Espirales revista multidisciplinaria de invesitgación científica
ISSN: 2550-6862
compasacademico@icloud.com
Grupo Compás
Ecuador

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Espirales revista multidisciplinaria de invesitgación científica, vol. 4, núm. 32, 2020
Grupo Compás, Ecuador
Disponible en: https://www.redalyc.org/articulo.oa?id=573261514001

Nutritional optimization of milk mixtures based on rice flour (Oryza sativa L.) and soybean (Glycine max L.): Bromatological-sensory determination

Optimización nutricional de mezclas lácteas a base de harina de arroz (Oryza sativa L.) y soya (Glycine max L.): determinación bromatológica-sensorial

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Espirales revista multidisciplinaria de invesitgación científica, vol. 4, núm. 32, 2020

Grupo Compás, Ecuador

Recepción: 16 Mayo 2019
Aprobación: 31 Octubre 2019

Redalyc: https://www.redalyc.org/articulo.oa?id=573261514001

Resumen: Hoy en día, la necesidad de consumir mezcla láctea con nutritivos saludables se ha incrementado por la falta de expendio de bebidas completas desde el punto de vista nutricional. La mezcla láctea elaborada con leche, harina de arroz, soya y miel representa un alimento nutritivo para el consumo humano por su alta tasa de proteínas de alto valor biológico, contenido de vitaminas y minerales; todos esenciales para el buen funcionamiento del organismo. En este sentido la agroindustria ha realizado avances tecnológicos para lograr formulaciones que aporten los nutrientes necesarios en las dietas diarias y así contribuir con la salud de los individuos. El objetivo de esta investigación fue determinar el contenido nutricional óptimo de la mezcla láctea a base de harina de arroz (Oryza sativa L.) y soya (Glycine max L.) a partir de la determinación bromatológica-sensorial. La investigación se realizó en las instalaciones de la planta de lácteos de la carrera de Ingeniería Agroindustrial de la Universidad Católica de Santiago de Guayaquil, Ecuador. Los materiales y métodos empleados se caracterizaron por la aplicación de la norma técnica para la realización de análisis fisicoquímicos a las materias primas y a la bebida láctea de mayor aceptación, considerando la Norma Técnica Ecuatoriana NTE 2564. Se empleó el software estadístico Design-Expert, versión 11. Se diseñaron 16 formulaciones que contenían harinas de arroz y soya, miel, leche; estas fueron evaluadas sensorialmente con una encuesta de escala hedónica de nueve puntos por un panel sensorial entrenado. El resultado del estudio mostro que la mejor formulación determinada correspondió a: harina de arroz 2 %, harina de soya 3,75 %, miel de abeja 5,25 % y leche 89 %. Se concluyó que la formulación elaborada cumple con los parámetros nutricionales establecidos en la norma NTE INEN 2564.

Palabras clave: análisis químico, cereal, leche, materia prima, microbiología.

Abstract: Today, the need to consume healthy nutritious milk mix has increased, due to the lack of complete beverage sales from the nutritional point of view. The dairy mixture made with milk, rice flour, soy and honey represents a nutritious food

for human consumption, due to its high rate of proteins of high biological value, vitamin and mineral content; all essential for the proper functioning of the body. In this sense, agribusiness has made technological advances to achieve formulations that provide the necessary nutrients in daily diets and thus contribute to the health of individuals. The objective of this research was to determine the optimal nutritional content of the dairy mixture based on rice flour (Oryza sativa L.) and soy (Glycine max L.) from the bromatological-sensory determination. The research was carried out at the facilities of the Dairy plant of the Agroindustrial Engineering degree of the Catholic University of Santiago de Guayaquil, Ecuador. The materials and methods used were characterized by the application of the technical standards for the realization of the physical-chemical analyzes to raw materials and milk drink of greater acceptance considering the Ecuadorian Technical Standard NTE 2564. The statistical software Design-Expert version 11 was used. 16 formulations containing rice and soy flour, honey, milk; these were sensory evaluated with a nine-point hedonic scale survey by a trained sensory panel. The result of the study showed that the best determined formulation corresponded to: rice flour 2 %, soy flour 3.75 %, honey 5.25 % and milk 89 %. It was concluded that the elaborated formulation complies with the nutritional parameters established in the NTE INEN 2564 standard.

Keywords: Chemical analysis, cereal, milk, raw material, microbiology.

INTRODUCTION

Milk and its dairy products are essential for food because of their nutritional qualities. In 2017, milk production in Ecuador was 7.11 L/cow in the mountains, 4.29 L/cow in the east and 3.93 L/cow on the coast. The Dairy Industry Center of Ecuador indicates that milk is sold as: whole, flavored, with cereals, raw, heat treated, concentrated, special, supplemented, modified, and biological. Guerra, Sangronis and Jaffé (2015) indicate the study of dairy mixtures is a current situation of science and technology for obtaining food with high nutritional value. The Institute of Nutrition of Central America and Panama referred to the flour mixture consisting of cereal and protein with a high nutritional value (Elias, 2006).

Veisseyre (1988) indicates that milk contains proteins, essential amino acids, minerals such as calcium, phosphorus, water-soluble and fat-soluble vitamins, mainly lactose carbohydrates giving it an important energy contribution in the nutrition of consumers. The FAO indicates that milk provides essential biomolecules for humans such as carbohydrates, proteins, lipids. These contain energy, calcium, magnesium, selenium, vitamin B2, B5, B12 (de Beer, 2012).

Villegas (2018) reported that diseases and nutritional deficiencies require the consumption of dairy drinks to protect health; they have calcium that contributes to improve immunity and strengthen the bone system. They are related to the growth of children and young people in their development (Huncharek, Muscat and Kupelnick, 2008). Gómez and Mejía (2005) points out that the absorption of calcium helps the growth, maintenance of the bones avoiding diseases during their life cycle.

Food safety is the responsibility of governments, developing these worldwide with the application of food standards. A balanced diet has the right foods allowing an optimal nutritional status; these give energy, help

tissue formation and regulate metabolic processes by finding themselves in balanced quantities (Martínez y Garcia, 2005).

Rueda, Kil-Chang and Bustos (2004) notes the bromatological composition of soybean meal has 35 g of protein, 30 g of carbohydrates, 18 g of lipids, 0.85 mg of vitamin B1, 0.40 mg of vitamin B2. It has essential amino acids such as arginine, histidine, isoleucine (Ávila, 1983). Its consumption favors in the growth stage, reduces cholesterol, helps calcium assimilation, has essential amino acids necessary for the human diet.

The purpose of this research is to determine the optimal nutritional content of the dairy mixture based on rice flour (Oryza sativa L.) and soy (Glycine max L.) from the bromatological-sensory determination of its components.

For this research, 16 treatments were evaluated with three repetitions each which resulted in 48 samples, of which the formulation 2 % rice flour, 3.75 % soybean meal, 5.25 % bee honey, and 89 % milk. It gave us better results compared to the commercial control, and the best treatment obtained was carried out the corresponding bromatological analyzes of: proteins, fat, pH, acidity, brix degrees, molds and yeasts, Escherichia coli, and calories.

MATERIALS AND METHODS

The experimental design is structured in stages.

Phase I. In this phase the analyzes required by the Ecuadorian, Mexican and Colombian technical standards are carried out.

The reception and analysis of:

(i) The rice flour in the parameters of: granulometry, ashes, humidity, acidity, molds and yeasts, the results were compared with the Ecuadorian norm NTE INEN 3050 and the Mexican norm NMX-F 160-1982.

(ii) Soybean meal parameters: granulometry, ashes, humidity, acidity, molds and yeasts, the results were compared with the Ecuadorian norm NTE INEN 1705 and the Colombian norm NTC 2457.

(iii) The milk parameters: density, protein, fat, acidity, pH, the results were compared with the Ecuadorian standard NTE INEN 9-2012 and the Mexican standard NMX-F 026-1997.

(iv) Bee Honey analyzes the parameters of: brix degrees, humidity, acidity, the results were compared with the Ecuadorian norm NTE INEN 1572 and the Mexican norm NMX-F 036-981.

Phase II. Sample design proposal.

The statistical software Design-Expert version 11 was used by entering the following restriction parameters: rice flour (1.5-2.5 %); soy flour (3-5 %); bee honey (4.5-6.5 %). According to the analysis of variance, 48 samples will be evaluated, which can be seen in Table 1 below.

Table 1
Analysis of variance with degrees of freedom

Source of Variation		G.L.
Treatments	a*s*m-1	16
Blocks	(r-1)	2
Factor A (rice flour)	(a-1)	2
Factor S (soy flour)	(s-1)	2
M factor (honey)	(m-1)	2
Interaction (A* S * M)	(a-1) (s-1) (m-1)	8
Experimental Error	(A*s*m-1)(r-1)	32
Total	(a*s*m*r)-1	48

Author's elaboration.

The experimental design will have 16 treatments, the same ones that differ in percentage of rice flour, soy flour and bee honey, as we can see in Table 2.

Table 2.
Combinations of treatments

No.	Rice Flour (%)	Soy Flour (%)	Bee Honey (%)
1	2.07	3.00	5.93
2	1.55	4.47	4.98
3	2.09	3.02	5.95
4	2.50	3.00	5.50
5	1.64	3.94	5.42
6	2.00	3.75	5.25
7	2.11	4.39	4.50
8	1.50	5.00	4.50
9	2.50	3.45	5.05
10	1.50	3.00	6.50
11	1.67	3.97	5.45
12	2.04	3.48	5.48
13	2.14	4.42	4.53
14	1.50	3.52	5.98
15	2.50	3.90	4.60
16	2.04	3.48	5.48

Author's elaboration.

Phase III. Sensory evaluation.

In this phase a hedonic scale survey was conducted, the parameters evaluated were: color, flavor, aroma, texture, acceptability.

Phase IV. Determination of variance coefficient.

Then in this phase the results of the sensory evaluation of the 16 treatments are entered into the software Design-Expert reporting the coefficient of variance, reliability and mixing model of the parameters evaluated.

Phase V. Comparison and selection of optimal mix.

At the best treatment the analyzes of pH, brix degrees, acidity, proteins, fat, molds and yeasts, Escherichia Coli are performed.

RESULTS

Characterization of raw materials

Rice flours

The results obtained in the analysis of rice flour are presented within the parameter established according to Mexican standards NMX-F-160 and NTE INEN 3050 Ecuadorian Technical Standards described in Table 3. There is only one difference with the presence of fungi and yeasts, in the aforementioned regulations; however the sample is within the allowable value according to the NTE INEN 3050 standard.

Table 3.
Physical-chemical and microbiology composition of rice flour

Parameter	Result	Rule Ecuador NTE	Values Min-max Allowed	Rule Mexico NMX-F-	Values Min-max Allowed
Grain size %	98.50	INEN 3050	85-100	160-1982	-
Ashes %	0.62	INEN 3050	N/A - 1	160-1982	N/A - 1
Humidity %	7.15	INEN 3050	N/A -12	160-1982	N/A -12
Acidity %	0.18	INEN 3050	N/A - 3	160-1982	-
Molds and yeasts CFU/g	1×10^3	INEN 3050	1×10^3 máx.	160-1982	0

Author's elaboration.

Characterization of soy flour

The results obtained in the analysis of soybean meal are presented within the parameter established according to Colombian Standards NTC 2457 and Ecuadorian Technical Standards NTE INEN 1705 described in Table 4. The moisture parameter differs in the Colombian standard, but the sample is within the allowed value according to the NTE INEN 1705 standard.

Table 4.
Physical-chemical and microbiology composition of soybean meal

Parameter	Result	Rule Ecuador NTE	Values Min-max Allowed	Rule Colombia NMX-F-	Values Min-max Allowed
Grain size %	94.50	INEN 1705	90-97	2457	95-N/A
Ashes %	6.98	INEN 1705	N/A - 7	2457	N/A - 7
Humidity %	11.62	INEN 1705	N/A - 13	2457	N/A - 10
Acidity %	1.74	INEN 1705	N/A - 3	2457	-
Molds and yeasts CFU/g	30×10^3	INEN 1705	30×10^3 máx.	2457	N/A -1500

Author's elaboration.

Milk characterization

The results obtained in the milk analysis are presented within the parameters established according to Mexican standards NMX-F-026-1997 and Ecuadorian Technical Standards NTE INEN 9-2012 described in table 5. The sample is within the allowable value according to the NTE INEN 3050 standard.

Table 5
Physical-chemical composition of milk

Parameter	Result	Rule Ecuador NTE	Values Min-max Allowed	Rule Mexico NMX-F-	Values Min-max Allowed
Density 20 °C g/ml	1.03	INEN 9:2012	1.028-1.032	026-1997	1.02- N/A
Protein %	2.90	INEN 9:2012	2.9 - N/A	026-1997	30- N/A
Fat %	3.55	INEN 9:2012	3 - N/A	026-1997	N/A
pH	6.51	INEN 9:2012	N/A	026-1997	N/A
Acidity %	0.15	INEN 9:2012	0.13-0.17	026-1997	1.301.70

Author's elaboration.

Characterization of honey bee

The results obtained in the analysis of honey are presented within the parameter established according to Mexican standards NMX-F-036-981 and Ecuadorian Technical Standards NTE INEN 1572 described in Table 6.

Table 7.
Sensory evaluation averages entered into the Design-Expert program

Treatment	Cream color	Sweet flavor	Vegetable aroma	Texture	Acceptability
T 1	8.33	9.20	7.80	7.40	8.40
T 2	9.20	8.20	9.20	8.20	7.20
T3	8.33	9.20	7.60	7.40	8.40
T 4	8.10	8.60	7.80	7.80	8.20
T 5	8.57	8.40	7.70	8.00	7.00
T 6	8.44	8.46	7.20	7.50	8.00
T 7	9.00	8.10	9.00	7.20	7.30
T 8	9.60	8.10	9.80	8.40	7.00
T 9	8.36	8.70	7.80	8.00	7.60
T10	8.39	9.60	8.20	7.30	7.30
T 11	8.57	8.40	7.70	8.10	7.00
T12	8.44	8.46	7.20	8.00	8.00
T 13	8.80	7.60	7.80	7.50	7.10
T14	8.48	9.40	7.50	7.30	8.30
T 15	8.42	8.20	7.55	8.10	7.40
T16	8.45	8.46	7.20	8.00	8.00

Author's elaboration.

Next in Table 8, the results of the software Design-Expert of the 16 treatments to the sensory evaluation parameters are shown; the color parameter has a coefficient of variance that corresponds to a 96 % reliability value using a quadratic mixing model; and acceptability has 99 % reliability with a cubic mixing model; in addition, all parameters have reliability with their respective mixing model.

Table 8
Analysis of variance coefficient, reliability and treatment mix model

Parameters	Coefficient of variance C.V	Reliability %	Mixing model
Color	1.05	96	Quadratic
Smell	4.87	83	Quadratic
Texture	2.71	87	Cubic
Flavor	2.85	82	Linear
Acceptability	1.09	99	Cubic

Author's elaboration.

Subsequently, Figure 1 shows the sensory profile of the beverage selected in the sensory evaluation and the control drink based on milk and oatmeal, differences in taste and color characterized by the use of bee honey and soybean meal were observed.

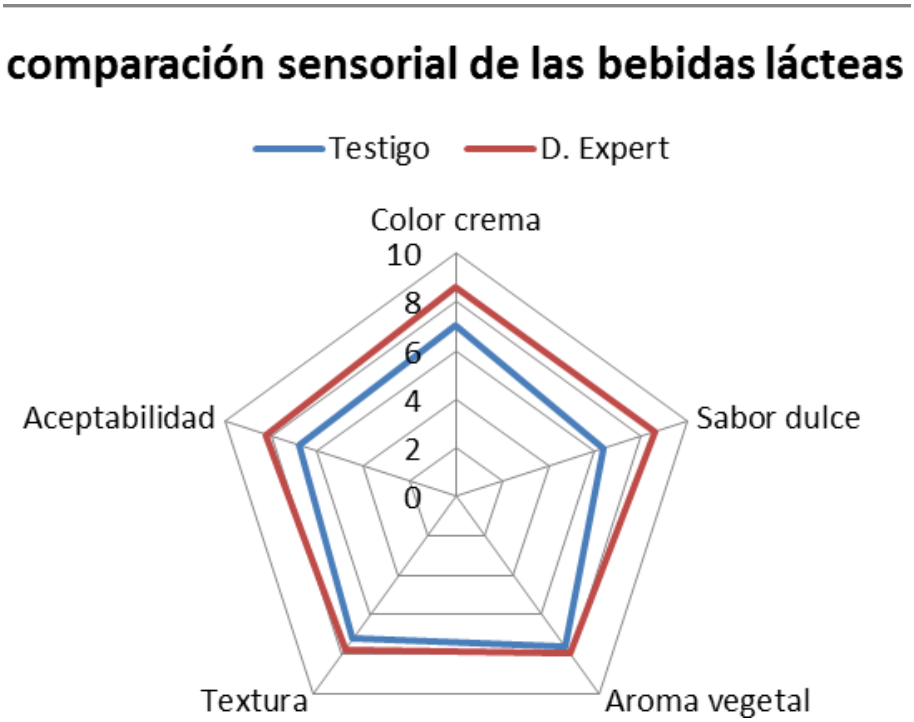

Figure 1
Sensory profile formula selected and control
Author's elaboration

Comparison of the sensory profile of the chosen milk beverage with the control

The results indicated that the selected formula had a higher score than the control, as we can see in Table 9, for which an electronic sheet was used, in which its characteristics were determined.

Table 9
Comparison of sensory profiles of Witness vs. Design-Expert

QDA	Cream color	Sweet flavor	Vegetable smell	Texture	Acceptability
F selected	8.59	8.62	7.94	7.76	8.20
F Witness	7.00	6.40	7.60	7.20	6.80

Author's elaboration.

Bromatological determination of the milk drink

Table 10 shows that the results obtained are within the values allowed by the Ecuadorian standard NTE 2564 2011 and the Mexican standard NMX-F- 026-1997 indicating that the product is nutritious and suitable for human consumption.

Table 10
Bromatological analysis of milk drink with rice flour and soy

Parameter	Result	Rule Ecuador NTE	Values Min -max Allowed	Rule Mexico NMX -F-	Values Min -max Allowed
Protein %	3.94	INEN 2564:2011	1.5 - N/A	026-1997	2.2- N/A
Fat %	2.70	INEN 2564:2011	N/A-3	026-1997	N/A
pH	6.30	INEN 2564:2011	N/A	026-1997	N/A
Acidity %	0.13	INEN 2564:2011	N/A	026-1997	0.9-1.3
Brix Grade°	22.00	INEN 2564:2011	N/A	026-1997	N/A
Moist and yields UFC/ml	2.3 x 10^3	INEN 2564:2011	N/A	026-1997	N/A
E Coli UFC/g	< 1.0	INEN 2564:2011	< 1.0	026-1997	N/A
Calories Kcal	302.00	INEN 2564:2011	N/A	026-1997	N/A

Author's elaboration.

CONCLUSION

The optimal nutritious milk drink is the one that contains 2 % rice flour, 3.75 % soy flour, 5.25 % bee honey and 89 % milk.

The raw materials used to make dairy drinks: rice flour, soy flour, milk and bee honey, meet the Ecuadorian Technical Standards NTE (3050, 1705, 09, 1572), the Mexican standards NMX-F (160-1982, 026-1997, 036-981) and Colombian standards NTC 2457, are suitable for the development of nutritional quality dairy drinks.

The developed dairy beverage using rice flour and soy sweetened with bee honey complied with the provisions of NTE INEN 2564 and Mexican standard NMX-F 026-1997; both physical, chemical, microbiological quality and level protein is higher compared to the witness milk drink, being this milk drink based on rice flour and nutritious soy.

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