia, among others. The main objective of the study was to prepare a nutritious snack based on corn flour (*Zea mays*) and cassava (*Manihot esculenta*), fortified with teberinto (*Moringa oleífera*).

Materials and Methods

The research was experimental in nature, since it aims at obtaining a functional food through ingredients of high nutritional value that can combat the undernourishment, therefore, two formulations were chosen. The study population were staff and students of the Dr. José Matías Delgado University, Agricultural Research Faculty "Julia Hill de O 'Sullivan". The population were of both sexes, i.e., male and female. Almost 15 steps were involved in the production process starting from reception of raw material to packaging. For the determination of the samples, bromatological and sensory analyses were also carried out in the laboratory mobile sensorial analysis located within the Faculty of Agriculture and Research Julia Hill of O'Sullivan, taking into account the opinion of 50 judges whose data were tabulated and then an analysis of variance (ANOVA) was performed to determine significant differences between the two samples. Finally, the sample was carried out a winner at the Industrial Quality Control Center (CCCI) located in the city of San Savior. To investigate the results, ANOVA, Friedman test, correction factor, and econometric functions were used. Some detail of these models/tests are given below.

Correction factor: CF = T2/N

Sum of squares for sample = SSF (Sum of squares formula)

$$SSF = \frac{(\Sigma\ MA)\ 2 + (\Sigma\ MB)\ 2 + (\Sigma\ MC)\ 2 - FC}{n}$$

Mean square samples MSs

MSs samples = SCm/g

Variation ratio for samples

Fm = MS sample/MS error

Hypothesis test process

H_0: Sample A is superior to Sample B in all terms.

H_1: Sample B is superior to Sample B in all terms.

Results and Discussion

This investigation began with a compilation of material related to corn (*Zea mays*), Cassava root (*Manihot esculenta*) and Teberinto (*Moringa oleífera*). The study focused on their various stages of cultivation, their uses, their classification of taxonomic and nutritional properties, as well as an evaluation of the frying process involved in the creation of the snack. Finally, the results

obtained from the statistical methods revealed a winning formula, which was sent to a quality laboratory for microbiological (*E. coli*, *Salmonella* and *Staphylococcus aureus*) and bromatological analysis (proteins, moisture and ash). Further results are as follows.

Snack production process: A total of 14 steps was involved in the production process such as: 1. Reception of raw material, 2. Selection, 3. Peeling, 4. Washing, 5. Chopped, 6. Cooking, 7. Cassava grinding, 8. Preparation of corn dough, 9. Mixture of ingredients, 10. Kneading and spread of the dough, 11. Baking, 12. Fry, 13. Drained and 14. Packaging.

Comparative results of the samples: Two samples were tested containing 1 and 2% moringa based snacks (Table 2). The results revealed a variation in age range among young people, the highest being 54% between the ages of 21 - 23. In second place are ages 18 - 20 with 20%, and finally there is a tie between the age ranges of 24 - 26 and 27 - 29 with 13%. Sample A was superior to sample B, as sample B only obtained an average of 7.87, and was rated 6.53. This means that sample B scored between "do not like it" or "disliked it" and "liked it little." Sample A scored between "slightly liked" and "moderately liked." sample A was the winner, because its average score of 8.20 is greater than that of Sample B's average of 7.27. This places the winner among "moderately liked" and "liked a lot," while Sample B scored between "liked it little" and "moderately liked." Regarding the appearance, the winning sample was again sample A. It obtained an approval average of 8.13, categorizing it as "moderately liked", while sample B obtained an average of 7.60, placing it within the "slightly liked" category (Fig. 1).

Table 2. Formulation of samples with 1 and 2% of moringa.

Formulation of sample A: 1% moringa			Formulation of sample B: 2% moringa		
Ingredients	Percentage	Amount (g)	Ingredients	Percentage	Amount (g)
Cassava	35	317.51	Cassava	35	317.51
Corn	64	580.56	Corn	63	571.53
Canola oil	-	-	Canola oil	-	-
Fortification of Teberinto	1	9.07	Fortification of Teberinto	2	18.14
Total	100	907.18	Total	100	907.18

In terms of texture, sample A was the winner with an average of 8.07, or "moderately liked." sample B received an average of 7.60, which is rated between "liked slightly" and "moderately liked." Fig. 2 presents a comparative analysis of both samples. As for taste, sample A was the winner, obtaining an average of 8.87. This score is categorized as "liked it a lot," which is the highest standard on the hedonic scale. Sample B received an average of 7.67, which is between "slightly liked" and "moderately liked." When the table was analyzed, it was observed that the calculated F values were greater than F, indicating a significant difference in judges, as well as in the samples. This is a significant difference of 5%. Thus, there was a significant difference between the samples presented.

Industrial uses and benefits of moringa mixed products: The consumption of moringa as a food can help in many different ways, as it has adapted to tropical regions, and is capable of developing in arid climates and drought. So, it can be consumed through the following means: (i) Powdered leaves which prevent asthma and diabetes, (ii) controls and prevents goiter, (iii) its biomass is a fertilizer that accelerates the growth of other plants; (iv) teberinto seeds purify contaminated water, (v) it is used as livestock fodder, (vi) it absorbs agrochemicals from

agricultural crops, (vii) it cures anemia, (viii) the leaves serve as an antioxidant and (ix) it increases the production of breast milk.

Moringa oleífera is mainly grown in orchards in Asia, Africa and Central America. It is quite an efficient crop, as it adapts easily. Although this plant prefers well-drained and watered soils, it can tolerate clay soils. Due to its purifying power, teberinto trees even accept wastewater. It is grown most effectively in soils that have a neutral or slightly acidic pH. Its temperature ranges between 20 - 40°C and can grow up to 3000 ms nm^2 in height. The conditions necessary for the

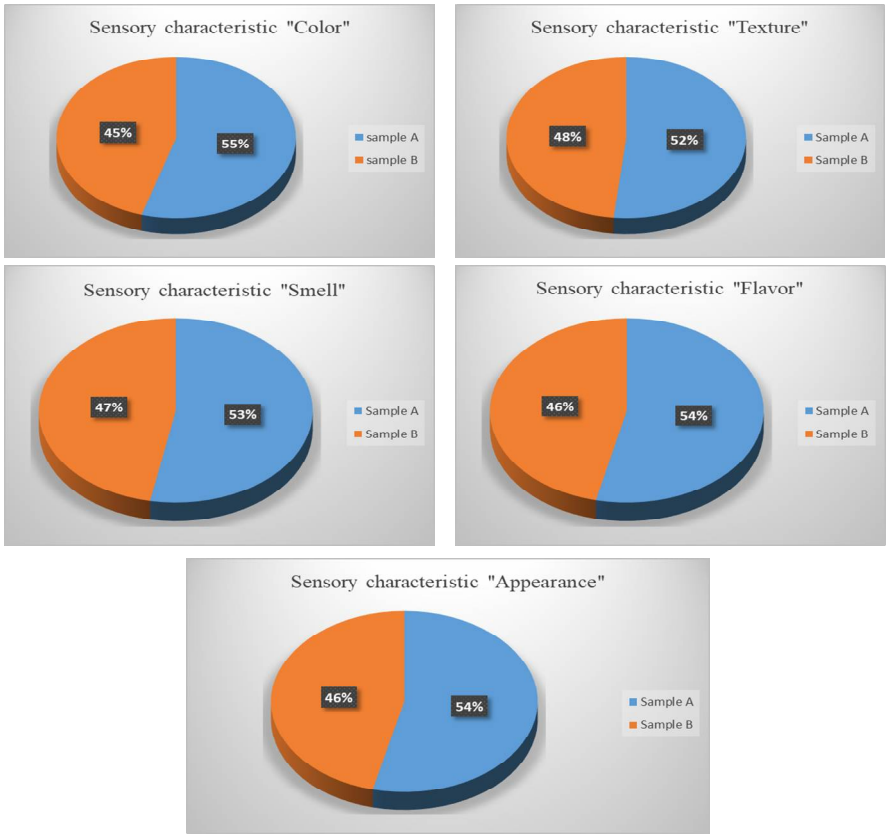

Fig. 1. Multiple results of sensory analyses.

development of the teberinto tree are fulfilled in almost 90% of the national territory which facilitates its planting and reproduction. Further, that already 95% of the surface waters are contaminated in El Salvador the tree of teberinto did not have much difficulty to achieve maximum gestation. The teberinto (*Moringa oleífera*) is known to have a rapid growth that can reach up to 12 m high. It is characterized by having an open cup and fragile branches a leafy foliage and a thick bark. Its means of propagation is usually by seed or by sexual way; it is also characterized as being an evergreen tree. It should be noted that India is one of its main consumers since it is used in the area of naturopathic medicine for its pharmaceutical properties.

It is concluded that the production of a nutritious snack based on corn flour and cassava flour is feasible since the combination of these ingredients possess some pleasant sensory qualities in addition to being similar to products currently existing in the market. To formulate the snack, the ideal proportions for the elaboration of this one are 60% corn flour, 39% cassava flour, and 1% dehydrated theberinth. Owing to these proportions, the product presents adequate physicochemical characteristics in relation to moisture and ash present in the product. As a consequence, the most accepted sample was the 1% fortified sample with teberinto dehydrated since it received a better qualification on the part of the judges. Performing three microbiological examinations (*E. coli*, *Salmonella*, *Staphylococcus aureus*) gave favorable results according to the RTCA Standard 67.04.50 : 08, where the levels found in the product of these three microorganisms were within the

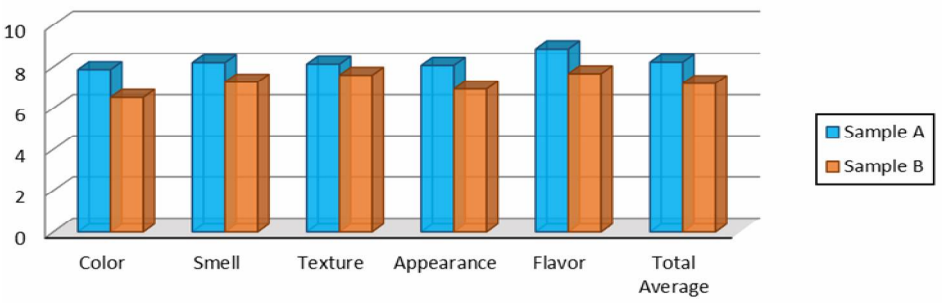

Fig. 2. Comparative analysis of samples A and B.

allowed parameters. Three physicochemical experiments (protein, moisture and ash) provided favorable results as per with to the requirements, since it fulfills the purpose, i.e., mitigating undernourishment through a functional food (nutritious snack). The largest moringa producing countries are found in the Asian and African continents. Grown in Africa where it takes its greatest advantage to be a tree resistant to climatic changes and easily adaptable to different environments, moringa represents a source of natural protein of high nutritional value that serves as a development factor. Advantage can be taken of its leaves, seeds, stems, oil, roots and bark. The benefits provided by frying this food is focused on the infants and young people of El Salvador, since they are the main consumers of this class of products; hence, it would be highly important for parents to have a healthier option which can serve as a snack to both children and adults.

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