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Bromatological characterization of a fermented yoghurt-type milk drink from whey with aloe vera crystals (*Aloe barbadensis* Miller) and granadilla (*Passiflora ligularis Juss*)

Caracterización bromatológica de una bebida láctea fermentada tipo yogur a partir de lactosuero con cristales de aloe vera (*Aloe barbadensis* Miller) y granadilla (*Passiflora ligularis Juss*)

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ABSTRACT

The aim of this research was to characterize a fermented yogurt-type milk drink that was elaborated from whey with the addition of aloe vera crystals and granadilla (Passiflora ligularis Juss). Four formulations for characterization were obtained: F1 (control), F2 (5% aloe vera and 15% granadilla), F3 (10% aloe vera and 10% granadilla) and F4 (15% aloe vera and 5% granadilla). Next, a sensory evaluation through a hedonic test was conducted to choose the formulation with the highest acceptance. After the best formulation was chosen, a bromatological and syneresis characterization was performed. The F4 sample had the best results in the sensory evaluation. Compared to the F1 sample, statistically significant differences (p<0.05) in all parameters except in total carbohydrates was observed for the bromatological analysis. In the percentage of syneresis, at the end of the 15 days, F4 presented a lower value in this parameter with respect to the control sample. It could be determined that the higher percentage of aloe vera and the lower percentage of granadilla had a big influence on the parameters evaluated, where it presented the best results compared to the other samples evaluated.

Keyword: Bromatology; Milk drink; Passiflora ligularis; Syneresis; Whey.

RESUMEN

El objetivo de esta investigación fue caracterizar una bebida láctea fermentada tipo yogur que se elaboró a partir de lactosuero con la adición de cristales de aloe vera y granadilla (Passiflora ligularis Juss). Se obtuvieron cuatro formulaciones para la caracterización: F1 (control), F2 (5% de aloe vera y 15% de granadilla), F3 (10% de aloe vera y 10% de granadilla) y F4 (15% de aloe vera y 5% de granadilla). A continuación, se realizó una evaluación sensorial mediante una prueba hedónica para elegir la formulación de mayor aceptación. Una vez elegida la mejor formulación, se realizó una caracterización bromatológica y de sinéresis. La muestra F4 obtuvo los mejores resultados en la evaluación sensorial. En comparación con la muestra F1, se observaron diferencias estadísticamente significativas (p<0,05) en todos los parámetros, excepto en los carbohidratos totales. En el porcentaje de sinéresis, al final de los 15 días, F4 presentó un valor inferior en este parámetro con respecto a la muestra de control. Se pudo determinar que el mayor porcentaje de aloe vera y el menor porcentaje de granadilla influyeron mucho en los parámetros evaluados, en los que presentó los mejores resultados en comparación con las otras muestras evaluadas.

Palabras clave: Bebida láctea; Bromatología; Lactosuero; Passiflora ligularis; Sinéresis.

INTRODUCTION

Whey is a by-product obtained in the process of cheese production. It is often not used and discarded as effluent to rivers, which causes economic losses to the company and

pollutes the environment[1]. Whey is rich in nutrients, since it retains about 55% of milk components, such as proteins of high biological value, minerals (potassium, calcium, phosphorus, sodium and magnesium), lipids, and amino acids, among others[2,3,4]. In industry, whey has been used as an ingredient in the production of milk drinks with fruit, kumis and kefir. Another type of food in which whey has been recently used is in the production of fermented milk drinks from lactic acid bacteria, which are usually mixed with fruits or flavors. Fermented milk drinks based on whey have been widely accepted because of their nutritional value, acceptable taste and low production price[1,5].

In tropical countries, there is a great variety of local fruits and vegetables that are available to be used for the preparation of processed foods[6]. Due to their composition, they provide vitamins, minerals, essential and non-essential amino acids, enzymes, carbohydrates, lipids and organic compounds, among others[7,8,9,10]. Aloe vera (*Aloe barbadensis* Miller) is one of these raw materials that can be used for the production of functional foods[11,12,13].

A fruit that has been of great interest lately after maracuya (*P. edulis f. flavicarpa Degener*), is the granadilla (*Passiflora ligularis Juss*), occupying the second place of the genus *Passiflora* L. This fruit is of great economic importance due to its participation in the Colombian and international market. It is a fruit that contains seeds surrounded by a sweet aril, with great sensory attributes (moderate and characteristic aroma of granadilla, intense and homogeneous color, characteristic flavor of granadilla), and is consumed fresh[14]. This fruit is produced mainly in Colombia, with a yearly production of 241,393 tons and average yields of 9.3 tons per hectare per year during 2018. The department of Huila is the main producer, with 54,426 tons, followed by the departments of Antioquia and Meta[15]. Recently, research has been conducted on the use of whey in food production, such as alcoholic fermented beverages[16], functional beverages[17], and yoghurt-type drinks[18,19,20], among other products. However, the combination of granadilla and other foods from the region, such as aloe vera, has not been studied. Therefore, the aim of this research was to characterize a fermented yoghurt-type milk drink made from whey, with the addition of aloe vera crystals and granadilla (*Passiflora ligularis Juss*).

MATERIALS AND METHODS

Raw material

Whey used to make the fermented yoghurt-type milk drink was obtained from a local cheese company. Aloe vera leaves (used for the extraction of the pulp) and the previously selected granadillas were purchased from a local market in the city of Cartagena de Indias, Colombia. Granadillas were chosen to be of similar size, free of insect bites and with a maturity degree of 6, as indicated by Rivera et al.[21] Aloe vera leaves came from mature, 4-year old plants.

Extraction of aloe vera crystals

Aloe vera leaves were disinfected with sodium hypochlorite at 100 ppm. These were left immersed in the solution for 5 min and then washed with abundant water to remove all residue of the solution. Subsequently, the lower part and the lateral sides of each leaf were cut and placed vertically over water for 24h to eliminate iodine. After this time, the epidermis of each leaf was manually removed to obtain the pulp, which is commonly denominated in Colombia as aloe vera crystal. After blanching (72 ºC for 15 s to eliminate the aloin), the pulp was cut into 3x3x3 cm cubes.

Granadilla pulp processing

Granadillas were washed and disinfected with sodium hypochlorite at 50 ppm for 5 min, then washed with abundant water to eliminate the remains of the disinfectant. After this process, the skin was scalded at 65 °C for 3 min, then manually removed and passed through a pulper machine and where they were pasteurized at 90 °C for 30 s.

Formulation and production of the fermented milk drink

A factorial design of 32 was used where aloe vera and granadilla are the factors and 5, 10 and 15% for both, (the sum of both levels should give 20%, so 3 formulations plus a control sample resulted). The percentages of aloe vera and granadilla used were chosen through previous tests.

Whey was pasteurized at 62 ºC for 30 min and then homogenized with the rest of the ingredients (semi-skimmed milk powder and sugar). The mixture was then cooled to 40 °C, which allowed the inoculation of lactic acid bacteria (*Lactobacillus bulgaricus* and *Streptococcus thermophilus*) and followed by a fermentation process was carried out for 240 min at 44.5 ± 1 °C. Once the process was finished, it was stored at 4 °C.

Sensory analysis

To evaluate consumer acceptance and determine the best formulation, a five-point hedonic scale was used where 1 was "I dislike it a lot" up to 5 was "I like it a lot". Five aspects were evaluated: color, odor, viscosity, acidity and overall acceptability. A semi-trained panel of 50 people of both sexes between the ages of 20 and 30 was used. The test was presented in disposable cups containing approximately 15 mL of the product, which were identified by four-figure random numbers. The formulation with the highest sensory acceptance was chosen for bromatological and syneresis analysis.

Bromatological evaluation and antioxidant capacity

The parameters determined to be the best formulation according to the AOAC[22] were: moisture (927.05), protein (979.09), fats (920.39), ash (923.03), calcium (944.03), iron (944.02), potassium (985.35), magnesium (985.35), sodium (985.35), vitamin C[23] and carbohydrates equation (1):

$$\%\ Total\ carbohydrates = 100\% - (\%\ moiture + \%\ protein + \%\ fat + \%\ ash) \quad (1)$$

The methodology explained by Repo and Encima[24] was used to determine antioxidant capacity.

Syneresis determination

For syneresis determination the method proposed by Staffolo et al.[25] was used. 10 g of the preferred formulation were centrifuged at 3000 rpm/min for 20 min in a test tube. After this time, the centrifuged sample was left to rest for 1 min and the supernatant (serum) was measured (2). The syneresis was expressed as a percentage of volume of drained serum per 100 ml of yoghurt. The tests were carried out at 4° C for 15 days, taking the sample every three days starting on day 0.

$$\% \ syneresis = \frac{g \ supernatant}{g \ samole} \ x \ 100\% \qquad (2)$$

Statistical analysis

The obtained data were analyzed using analysis of variance (ANOVA) and the Tukey post-hoc test with a confidence level of 95% using the Statgraphic Centurion XVI.I program. All the tests performed in the investigation were done in triplicate.

RESULTS

Sensory analysis

The sensory evaluation of the fermented beverage can be seen in table 1. We observed statistically significant differences ($p<0.05$) in three of the five parameters. F4 had the highest scores on all five parameters, but only statistically significant differences ($p<0.05$) in terms of odor, acidity and overall acceptability. While in terms of color there were statistically significant differences ($p<0.05$) between F1 (control) and the other three, which were equal to each other, which indicated that aloe vera and granadilla had an effect that favored these parameters according to the panelists. There were no statistically significant differences in viscosity ($p>0.05$).

Bromatological analysis and antioxidant capacity

The F4 sample was used for bromatological analysis and compared to F1. The bromatological analyses of the control sample (F1) and the sample with the best acceptance by the panelists (F4) are presented in table 2. Statistically significant differences ($p<0.05$) were found in all parameters evaluated between the samples. These results showed the influence that aloe vera and passion fruit had on these parameters.

Syneresis Analysis

The samples showed an increase in the percentage of syneresis during storage, from 10.4% at the initial time to 19.1 for F1 and from 7.2 to 14.8 for F4 at 15 days (Figure 1). In the first eight days there was a progressive increase, after which there was a tendency to stabilize.

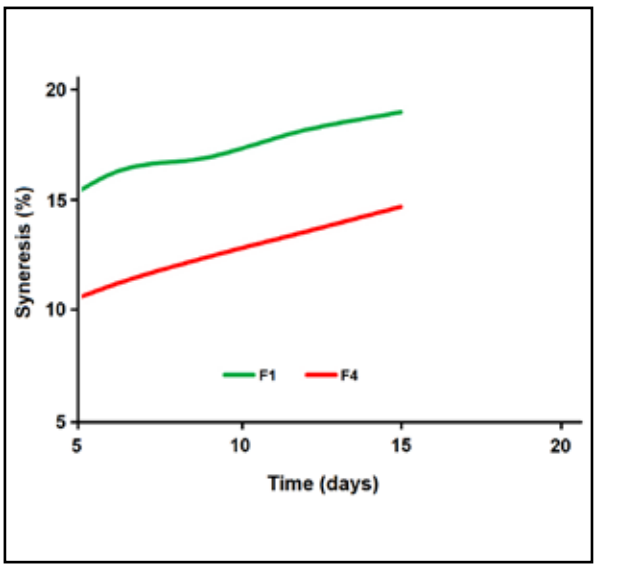

Figure 1: Evaluation of syneresis percentage in yoghurt stored at 4 °C for 15 days.

Table 1. Sensory analysis of the four formulations (mean± standard deviation).

F	Sensory characteristics				
	Color	Odor	Viscosity	Acidity	Overall Acceptability
F1	3.72±0.21[a]	3.32±0.25[a]	4.04±0.06[a]	3.68±0.19[a]	3.06±0.19a
F2	4.08±0.04[b]	3.94±0.07[b]	4.07±0.19[a]	3.87±0.14[a]	3.82±0.29[b]
F3	4.09±0.11[b]	4.05±0.21[b]	4.01±0.11[a]	3.75±0.28[a]	3.89±0.18[b]
F4	4.11±0.17[b]	4.47±0.27[c]	4.19±0.05[a]	4.24±0.11[b]	4.39±0.16[c]

F= formulations; Different letters in a column represent statistically significant differences ($p<0.05$).

Table 2. Bromatological analysis (mean± standard deviation).

Parameters	F1	F4
Moisture (%)	83.1±0.26[a]	80.5±0.5[b]
Protein (%)	3.42±0.02[a]	5.14±0.06[b]
Fat (%)	3.8±0.01[a]	4.11±0.10[b]
Total Carbohydrates (%)	5.84±0.38[a]	5.07±0.87[a]
Ash (%)	4.14±0.05[a]	5.18±0.05[b]
Vitamin C (mg)	0[a]	39±0.95[b]
Ca (mg)	115.2±0.76[a]	130.3±0.58[b]
Fe (mg)	89.1±0.81[a]	114.4±0.40[b]
K (mg)	141.8±1.66[a]	362.7±3.055[b]
Mg (mg)	11.7±0.64[a]	45.3±0.99[b]
Na (mg)	56.3±1.45[a]	77.6±0.53[b]
Antioxidant capacity (µmol trolox/100 g of extract)	0[a]	14.8±0.26[b]

Different letters in a row represent statistically significant differences ($p < 0.05$).

DISCUSSION

Sensory analysis

The results found indicate that the heat treatment of the aloe vera crystals eliminated the presence of aloin, which negatively affects the sensory characteristics (in terms of color, odor, taste, general acceptability) of the foods where this ingredient is used, as mentioned by some authors[26,27,28]. The results obtained here were similar to what was reported by Wijesundara and Adikari[29], who elaborated different yogurt formulations with the addition of aloe vera, and the formulation that had 15% of the latter, was the one that had the best sensory results. Another similar result was found by Govindammal et al.[30], who showed that yogurt with 15% aloe vera had the best acceptance.

Bromatological analysis

The percentage of moisture found in the research was similar to that expressed by Sepulveda et al.[31] who found 80.8% in a beverage fermented from whey with granadilla pulp (Passiflora edulis var. purple). The percentage of fat obtained in both samples was higher than that obtained by Miranda et al.[32] and Tirado et al.[19] which obtained percentages of 0.01 and 0.1, respectively, in milk drinks fermented from whey. The percentage of protein found in F1 and F4 was higher than those presented by Miranda et al.[32] and Martínez et al.[33]. The ash percentage was higher than that found by other authors[5,31,34]. The content of vitamin C and antioxidant capacity (DPPH) was higher in F4, given that both aloe vera and granadilla provided it, the content of this parameter in the case of granadilla is due to the content of pigments it has[24], in addition to the percentage of vitamin C provided by aloe vera[26]. The differences found between the two samples in all parameters is due to the addition of aloe vera and granadilla, as has already been demonstrated in various articles[10,35,36,37].

Syneresis Analysis

As can be seen in figure 1, the percentage of F4 syneresis was below F1, indicating that aloe vera had an influence on this parameter, as indicated by Mukhekar et al.[38] and Fox et al.[39]. This increase in the percentage of syneresis may be due to acidity behavior through its increase and a decrease in the pH of the product, whose behavior is ideal in a yoghurt-type dairy product[40]. Therefore, it can be considered that the percentage of syneresis is directly related to storage time. This behavior was similar to that presented by Panesar and Shinde[41], who elaborated an aloe vera yoghurt fortified with probiotics stored under the same conditions. The caseins in the fermented beverage exhibit a porous structure, have excellent water fixation and are gel-forming[3], so the decrease of these proteins could affect the stability of the product[42]. It has been established that the increase of whey in milk beverages contributes to the formation of acid gels with an open structure due to the reduction of molecular interactions and are thus are more susceptible to syneresis[43].

CONCLUSION

The fermented yoghurt-type milk drink made from whey with the addition of aloe vera crystals and granadilla

obtained its greatest sensory acceptance in the parameters of color, odor, acidity and general acceptability in the F4 formula (15% aloe vera and 5% granadilla). Regarding bromatological evaluation, the sample that obtained the best sensory mean (F4) had better values in most of the evaluated parameters. The percentage of syneresis was influenced by aloe vera, since F1 had a higher value than F4. In general, it was observed that aloe vera and granadilla had a great influence on most of the evaluated parameters.

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