SENSORY AND PHYSICAL-CHEMICAL ANALYSIS OF A FUNCTIONAL BEVERAGE BASED ON ANCESTRAL CULTURES

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Abstract

Ancestral knowledge related to food is being lost at an accelerated rate due to the influence of a series of factors, including the supply of processed foods and their dissemination through the media, low-cost products with little nutritional value such as sugary drinks (soft drinks, tea, isotonic drinks), influencing the short- and long-term suffering of chronic non-communicable diseases (NCDs).

Objective: to elaborate a quality beverage, with ancestral foods (black corn *Zea mays L* and mortiño *Vaccinium floribundum Kunth*) to rescue the food cultural heritage, with a low-calorie functional beverage with purple pigments that are related to antioxidant compounds.

Methodology: experimental research. For the elaboration of the functional beverage treatments, purple corn kernels, mortiño, stevia as a non-caloric sweetener and 0.1% ascorbic acid as a preservative were used; variations were made in the formulations, obtaining 3 treatments, the amounts of stevia, ascorbic acid and water were kept constant for the three treatments. The formulations were subjected to physical, bromatological and microbiological analysis. Sensory evaluation was carried out with a panel of experienced judges using a 5-point hedonic scale, evaluating parameters such as texture, flavor, color, appearance and odor; statistical analysis was performed with a computer package InfoStat free version 2020.

Results: when comparing the attributes of texture, flavor, color, appearance and odor, significant statistical differences were observed only in color with a p-value of 0.003770. The color of T1 was the attribute that obtained the highest score by the panelists, qualifying it as pleasant, and it was also considered the color with the highest brightness; T1 also obtained the highest score for the overall product. The bromatological analysis revealed significant differences between the kilocalorie content, % carbohydrate and % fiber, among the formulations performed. **Conclusions**: The results of this study open the possibility of the use of two ancestral crops, black corn (*Zea mays L*) and mortiño (*Vaccinium floribundum Kunth*.) for the elaboration of a beverage with good organoleptic acceptance and suitable for all population groups.

Keywords: Functional beverage, purple corn, antioxidants, mulberry.

Resumen

Introducción: los saberes ancestrales relacionados con la alimentación se pierden de manera acelerada por la influencia de una serie de factores, entre ellos la oferta de alimentos procesados y su difusión a través de los medios de comunicación, de productos de bajo costo y de poco valor nutricional como las bebidas azucaradas (gaseosas, té, bebidas isotónicas), influyendo en el padecimiento a corto y largo plazo de enfermedades crónicas no transmisibles (ECNT).

Objetivo: elaborar una bebida de calidad, con alimentos ancestrales (el maíz negro *Zea mays L* y el mortiño *Vaccinium floribundum Kunth*) para rescatar el patrimonio cultural alimentario, con una bebida funcional baja en calorías con pigmentos de color morado que se relacionan con compuestos antioxidantes.

Metodología: investigación de tipo experimental. Para la elaboración de los tratamientos de la bebida funcional se utilizaron granos de maíz morado, mortiño, stevia como edulcorante no calórico y 0,1% de ácido ascórbico como conservante, se realizaron variaciones en las formulaciones, obteniendo 3 tratamientos, las cantidades de stevia, ácido ascórbico y agua se conservaron constantes para los tres tratamientos. Las formulaciones fueron sometidas a análisis físico, bromatológico y microbiológico. La evaluación sensorial se realizó con un panel de jueces experimentados con una escala hedónica de 5 puntos, se evaluaron parámetros como textura, sabor, color, apariencia y olor, el análisis estadístico se realizó con un paquete informático InfoStat versión libre 2020.

Resultados: al comparar los atributos de textura, sabor, color, apariencia y olor, se observó diferencias estadísticas significativas únicamente en el color con un p-valor de 0.003770. El color del T1 fue el atributo que mayor puntaje obtuvo por los panelistas, calificando como agradable, así también fue considerado el color con mayor luminosidad, el T1 obtuvo además la mayor puntuación para el producto general. El análisis bromatológico reveló diferencias significativas entre el contenido de kilocalorías, % de carbohidratos y % de fibra, entre las formulaciones realizadas.

Conclusiones: Los resultados de este estudio abren la posibilidad de la utilización de dos cultivos ancestrales, el maíz negro (*Zea mays L*) y el mortiño (*Vaccinium floribundum Kunth*.) para la elaboración de una bebida con buena aceptación organoléptica y adecuada para todos los grupos poblacionales.

Palabras claves: Bebida funcional, maíz morado, antioxidantes, mortiño.

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INTRODUCTION

Nowadays, the world population's diet has changed, so malnutrition problems have increased, generating non-communicable diseases in the short and long term (1).

In a report prepared by the Association of Non-Alcoholic Beverage Industries, Ecuadorians consume about 1560 million liters of sugary drinks, such as soft drinks, water, tea, and isotonic drinks. Also, ENSANUT associates a risk factor with poor eating habits that incorporate daily practice from childhood at each stage of development into adulthood, the consumption of sugary drinks and soft drinks. In Ecuador, 35 out of every 100 children aged 5 to 11 years are overweight and obese and the current trend in adolescents seems to indicate, according to scientific evidence, that the predisposition of the adolescent population to overweight and obesity is associated with a low frequency of healthy meals and high consumption of sugary processed beverages (2).

In Ecuador, overweight and obesity affect more than two-thirds of the adult population and are more prevalent in women than in men, however, a stagnation is observed from the period 2014-2018. Arterial hypertension (AHT) affects 1 in 5 adults aged 18-69 years; 7.8% of the population has hyperglycemia, which increases the risk of developing diabetes mellitus; and 7.1% of the population has altered glucose, with ranges suggestive of diabetes mellitus. More than one-third of adults between 18 and 69 years of age have elevated cholesterol, which increases the risk of cardiovascular disease. 11.6% of the population between 40 and 69 years have a 10-year cardiovascular risk ≥30% (3).

Diabetes, heart problems and obesity are among the chronic non-communicable diseases (NCDs) resulting from the influence of a series of events that have led to a decline in the community's ability to function in a stable and generative manner. Environmental destruction, economic transformation, disruption of food security, disruption of social order, physical relocation, educational colonization and religious conversion are externally defined developmental characteristics leading to community trauma which in turn is linked to nutritional trauma and a dramatic food transition, whereby the food consumed is no longer produced by the people, but acquired (4).

At present, the loss of ancestral knowledge and know-how is a worldwide reality, especially concerning food consumption. Among its causes, there are several factors, among which is globalization, which has generated rapid environmental, socioeconomic and cultural changes and the migratory processes from rural areas to urban areas, which implies a generational leap that causes the loss of communication between parents and children and therefore there is no transmission of the knowledge of ancestral knowledge (5).

From the above, the importance of health care for the population is evident (6). Therefore, the food industry has formulated several food options. The worldwide trend for innovation in food production is to include substances of natural origin extracted from vegetable sources and through food technology are incorporated into products considering their organoleptic characteristics such as color and texture, and according to several authors, ingredients are considered nutraceuticals for the benefits they confer (7).

These alternatives have the common function of favoring the health of the organism, thus, using purple corn (*Zea mays L*) that in the Ecuadorian highlands is used for the preparation of beverages with and without alcohol, is one of the most consumed products, and has gained interest mainly for its content of anthocyanins and other phenolic compounds (8). It has gained interest mainly for its content of anthocyanins and other phenolic compounds (9).

Another ancestral crop is the mortiño (*Vaccinium floribundum Kunth*), which is a wild shrub endemic to Ecuador and Colombia, has a berry of pleasant flavor and aroma, the same were consumed since the Conquest, elevating it to ceremonial fruit (7). It has been determined by bromatological analysis that it contains polyphenolic compounds with pigmenting and antioxidant properties potentially protective of health, in addition to its high content of anthocyanins and phenols (10). So its consumption is presented as an alternative to reduce the incidence of a variety of chronic diseases, as they are antioxidant, anti-inflammatory, anti-mutagenic, anti-carcinogenic, and also possess blood pressure regulating properties (11).

The study consisted of elaborating a quality beverage, with ancestral foods (purple corn and mortiño) to rescue the cultural food heritage, with a low-calorie functional beverage with purple pigments that are related to antioxidant compounds, necessary for people interested in reducing oxidative stress that could be involved as a common factor in a large number of diseases, such as cancer, atherosclerosis and Alzheimer's disease (12).

MATERIALS AND METHODS

The study was developed in the Bromatology laboratory and Gastronomy workshop of the Faculty of Public Health of the Escuela Superior Politécnica de Chimborazo in the city of Riobamba -Ecuador.

The elaboration of the beverage based on ancestral foods was carried out under the experimental modality.

Raw materials

The raw material used was purple corn (*Zea mays L*) variety of Black Corn INIAP-199 "Racimo de Uva" acquired in the local Wholesale Market and that according to INIAP is the main variety with the characteristics of purple color with a tendency to the black of cob and type of round grain that is cultivated and harvested in the province of Chimborazo (13). The endemic mortiño fruit (*Vaccinium floribundum Kunth*) was also acquired from the Wholesale Market in the city of Riobamba, with an appropriate degree of maturity as evidenced by its firmness, color and the absence of physical or biological damage. Organic stevia was used as a sweetener.

Beverage formulations

A randomized design was elaborated based on purple corn extract after gastronomic recommendation, 50% purple corn in an aqueous medium was estimated as the control treatment (T0) from which formulations were derived with various percentages of purple corn extract with different amounts of mulberry juice as indicated in Table 1; stevia was used as a non-caloric sweetener and 0.1% ascorbic acid as a preservative. The amounts of stevia, ascorbic acid, and water were kept constant for the three treatments.

Table 1. Formulation of the functional beverage based on corn and mulberry.

INGREDIENTS	T1		T2		T3	
	g	%	g	%	g	%
Purple corn	50	12.5	70	17.5	35	8.75
Mortiño	35	8.75	15	3.75	50	12.5
Stevia	15	3.75	15	3.75	15	3.75
Water	300	75	300	75	300	75
Total	400	100	400	100	400	100

Beverage production process

For the production of the functional beverage, 1 kg of purple corn was first prepared and left to soak in 1 liter of water for 40 minutes. Subsequently, another liter of water was added at 100°C, then the liquid was extracted and allowed to cool; on the other hand, different amounts of purple corn (Table 1) were previously washed, liquefied with water and filtered. For the formulation, three treatments were carried out in combination with purple corn extract and mortiño juice, adding 0.1% ascorbic acid. Subsequently, the beverages were bottled and pasteurized at 65°C for 30 minutes. Finally, the beverages were refrigerated and then underwent physical, chemical and microbiological analysis.

Physical Analysis

For the physical analyses, it was considered to compare the control treatment To the mulberry extracts MT1, MT2, and MT3 in different percentages with T1, T2 and T3. Triplicate tests of the following analyses were performed:

A portable PH Meter PH100 pH meter was used, with automatic calibration and pH reading almost in an instant when the electrode was inserted in the beverages; accuracy ± 0.1 with built-in temperature value.

Degrees Brix, a Portable Refractometer with ATC Degrees Brix 0-60 %, resolution 0.1% with automatic temperature compensation (ATC) from 10 to 30°C was used, for the reading, a drop of the beverages was required, in addition, the density of the sample could be read.

Water activity, to establish the amount of free water in the beverage, a direct method was applied, using the AQUALAB 4TE water activity measuring equipment with a range of 0.03 to 1 aw; with a resolution of 0.0001 aw, the measurements are taken in a maximum of 5 minutes with a margin of error of ± 0.001, the equipment consists of dew point sensors, vapor pressure balance and internal temperature control with a range of 15 to 50°C.

The color of the samples was analyzed quantitatively on the surface of the samples with POLYLAC PA-765 (ABS) equipment incorporating a wavelength range of 400-700 nm with a wavelength interval of 10 n; the reading environment of the equipment is 0-40°C, 0 85%HR (non-condensing) at altitude <2000m. The readings yielded three-dimensional color space information where Luminosity (L) from black to white, *a** negative values indicate green while positive values indicate magenta; b* negative values indicate blue and positive values indicate yellow.

Bromatological analysis

The bromatological analysis was performed on Treatments T1, T2, T3 and the To control using the following analyses:

Total solids. Previous evaporation was carried out for subsequent drying in a constant climate chamber model HPP 110, with a LED lighting module, temperature from 0°C to 70°C, and humidity from 10 to 90 % fh, for a period of 6 hours (14).

Ashing. The dry samples were carbonized in a Yamato 1.5 L laboratory muffle with controlled thermoregulators that allow repeatability. The

samples were placed at 550°C for 4 hours to obtain the weight of lead-colored ash (14).

Fat. Employing the Goldfish method in lipid extractor equipment model GL-45; to extract the amount of fat on a dry basis, ether was used as an organic solvent for 4 hours and its content was established by weight difference (14).

Protein. The universal Kjeldahl method was applied, with a process of digestion in an acid medium of the dry matter, then distillation and finally titration. The nitrogen to protein conversion factor was 6.25 (14).

Fiber. In fiber digester equipment, the digestive simulation was carried out in an acid and basic medium, followed by drying and incineration (14).

Carbohydrate. By titration to determine total carbohydrates, the dry sample was diluted in an aqueous medium and titrated a 20 ml aliquot of Fehling's reagent based on the reducing power of copper II salt in an alkaline medium to copper I oxide (14).

The number of calories was executed with calculations from the carbohydrate, protein and fat components of each of the treatments (Benítez, 2014).

In T1, T2, T3 and control treatment T0, the microbial load of mesophilic aerobes in the beverages was analyzed using the REP method, with Agar for REP as culture medium and peptone water as a diluent; 3 dilutions were carried out (15).

As an indicator of handling conditions, cleaning and disinfection process, total coliforms were analyzed in each sample by the most probable number method, by dilution technique in tubes using brilliant green broth as a selective liquid medium (16).

Sensory Evaluation

Sensory testing was conducted using a hedonic scale for the beverages. The test was used to evaluate five attributes: appearance, color, aroma, texture and overall product, where 18 previously trained panelists evaluated with scores of 1 very unpleasant, 2 unpleasant, 3 neither pleasant nor unpleasant, 4 pleasant and 5 very pleasant.

Statistical Analysis

The results were analyzed in a computer package InfoStat free version 2020. A Kruskal-Wallis nonparametric analysis and analysis of variance (ANOVA) were used for acceptability testing, with a confidence level of 0.05 for physical and bromatological analyses.

RESULTS

Acceptability of the functional beverage

The sensory evaluation test did not present normal distribution with a p-value < 0.05 and for the homogeneity of variances test, there was no difference for p-value > 0.05 for attributes of appearance, aroma, flavor and product in general when comparing the three treatments. The Kruskal-Wallis non-parametric test to compare the attributes is shown in Table 2, which presents significant statistical differences only for color with a p-value of 0.003770; in addition, heterogeneity is observed in most of the attributes of the acceptability test with the presence of atypical values for color, texture and general product for the treatment.

Table 2. Kruskal-Wallis nonparametric analysis for the acceptability of the three functional beverage treatments.

ATTRIBUTE	TREATMENT	Media	±DE	Variance	Kruskal-Wallis p-value
APPEARANCE	T1	[a]3.72	**±0**.67	0.45	0.252441
	T2	[a] 3.50	**±0**.62	0.38	
	T3	[a] 3.83	**±0**.51	0.26	

ATTRIBUTE	TREATMENT	Media	±DE	Variance	Kruskal-Wallis p-value
COLOR	T1	[b]4.06	**±0**.42	0.17	0.003770
	T2	a3.44	**±0**.62	0.38	
	T3	[b]3.94	**±0**.54	0.29	
AROMA	T1	[a] 3.78	**±0**.73	0.54	0.616053
	T2	[a] 3.67	**±0**.77	0.59	
	T3	[a] 3.56	**±0**.62	0.38	
TEXTURE	T1	[a] 3.83	**±0**.51	0.26	0.616053
	T2	[a] 3.39	**±0**.78	0.60	
	T3	[a] 3.56	**±0**.62	0.38	
TASTE	T1	[a] 3.50	**±0**.62	0.38	0.773357
	T2	[a] 3.61	**±0**.70	0.49	
	T3	[a] 3.44	**±0**.78	0.61	
GENERAL PRODUCT	T1	[a] 3.89	**±0**.58	0.34	0.225157
	T2	[a] 3.56	**±0**.51	0.26	
	T3	[a] 3.56	**±0**.78	0.61	

Means with a common letter are not significantly different (p > 0.05); T1:12.5% Purple maize,8.75% purpleberry; T2:17.5% Purple maize, 3.75% purpleberry; T3:8.75% Purple maize, 12.5% purpleberry.

T3 presented the highest score for an appearance with an average of 3.83 ± 0.51 close to agreeable for showing homogeneous liquid consistency, and T2 had the lowest score for presenting particles of fruit and corn residues. The texture of the three formulations was liquid, but T2 contained a greater number of suspended particles giving a slightly heterogeneous appearance and obtained the lowest score in texture acceptability. Both flavor and aroma did not present statistical differences with a p > 0.05, but the highest score in the aroma was T1 and flavor was T2, the flavors of the three beverages were slightly acidic to neutral with a predominance of mortiño flavor. For color, T2 was visualized with a dark violet tone differentiating from T1 and T3 because it contains less amount of purple corn. T1, concerning color, was the attribute that received the highest score from the panelists, rated as pleasant. Likewise, the highest score for the overall product is for T1.

Table 3 CIEB Color Analysis (L a* b*)

					ANOVA	
CIELAB	**TREATMENTS**	**Media**	**DE**	**Varianc e**	**F**	**p-value (0.05)**
L	T1	[b] 25.89	**±1**.81	3.28		
	T2	[a] 20.62	**±4**.14	17.10		
	T3	[ab] 25.66	**±0**.47	0.22		
	T0	[b] 26.43	**±0**.84	0.71	3.03	0.02063
	MT1	[ab] 25.63	**±3**.57	12.73		
	MT2	[ab]25.35	**±3**.25	10.59		
	MT3	[b]26.25	**±1**.58	2.50		
a*	T1	[b]5.62	**±0**.80	0.65		
	T2	[ab]4.75	**±1**.17	1.37		
	T3	[ab]2.98	**±1**.82	3.33		
	T0	[a] 1.64	**±0**.11	0.01	12.61	<0.0001
	MT1	[b]6.12	**±2**.37	5.60		
	MT2	[ab] 4.87	**±2**.59	6.69		
	MT3	[c] 9.98	**±1**.28	1.63		
b*	T1	[ab]0.10	**±0**.53	0.28		
	T2	[a] -1.15	**±0**.53	0.28		
	T3	[ab]0.00	**±0**.29	0.08		
	T0	[ab]-0.80	**±1**.31	1.71	11.01	<0.0001
	MT1	[b] 0.58	**±1**.10	1.21		
	MT2	[b] 0.58	**±0**.26	0.07		
	MT3	[c] 2.29	**±0**.59	0.34		

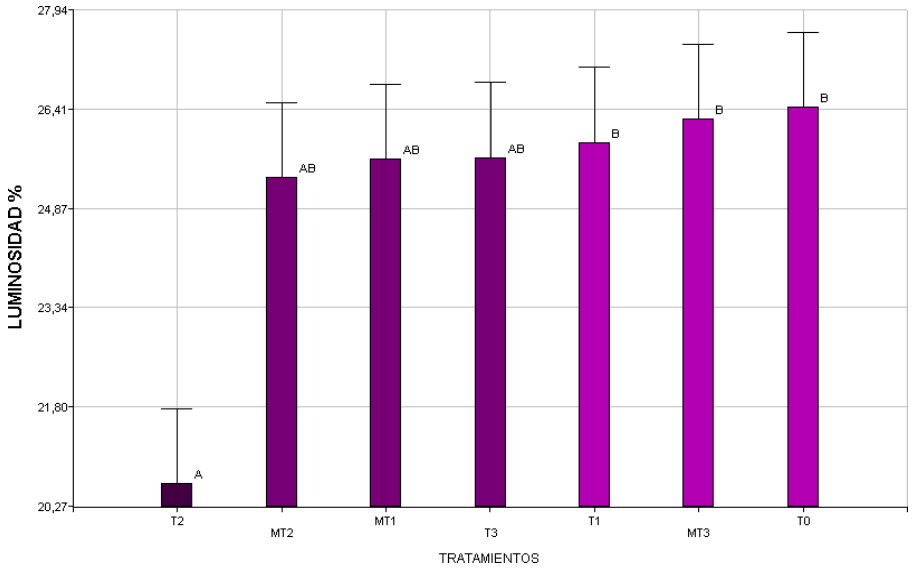
Means with a common letter are not significantly different (p > 0.05); L: luminescence; a negative values indicate green while positive values indicate magenta; b* negative values indicate blue and positive values indicate yellow; T0:50% Purple corn aqueous extract; T1:12.5% Purple corn, 8.75% dye; T2:17.5% Purple corn, 3.75% dye; T3:8.75% Purple corn, 12.5% dye; MT1: 8.75% dye; MT2:3.75% dye; MT3:12.5% dye.*

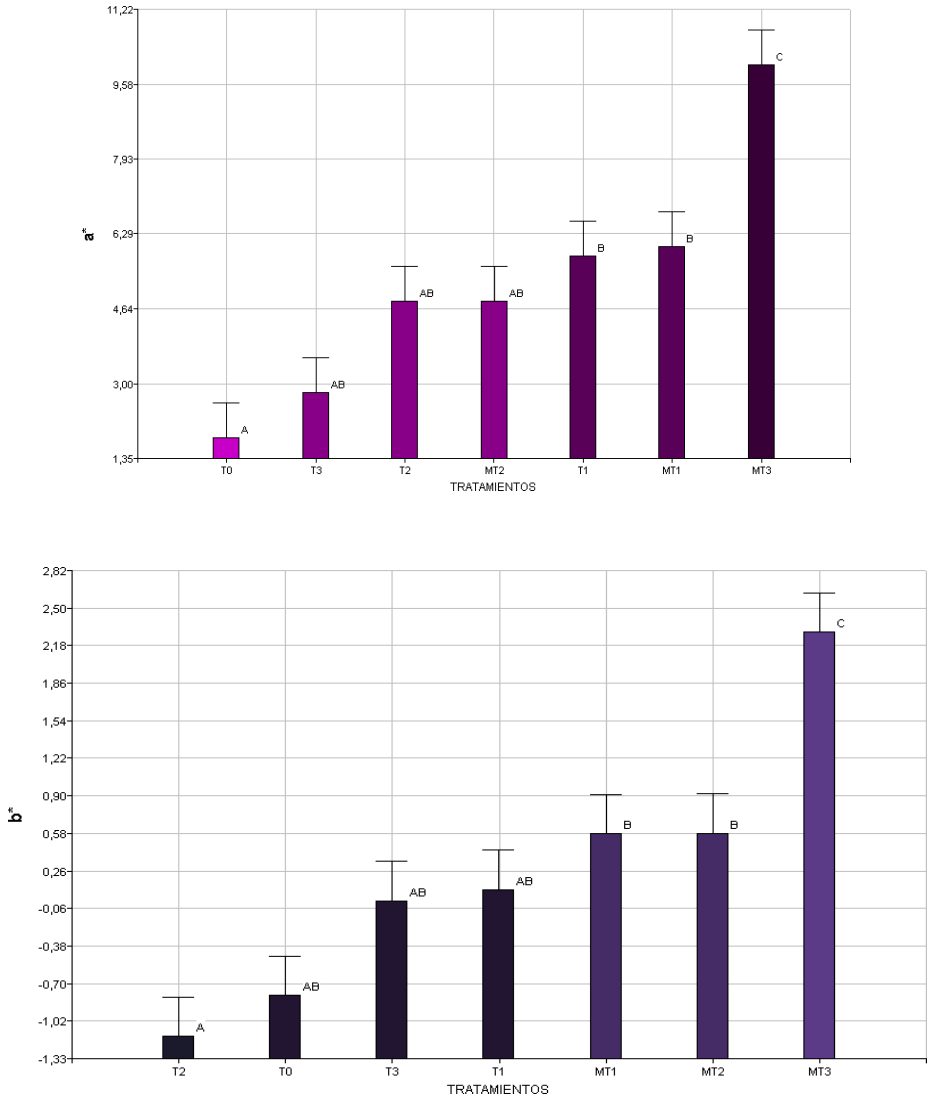
From the quantitative analysis of color, in observance of luminosity (L), significant statistical variations were estimated with a p-value <0.05, providing three ranges of variation, visible in Table 4 and Figure 2; the minimum average of 20.62 **±** 4.14 % for T2 presented lower brightness, the same contains less percentage of mortiño in the formulation and higher contribution of the purple corn extract; on the other hand, the maximum average brightness was 26.43 **±** 0.84 %, corresponds to the corn extract in water without the addition of mortiño. According to the acceptability test, the highest acceptability score for color corresponded to T1 with 4.04 **±0**.42 points with a p-value = 0.003770; it is possible to assume that the trained judges liked the color with higher luminosity for T1 and it was 25.89 **±1**.81 % of similar range to the aqueous extract of purple corn.

Regarding the color space a*, significant statistics were evidenced with a p-value <0.05, with four ranges of differentiation as shown in Table 4 and Figure 2, where the previous mixture MT3 (3.7 % mortiño) exhibited the highest value in 9.98±1.28 of a tendency to magenta with a positive value for a*, possibly due to the majority contribution of mortiño in the formulation, since mortiño has appreciable amounts of pigments with striking colors from dark red or violet (17). Likewise, the lowest magenta intensity value was the aqueous extract of purple corn without the addition of mortiño with an average of 1.64 **±0**.11. T2 presented a value of 4.75±1.17 in the intermediate range between the magenta intensity due to the combination of a similar percentage of mortiño in the formulation. The trained judges liked the perceived color of magenta tendency corresponding to T1 with a value of 5.62 **±** 0.80.

Similarly, for the color space b*, significant statistics with a p-value <0.05 were found, with four ranges of difference as shown in Table 4 and Figure 2. The samples that showed a predisposition toward blue color were the corn extract with a value of -0.80 **±** 1.31 and T2 with -1.15±0.53, possibly due to the higher percentage of corn in the formulation. On the other hand, T3 showed identical chromaticity coordinates with an average value of 0.00 **±** 0.29, the tendency for this case is neutral color from the contribution of the mortiño pigments in equilibrium with corn pigments.

Figure 1. Representation of the CIEB color analysis (L a* b*) of functional beverages based on purple corn and mortiño.





L: luminescence; a negative values indicate green while positive values indicate magenta; b* negative values indicate blue and positive values indicate yellow; T0:50% Purple corn aqueous extract; T1:12.5% Purple corn, 8.75% purple; T2:17.5% Purple corn, 3.75% purple; T3:8.75% Purple corn, 12.5% purple; MT1: 8.75% purple; MT2:3.75% purple; MT3:12.5% purple; MT3:12.5% purple.*

Table 4. Physical properties of functional beverages based on purple corn and mortiño.

				Anova	
	TREATMENT	**Media**	**DE**	**F**	**p**
pH	T0	^{d} 6.20	±0.03	22.98	<0.0001
	T1	^{ab} 4.56	±0.17		
	T2	^{abc} 4.93	±0.15		
	T3	^{a} 4.54	±0.49		

Table 4. Physical properties of functional beverages based on purple corn and mortiño.

				Anova	
	TREATMENT	**Media**	**DE**	**F**	**p**
	MT1	bc 5.16	±0.18		
	MT2	ab 5.57	±0.04		
	MT3	c 5.51	±0.16		
Water activity	T0	a 0.99	±0.01		
	T1	a 0.99	±0.01		
	T2	a 0.99	±0.01		
	T3	a 0.99	±0.01	1.11	0.4066
	MT1	a 0.98	±0.01		
	MT2	a 0.99	±0.01		
	MT3	a 0.99	±0.01		
Brix degrees	T0	a 1.33	±0.58		
	T1	d 4.93	±0.12		
	T2	c 4.00	±0.13		
	T3	b 3.00	±0.13	148.95	<0.0001
	MT1	e 6.00	±0.13		
	MT2	d 5.00	±0.13		
	MT3	d 5.00	±0.13		
Density	T0	a 1.01	±0.01		
	T1	a 1.01	±0.01		
	T2	a 1.02	±0.01		
	T3	a 1.04	±0.01	0.86	0.5635
	MT1	a 1.02	±0.01		
	MT2	a 1.02	±0.01		
	MT3	a 1.02	±0.01		

Table 4. Physical properties of functional beverages based on purple corn and mortiño.

			Anova	
TREATMENT	**Media**	**DE**	**F**	**p**

Means with a common letter are not significantly different (p > 0.05); T0:50% Purple maize aqueous extract; T1:12.5% Purple maize, 8.75% dye; T2:17.5% Purple maize, 3.75% dye; T3:8.75% Purple maize, 12.5% dye; MT1: 8.75% dye; MT2:3.75% dye; MT3:12.5% dye; MT3:12.5% dye.

Table 5. Bromatological analysis of functional beverages based on purple corn and mortiño.

	Treatments				
	T0	**T1**	**T2**	**T3**	**ANOVA**
Bromatological analysis	Mean ± S.D	Mean ± S.D	Mean ± S.D	Mean ± S.D	**P-value (0.05)**
Kcal /100 g	[b] 58.98 ±1.23	[c] 65.70 ± 1.95	[d] 93.37 ± 2.72	[a] 50.90 ± 0.36	<0.0001
Water	[a] 81.20 ± 5.29	[a] 83.69 ± 3.02	[a] 84.14 ± 2.15	[a] 87.28 ± 1.49	0.2429
%Carbohydrates	[b] 18.89 ± 1.50	[a] 10.37 ± 1.45	[a] 12.01 ± 1.52	[a] 8.63 ± 0.60	<0.0001
% Fat	[a] 0.55 ± 0.08	[b] 0.59 ± 0.10	[ab] 0.80 ± 0.06	[a] 0.55 ± 0.12	0.02929
% Protein	[ab] 1.15 ± 0.12	[ab] 1.09 ± 0.12	[b] 1.41 ± 0.23	[a] 0.84 ± 0.08	0.01004
Fiber	[a] 0.10 ± 0.02	[c] 0.72 ± 0.04	[b] 0.34 ± 0.06	[d] 1.04 ± 0.10	<0.0001
% Ash	[a] 0.21 ± 0.05	[a] 0.20 ± 0.05	[a] 0.19 ± 0.04	[a] 0.18 ± 0.08	0.8972
Total Solids	[a] 17.82 ± 4.05	[a] 16.31 ± 3.02	[a] 15.86 ± 2.15	[a] 12.72 ± 1.49	0.2431

Means with a common letter are not significantly different (p > 0.05); T0:50% Purple maize aqueous extract; T1:12.5% Purple maize,8.75% dwell; T2:17.5% Purple maize, 3.75% dwell; T3:8.75% Purple maize, 12.5% dwell.

The analysis revealed significant differences between the kilocalorie, % carbohydrate and % fiber contents of the formulations. It is important to highlight that T2 presented higher caloric values, as well as a higher % of carbohydrates, fat, and protein. T3 had a higher % of fiber. The % of water, fat, protein, ash and total solids did not show statistically significant differences.

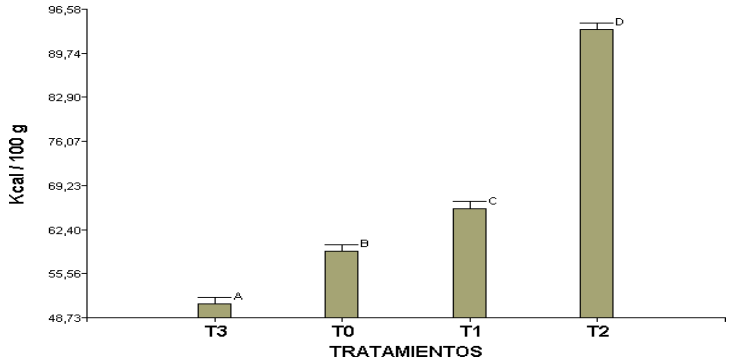


Figure 2.

Microbiological analysis

Microbiological analyses comply with food handling conditions, total coliforms evidenced with a value of zero, mesophilic aerobic counts less than 10^3 CFU/g.

DISCUSSION

Corn is an Andean crop that since ancient times was used to prepare chicha, at that time the corn was first moistened to ferment by placing it in achira leaves in a sheltered place, when it germinated when dried JORA was obtained, one part was ground and the other was chewed, then it was cooked with water for several hours and then placed in jars to finish fermenting in a sheltered place (18). In Mexico, a typical fermented corn-based drink is prepared: pozole, a traditional non-alcoholic drink from Chiapas (Zoque Chiapaneca culture), this drink contains a large number of bacteria, some of them with probiotic potential, and whose consumption is beneficial for human health (19). Over the years, and due to the cultural identity of the peoples of America with this crop, corn has been used as a raw material for the production of countless products, including not only fermented beverages but also sweet beverages, as is the case of the formulations in this research when performing the sensory analysis and reviewing the attributes of appearance, aroma, flavor, no difference was found for p-value (> 0.05) between treatments, this agrees with what was found in a research conducted by Contreras-Lozano, *et al.* (2019), where it was also appreciated that flavor and aroma were the most valued attributes in a beverage formulated without the addition of hydrocolloids, when adding them, an increase in the brightness of the beverages was observed, favoring the perception of the appearance of these beverages (20). The formulations made, unlike those elaborated in the aforementioned research, were not subjected to biofermentation processes or acid or alkaline extraction; however, it was observed that the color did present a significant statistical difference (p 0.003770), showing in the acceptability test, greater luminosity in T1 (12.5% purple corn, 8.75% purple), and T1 was the most heterogeneous in the attributes of color, texture and general product with the presence of atypical values.

In research conducted by Ramne S, Brunkwall, *et al*. (2021), it was found that beverages sweetened with sugar, as well as those sweetened with artificial sweeteners, are associated with the composition of the intestinal microbiota, the results suggest that the intake of sweetened beverages is negatively associated with the Lachnobacterium genus and positively with the Firmicutes: Bacteroidetes ratio. The formulations carried out contain stevia, and in future research, more extensive studies could be carried out to determine the link between the intake of sugars and sweeteners and the human intestinal microbiota (21; 22).

The mortiño (*Vaccinium floribundum Kunth*), considered an Andean berry(23) contains high levels of antioxidants and antimicrobial activity (24). For the elaboration of the formulations, in addition to the above-mentioned characteristics, its ancestral value was considered and it was highlighted among its physicochemical characteristics, that the MT3 formulation: which has a mulberry concentration of 12.5% tends to magenta, due to its appreciable amounts of pigments with colors ranging from dark red or violet, which would precisely evidence its content of polyphenols and anthocyanins (25), assigning to the formulations with purple corn and mortiño, the potential to become the source of bioproducts that could be used in the food and pharmaceutical industries to develop new nutraceuticals and antimicrobials (26).

The bromatological analysis evidenced statistically significant differences between the formulations, in their percentage of carbohydrates and fiber (<0.0001). These figures are directly related to the concentration of raw materials in the formulated treatments. Corn is a food with a high content of dietary fiber (9.8%) and carbohydrates (65%), these percentages modulate the glycemic index, slowing the speed of absorption and the response of serum glycemia levels, becoming a very important ingredient in the formulation (23). This makes it a very attractive ingredient in the elaboration of industrialized products, a characteristic that has been considered for the formulations elaborated in this research. T2 (17.5% purple corn, 3.75% mulberry) showed a higher carbohydrate content, while T3 (8.75% purple corn, 12.5% mulberry) had a higher fiber content, which plays an indispensable role in the prevention of digestive diseases and insulin resistance (24).

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