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EVALUATION OF THE NUTRITIONAL CHARACTERISTICS OF A FERMENTED MILK DRINK WITH WHEY AND SWEET POTATO FLOUR *ipomoea batatas*

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Abstract: Sweet potatoes are a food that provides countless nutrients suitable for meeting basic vitamin and other compound requirements, whose contribution has allowed for the development and enrichment of food products. However, there are no products on the market aimed at the meat or dairy industry and their contribution to nutrient intake requirements is unknown. The objective of this study was to evaluate the nutritional characteristics of a fermented milk drink made from whey and sweet potato flour (*Ipomoea batatas)*. **Method.** The evaluation was carried out taking into account the following: 1. Sensory evaluation of three trials, which were: 1 (treatment A), a mixture of milk and whey (80:20), with the addition of 3% sweet potato flour. 2. (treatment B), milk and whey (40:60), with the addition of 5% HB. 3 (treatment C) milk and whey (30:70), with the addition of 7% HB. Efficacy tests were carried out and the treatment whose results allowed the identification of nutritional components from the essential amino acids present was identified by high-performance liquid chromatography (HPLC). Likewise, the centesimal composition of the product was expressed in terms of protein, fat, calcium, iron, phosphorus, and carbohydrate content. **Results.** The standardized product shows the presence of essential and non-essential amino acids, showing better results than the target in essential amino acids such as methionine (720.22 mg/100g), phenylalanine (795.15 mg/100g), leucine (3265.75 mg/100g); and non-essential amino acids such as aspartic acid (2711.11 mg/100g). **Conclusion.** A fermented milk drink was obtained, whose sensory acceptance of the factors under study presented the best combination in T1 (80% milk, 20% whey, and 3% sweet potato flour). The concentration of amino acids present is reflected, whose distribution shows an increase in essential and non-essential amino acids, as well as a contribution of macronutrients such as calcium and phosphorus.

Keywords: *milk drinks, sweet potato, amino acids.*

INTRODUCTION

Sweet potatoes are a food that provides countless nutrients due to their protein (1.6 g), carbohydrate (20.12 g), fiber (3 g), and vitamin content, including: A (14,187 IU), C (2.4 mg), pantothenic acid (0.80 mg), niacin (0.557 mg), pyridoxine (0.209 mg), thiamine (0.078 mg), riboflavin (0.061 mg), among others, according to its centesimal composition. It is considered a product of great importance in Asian countries, where it has contributed to food security through the implementation of its production chain. In this regard, (Rodriguez, 2009) states that, given the high nutritional content of sweet potatoes (*Ipomoea batatas)*, they contain starch (60-70%), vitamin E, folic acid, calcium, potassium, iron, and zinc, affirming that it is a product that can be consumed fresh or in the form of flour.

It should be noted that one of the greatest difficulties faced by Colombian households is attributed to vitamin A deficiency, which triggers eye problems such as xerophthalmia, blindness, susceptibility to severe infections, physical and mental retardation, and can also cause maternal mortality. According to statistics, the regions with the highest rates of vitamin A deficiency are: the Amazon and Orinoquia (31.1%), the Caribbean Coast (28.4%), and Bogotá D.C. (28.1%). The population most at risk of suffering from this deficiency is children under 5, pregnant women, indigenous people, and Afro-descendants (Pérez, 2019).

In relation to the above, it should be noted that a large number of foods have been produced from sweet potatoes in their different varieties, specifically in the beverage, cereal, bakery, and pastry industries. However, there are no known products on the market made in other sectors, such as meat or dairy, and their contribution to human nutrient intake needs is unknown. In response to this, Gavilanes *et al. (*2018), in their research entitled "Evaluation of a novel fermented milk drink based on whey and sweet potato flour," evaluated the physicochemical parameters of the product, such as pH, °Brix, acidity, total solids, ash, viscosity, and protein. However, the nutritional quality of the product is not analyzed by quantifying essential and non-essential amino acids, taking into account that sweet whey is a good source of tryptophan (12.9 g/100 g), which is essential for growth and hormone production, and also contains phenylalanine (9.44 g/100 g), which is involved in the production of collagen, which is essential for the structure of the skin and connective tissue, and also plays a role in the formation of neurohormones. It also contains methionine (8.05 g/100 g), which is important for protein synthesis, and isoleucine (7.48 g/100 g), which plays a role in the formation and repair of muscle tissue, among other substances that are important for human life. (Corzo, 2008).

On the other hand, the vitamins present are not analyzed, considering that each cell in the body has the function of transforming amino acids, minerals, and trace elements into proteins, hormones, and enzymes. Some vitamins are part of these enzymes, making them essential for bodily function. In this regard, it should be noted that whey contains B vitamins (thiamine, pantothenic acid, riboflavin, pyridoxine, nicotinic acid, cobalamin, and ascorbic acid). (Chazi, 2006).

In this vein, research has demonstrated the nutritional value (amino acids and vitamins) of sweet potatoes (*Ipomoea batatas*) in the standardization of a fermented whey-based drink in the municipality of Valledupar.

METHOD

The research is a descriptive, quantitative, experimental study aimed at identifying and detailing the nutritional characteristics of a fermented milk drink enriched with sweet potato flour (*Ipomoea batatas*). A completely randomized DCA experimental design was developed by comparing three treatments of fermented milk drink, consisting of three concentrations of whey (20, 60, 70%) and three concentrations of sweet potato flour *(Ipomoea batatas) (3, 5, and 7%),* taking as reference the results obtained from the application of affective tests in which product characteristics such as odor, taste, texture, and appearance were determined.

For the purposes of this study, the population was the municipality of Valledupar (465,000 inhabitants) in the urban area. The sample size was determined with a margin of error of 10% and a confidence level of 80%, with a homogeneity of the universe of 50%; this allowed for a sample represented by 41 untrained tasters, who were selected according to the inclusion and exclusion criteria. The primary information corresponds to the qualitative and quantitative data collected in the field and/or experimental phase. The primary source corresponds to the information obtained from the data collection instruments, using the following techniques as a reference: registration matrices, checklists, and mixed questionnaires.

The research was carried out in the following phases:

Phase I: Standardization of a fermented milk drink using three concentrations of whey and three concentrations of sweet potato flour (*Ipomoea batatas*).

Sweet potato flour (*Ipomoea batatas*) was obtained. This was developed through consecutive stages, as shown in Figure 1.

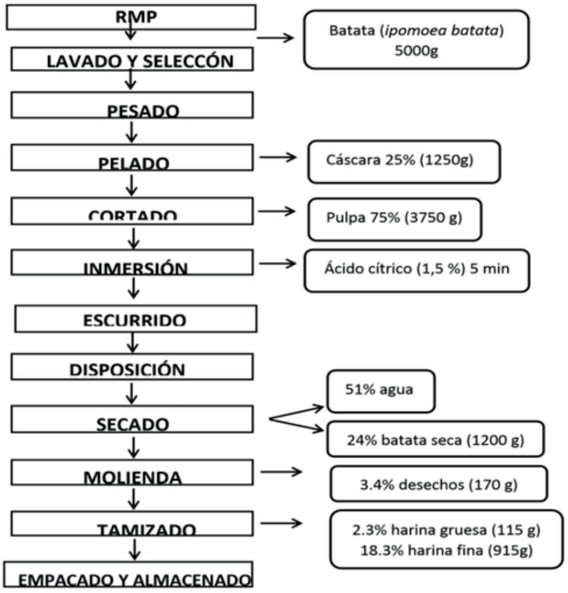

Figure1 . Obtaining sweet potato flour (Ipomoea batatas)

Source: the authors, (2021).

Phase II. Sensory evaluation of the standardized product through the application of affective tests.

For the sensory tests, inclusion and exclusion criteria were taken into account, which allowed for the selection of personnel with an average age between 23 and 35 years old. Prior to this, the samples were labeled and the trays were prepared, consisting of three 50 ml cups with a standard content of 30 ml. Each cup represented a sample and was labeled with three consecutive digits representing the tests: Test 1: Treatment A; Test 2: Treatment B; Test 3: Treatment C. Finally, a cup containing approximately 100 ml of water was used for mouth rinsing.

The second stage refers to the application of the "Acceptance Test." It was developed using the hedonic scale.

Hedonic Scale	
I like it extremely	9
I like it a lot	8
I like it moderately	7
I like it slightly	6
Neither like nor dislike	5
I dislike it slightly	4
I dislike it moderately	3
I dislike it very much	2
I dislike it extremely	1

1 . Hedonic scale of the product.

Source: Hernández E, (2005).

Phase IV: Determine the concentration of essential amino acids reflected in the standardized product.

Based on sensory analysis and evaluation of the experimental design, the sample was selected and the ideal characteristics of the product were defined. Amino acid analyses were then carried out.

Method used: Determination of total amino acids released after acid hydrolysis with 6 N-0.1% phenol HCl. The measurement was performed by liquid chromatography, after prior derivation to the column with o-phthalaldehyde (OPA) for primary AA and 9fluoroenylmethylchlorofromate FMOC for secondary AA; which was carried out in the specialized laboratory of the University of Antioquia, endorsed by the Nutrition and Food Technologies group of the aforementioned university. The tests were applied to the target corresponding to the natural yogurt sample. They were also applied to the sample of the fermented milk drink with the addition of sweet potato flour (*Ipomoea batata)* in order to analyze the variance between the respective samples.

DISCUSSION OF RESULTS

➢ **Obtaining sweet potato flour (*Ipomoea batata*).**

2 . Process for obtaining sweet potato flour.

Source: The authors, (2021).

The formulation was developed in accordance with the experimental design, in which the values of the milk and whey mixture and the amount of sweet potato flour (*Ipomoea batata*) varied in order to obtain the fermented milk drink with three (3) concentrations of sweet potato flour, respectively. In this regard, the formulations were developed as shown in the table.

Raw materials	**Quantities**		
	E1 (TA- 80:20)	**E2 (TB-40:60)**	**E3 (TC-70:30)**
Milk	**4 L**	**2 L**	**1.5 L**
Whey	**1 L**	**3L**	**3.5L**
Sugar	**0.563 kg**	**0.562 kg**	**0.561 kg**
Sweet potato flour	**0.15 kg**	**0.25 kg**	**0.35**

Table2 . Formulation of fermented milk drink from sweet potato flour

Source: The authors, (2021).

From the analysis of variance applied to treatments A, B, and C, the means for their respective evaluation were obtained using Tukey's honest significant difference test. Based on the hypotheses proposed ($H_0 = \mu_1 = \mu_j$ vs $H_1 = \mu_i \neq \mu_j$). The results showed that there were no significant differences between treatments A and B in terms of appearance, color, odor, taste, and texture; however, there was a significant difference between treatments A and C in at least one aspect, namely odor. There were no significant differences between treatments A and C in terms of appearance, color, taste, and texture. Finally, treatments B and C did not show significant differences between the aspects analyzed. In this regard, the treatment that showed the best results was treatment A (80:20, milk and whey, with the addition of 3% sweet potato flour), whose average exceeded six points on the hedonic scale, which is described as "slightly like."

➢ **Determination of the concentration of essential amino acids reflected in the standardized product using high-performance liquid chromatography (HPLC).**

Sample description	**Protein concentration (% w/w)**	**Standard deviation**	**Coefficient of variation (%)**
Plain yogurt	2.31	0.042	1.86
Sweet potato yogurt	2.25	0.040	1.74

Amino acid	**Retention time**	**Amount in mg/100g protein**	
		Plain yogurt	**Sweet potato yogurt**
Glycine	4.302	8,915.48	7,245.93
Aspartic acid	1.043	1,430.23	2711.11
Glutamic acid	2.120	20,606.06	31422.22
Asparagine	3,158	257.12	NI
Arginine	4,728	4675.32	4800
Histidine	4,148	NI	431.12
Alanine	4,843	6656.23	6844.44
Isoleucine	7.872	1345.2	763.76
Citrulline	4.983	NI	NI
Threonine	5,795	3,578.56	2,663.28
Cysteine	6,147	812.1	912.2
Methionine	6,693	552.01	720.22
Tyrosine	5,912	7084.88	6542.96
Serine	3,498	6,934.12	7,376.98
Valine	6,565	10,793.76	10,627.35
Phenylalanine	7,672	730.62	795.15
Leucine	8.093	2,548.06	3265.75
Lysine	8.762	3,858.88	3535.43

3 . Amino acids present in the standardized fermented beverage

Source: the authors, (2020).

When analyzing the results of the amino acids concentrated in the white, they show a higher presence of essential amino acids compared to the fermented milk drink, which tends to have a concentration of essential amino acids that are considered important for immune activities and for the proper functioning of the body's systems.

Among the essential amino acids identified from the samples analyzed in the fermented milk drink (80:20 milk and whey, with the addition of 3% sweet potato flour), the following stand out: isoleucine, leucine, lysine, methionine, phenylalanine, threonine, and valine, respectively. However, the fermented milk drink shows better results in some essential amino acids compared to the control (natural fermented mixture, called natural yogurt), among which methionine (720.22 mg/100g) stands out, whose function is protein synthesis, which determines the percentage of food to be used at the cellular level. In addition, phenylalanine (795.15 mg/100g) stands out, which has two functions: one is the production of collagen, mainly in the structure of the skin and connective tissue, and the other is the formation of various neurohormones. Another essential amino acid that shows a difference compared to the white variety is leucine (3265.75 mg/100g), which is characterized by its involvement in the formation and repair of muscle tissue in association with L-leucine and growth hormone (HGH).

As for non-essential amino acids, the standardized product shows the presence of: glycine, aspartic acid, glutamic acid, asparagine, arginine, histidine, alanine, cysteine, and serine. It shows better results than the standard for non-essential amino acids such as: aspartic acid (2711.11 mg/100g), which has two functions: it helps detoxify the liver and keep it working properly, and it forms molecules that can absorb toxins from the bloodstream in combination with other amino acids. Glutamic acid (3144.22 mg/100g), whose function is to intervene in the functioning of the central nervous system and act as a stimulant of the immune system. Arginine (4800 mg/100g) has four functions: one is to maintain the balance of nitrogen and carbon dioxide; the second is its participation in the production of growth hormones; the third is that it is directly related to tissue and muscle growth; and finally, it is related to the maintenance and repair of the immune system.

Other notable non-essential amino acids include histidine (431.12 mg/100g), which, in combination with growth hormone (CGH), contributes to tissue growth and repair, with a role specifically related to the cardiovascular system. Alanine (6844.44 mg/100g) is involved in glucose metabolism (a source of energy). Cysteine (912.2 mg/100g), in association with other amino acids, performs detoxification functions; it also helps maintain healthy hair due to its high sulfur content. Finally, serine (7376.98 mg/100g), which is involved in muscle growth and fat and acid metabolism, in association with other amino acids.

➢ Centesimal composition analysis

Composition of yogurt with sweet potato flour	
Protein	2.25 (mg/100g)
Acidity	68 °Th
pH	4.5
Total solids	14.2%
Fat	4.1%
Phosphorus	82.51 (mg/100g)
Calcium	90.0917 (mg/100g)
Carbohydrates	6.72 (g/100 g)
Iron	30.1275 (mg/kg)

Table4 . Centesimal composition of the product

Source: the authors, (2020).

Based on the referenced results for protein in the samples corresponding to the standardized mixture; 2.25% w/w; in this regard, Gavilanes *et al*. (2018) provide evidence for whey/milk trials (50:50, 60:40, 70:30) with the addition of sweet potato flour (4% and 6%), although the conditions are not the same, is taken as a reference for the respective analysis, whose results were 2.8% for the mixture consisting of (50:50 whey/milk and 6% sweet potato flour), However, for tests with a lower percentage of sweet potato flour (50:50 whey/milk and 4% sweet potato flour), values of 2.3% were reported. Finally, the author concludes that the protein content of lactose-fermented milk beverages is reduced as the amount of whey in the beverages increases, which is consistent with the results obtained in this study, whose values show the difference between the protein concentration of the final product.

On the other hand, NTC 805 establishes that for fermented milk-based beverages, the protein content must be at least 60% of the fermented milk from which it is obtained; therefore, the protein of the target (established as the natural fermented beverage, called natural yogurt) is taken as a reference, whose protein value is 2.31% w/w; where 60% corresponds to 1.368% w/w; based on the above, we could assume that the surplus could be the contribution of the proteins from the basic raw materials of the standardization, attributing the highest percentage to sweet potato flour.

The total solids of the standardized product show a result of 14.2%. From this, we could mention that the final total solids are derived from the solids that make up the sweet potato flour (Ipomoea *batatas*) and sugar, which improve the texture of the product, with reference to a similar product categorized as a milk drink. In this regard, Gavilanes *et al.* (2018) obtained results of 20.1% and 19.42%, respectively, for tests with 50:50 whey/milk and 6% sweet potato flour; However, for tests with a lower percentage of sweet potato flour (50:50 whey/milk and 4% sweet potato flour), this difference was attributed to standardization based on the use of whey.

The fat content of the fermented drink was 4.1%. In this regard, Gavilanes *et* al. (2018) report lower values in different trials, showing the best result for the mixture consisting of 50:50 whey/milk and 4% sweet potato flour, with a fat content of 2.30%.

On the other hand, the carbohydrate content of the product corresponds to 6.72 g/100 g, which could indicate an increase of around 20% in the product, considering that it is made up of a high percentage of whole milk, whose composition is lactose, glucose, and galactose, with other sugars in minimal concentrations, reaching an average of 5.3% (Amiot, 1991). However, this increase could be attributed to the contribution of sweet potato (22.1 g/100 g) despite the processing it undergoes to obtain the flour, bearing in mind that "tubers are good sources of carbohydrates" (Achundia & Pérez, 2018).

According to Fennema (1993), Amiot (1991) and Badui (1984), one of the most important contributions of milk and dairy products is their high mineral content, particularly calcium, phosphorus, and magnesium. The calcium content in whole milk is 125 mg/100; however, the calcium content in whey is 43 mg/100g (Amiot, 1991); Sweet potatoes contain 25 mg/100 g (ICBF, 2005) of this mineral; in this regard, the standardized product yielded a result of 90 mg/100 g, which shows a contribution of this macronutrient. Finally, the iron content in the product (30.1275 mg/kg) indicates that it probably comes from the iron in sweet potatoes (40 mg/100 g; ICBF, 2005). In this regard, the iron content in milk is relatively low (less than 5.0 mg/kg; Amiot, 1991), therefore, the amount of iron in the whey is limited or minimal. In addition to this fact, we can note that sweet potato flour enriched the final product with iron, which is important as it helps maintain red blood cell levels in the body, preventing health problems such as anemia.

CONCLUSIONS

A fermented milk drink was obtained, consisting of a mixture of milk and whey with the addition of sweet potato flour (*Ipomoea batatas*), whose sensory acceptance of the factors under study presented the best combination in T1 (80% milk, 20% whey, and 3% sweet potato flour). The same treatment was found to be the most acceptable in terms of appearance, odor, flavor, and texture.

The amino acid content concentrated in the target product showed a higher presence of essential amino acids compared to the standardized fermented milk drink, which tends to have a higher concentration of essential amino acids such as methionine, phenylalanine, and leucine, which are considered important for immune activities and the proper functioning of the body's systems. However, the non-essential amino acids present in the standardized product show the presence of glycine, aspartic acid, glutamic acid, asparagine, arginine, histidine, alanine, cysteine, and serine, showing better results than the target.

The standardized product provides macronutrients such as calcium and phosphorus, which are important for bone and tooth formation and also participate in and regulate certain enzymatic reactions. A significant amount of iron was found in the standardized product, which is important as a nutritional contribution, considering that whole milk, and therefore whey, contains relatively low levels of iron.

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