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Physicochemical, microbiological, and sensory characterization of fresh cheese made with the Amazonian plants *Mansoa alliacea* and *Eryngium foetidum* in Pastaza, Ecuador

Caracterización fisicoquímica, microbiológica y sensorial de queso fresco elaborado con las plantas amazónicas *Mansoa alliacea* y *Eryngium foetidum* en Pastaza, Ecuador

Caracterizaçao físico quimica, microbiológicas e sensorial das queijo fresco produzido a partir das plantas amazónicas *Mansoa alliacea* e *Eryngium foetidum* em Pastaza, Ecuador

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Abstract

Plants have nutritional properties and beneficial effects on health, so fortifying dairy foods with plants from the Ecuadorian Amazon could produce dairy products with high nutritional values and unique aromas and flavors. This study characterized the physicochemical, sensory, and microbiological properties of fresh cheese made from the Amazonian plants: wild garlic (*Mansoa alliacea*; (Lam.) A.H.Gentr) and culantro (*Eryngium foetidum* L.). Cheeses were made with both species (dry sample and ethanolic extract) at 5 % and 25 % under a completely randomized experimental design with a 2^3 factorial arrangement, with three replications and 24 experimental units. The physicochemical properties established in the NTE INEN 1528 Standard (moisture, ash, dry matter, protein, fat, pH, acidity, lactose content, lactic acid, and chloride) were determined in the cheeses. Sensory analysis was performed with an untrained panel. Microbiological quality was assessed in the cheese selected in the preference test, according to the NTE INEN 1528 Standard. The treatments affected ash content (3.20 %), pH (5.95), moisture (55.28 %), total solids (42.20 %), and protein (20.84 %). The cheeses QF7 (dry extract of culantro, 5 %) and QF3 (dry extract of wild garlic, 5 %) presented the highest median acceptance, corresponding to “I like it very much”, with QF7 getting the highest acceptance (71 %). The fresh cheese presented high protein, fat, and calcium content, as well as adequate microbiological quality, which characterizes it as a caloric and nutritional food.

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Resumen

Las plantas poseen propiedades nutritivas y efectos beneficiosos para la salud, por lo que la fortificación de alimentos lácteos con plantas originarias de la Amazonia ecuatoriana, podría generar productos lácteos con altos valores nutricionales, con aromas y sabores únicos. En este trabajo se caracterizaron las propiedades fisicoquímicas, sensoriales y microbiológicas del queso fresco elaborado con las plantas Amazónicas ajo de monte (*Mansoa alliacea*; (Lam.) A.H.Gentr) y culantro de monte (*Eryngium foetidum* L.). Se elaboraron quesos con ambas especies (muestra seca y extracto etanólico) al 5 % y 25 %, bajo un diseño experimental completamente al azar con arreglo factorial 2^3, con tres repeticiones y 24 unidades experimentales. En los quesos se determinaron propiedades fisicoquímicas establecidas en la Norma NTE INEN 1528 (humedad, cenizas, materia seca, proteínas, grasa, pH, acidez, contenido de lactosa, ácido láctico, cloruro). El análisis sensorial se realizó con un panel no entrenado. La calidad microbiológica se valoró en el queso seleccionado en la prueba de preferencia, de acuerdo a la norma NTE INEN 1528. Los tratamientos afectaron el contenido de cenizas (3,20 %), pH (5,95), humedad (55,28 %), sólidos totales (42,20 %) y proteína (20,84 %). Los quesos QF7 (extracto seco de culantro de monte, al 5 %) y QF3 (extracto seco de ajo de monte, al 5 %) presentaron la mayor mediana de aceptación, correspondiente a “me gusta muchísimo”, obteniendo QF7 la mayor aceptación (71%). El queso fresco presentó alto contenido de proteínas, grasas y calcio, así como adecuada calidad microbiológica, que lo caracteriza como un alimento calórico y nutricional.

Palabras clave: extractos vegetales, análisis bromatológico y microbiológico, evaluación sensorial.

Resumo

As plantas têm propriedades nutricionais e efeitos benéficos para a saúde, pelo que a fortificação de alimentos lácteos com plantas nativas da Amazônia equatoriana poderia gerar produtos lácteos com elevados valores nutricionais, com aromas e sabores únicos. Neste estudo, foram caracterizadas as propriedades físico-químicas, sensoriais e microbiológicas do queijo fresco elaborado com as plantas amazônicas ajo de monte (*Mansoa alliacea*; (Lam.) A.H.Gentr) e culantro (*Eryngium foetidum* L.). Os queijos foram elaborados com ambas as espécies (amostra seca e extrato etanólico) a 5 % e 25 %, sob um delineamento experimental inteiramente casualizado com arranjo fatorial 23, com três repetições e 24 unidades experimentais. Nos queijos foram determinadas as propriedades físico-químicas estabelecidas na Norma NTE INEN 1528 (humidade, cinzas, matéria seca, proteínas, gordura, pH, acidez, teor de lactose, ácido lático, cloretos). A análise sensorial foi realizada por um painel não treinado. A qualidade microbiológica foi avaliada no queijo selecionado no teste de preferência, de acordo com a NTE INEN 1528. Os tratamentos afetaram o teor de cinzas (3,20 %), o pH (5,95), a umidade (55,28 %), os sólidos totais (42,20 %) e as proteínas (20,84 %). Os queijos QF7 (extrato seco de coentros do mato, 5 %) e QF3 (extrato seco de alho do mato, 5 %) apresentaram a mediana de aceitação mais elevada, correspondente a “gosto muito”, tendo o QF7 recebendo a aceitação mais elevada (71 %). O queijo fresco apresentou um elevado teor de proteínas, gorduras e cálcio, bem como uma qualidade microbiológica adequada, o que o caracteriza como um alimento calórico e nutritivo.

Palavras-chave: extractos de plantas, análise bromatológica e microbiológica, avaliação sensorial.

Introduction

Cheese is one of the most popular foods in the Ecuadorian market; according to Pulso Ecuador (Consulting Company), 84.3 % of urban households in the 15 main cities regularly consume this product (INEC, 2021).

The nutritional value of cheeses is unquestionable due to the significant amount of protein and fatty acids they provide to the daily diet. Nowadays there is a greater awareness of its components and consequently of the types and quantities that should be consumed to obtain a healthy and balanced diet.

In recent years, efforts have been made to produce cheeses with greater health benefits (Nogueira *et al*., 2018), with reduced fat and reduced-sodium cheeses being marketed (Talbot-Walsh *et al*., 2018).

The fortification of dairy products with plants native to the Ecuadorian Amazon could help provide dairy-based foods with high nutritional values, in addition to imparting unique aromas and flavors, and in this way, the nutritional properties and beneficial effects on health provided by plants would be exploited (El-Sayed and Youssef, 2019).

Most of the plants found in the Ecuadorian Amazon have not been studied, especially in Pastaza, a province where there are countless plants that throughout history have been consumed by the natives (Nieto and Caicedo, 2012), among which the following stand out: wild garlic (*Mansoa alliacea;* (Lam.) A.H.Gentr) and culantro (*Eryngium foetidum* L.).

Wild garlic is used as an aromatic spice and as a popular natural medicine to cure various diseases such as blood circulation and blood pressure, it has also been used as an anti-inflammatory, sedative, and natural energizer (Sanchez, 2015). Additionally, wild garlic is used in gastronomy for its aroma, which is perceived mainly in the root and tender leaves, its flavor and its use as a condiment are attributed to the organosulfur compounds that are responsible for the smell and typical flavors of garlic.

On the other hand, culantro is a little-known plant from the Ecuadorian Amazon and is used in the preparation of some processed foods, especially for its concentrated aroma. It is considered as a natural therapeutic alternative to relieve the flu, treat diabetes, constipation, fever, and stimulate appetite (Palmarola, 2012).

Trends in the food industry in recent years include the use of compounds with biological activity, preferably of plant origin (Cenobio-Galindo *et al*., 2017). This interest, both from industry and consumers, has increased and has given rise to the concept of functional food (FF), which refers to foods or ingredients that improve the general state of health and/or reduce the risk of disease (Yang *et al*., 2015; Younesi and Ayseli, 2015). In this regard, the study of the native plants of the Ecuadorian Amazon could contribute significantly to scientific knowledge, in the creation of new functional products and their application in the food industry, for the benefit of human beings (Lalama *et al*., 2016) considering that studies have shown the antioxidant and antimicrobial potential of some plant extracts (Bezerra *et al*., 2022).

Based on the above, the objective of this study was the characterization of the physicochemical, sensory, and microbiological properties of fresh cheese made with the Amazonian plants *Mansoa alliacea* and *Eryngium foetidum* in Pastaza, Ecuador, incorporated into curd as an innovative ingredient, destined to be a natural fortifier due to its nutritional properties.

Materials and methods

The fresh cheese was prepared with pasteurized whole milk, rennet, and calcium chloride ($CaCl_2$), added to form the curd, following the flowchart described in figure 1.

The dairy industry (LACTO) of Ecuador, supplied the whole milk after heat treatment to guarantee the safety of the product to be made (65 °C/30 min), the cheese was manufactured in the laboratories of Agroindustry, Bromatology, Chemistry and Biology, attached to the Department of Earth Sciences at the State Amazonian University (UEA) according to the processing technique of González (2002). Curd was made by adding calcium chloride (20-30 mL) diluted in 1/4 cup of water to the milk (38-39 °C), followed by rennet (7-10 mL) also diluted in 1/4 cup of water, the milk was left to rest for 20-30 min. Subsequently, a knife was introduced to verify that it was perfectly curdled. The curd was cut into squares (~2 cm) and separated from the whey with a previously sterilized tissue (a process carried out according to the INEN 1528 standard (INEN, 2012)). Subsequently, the dough was turned with a stirring paddle and left to rest (10 min) to complete the draining (70-80 %). It was washed with potable water (35 °C) and salt (400-500 g) was added. It was then molded with PVC molds (4.5 cm Ø and 2 cm high). Finally, wild garlic and culantro were added, and eight formulations were prepared according to the description in table 1.

The wild garlic (*Mansoa alliacea*) and culantro (*Eryngium foetidum*) used in the production of fresh cheese were grown at the "Centro de Investigación, Postgrado y Conservación Amazónica (CIPCA)" of the State Amazonian University (Carlos Julio Arosemena Tola Canton, Napo Province, Ecuador).

Table 1. Treatments used in the production of functional fresh cheese.

Ingredients	Sample type	(% m/m)	Treatments
Wild garlic (*Mansoa alliacea*)	Ethanolic extract	5	QF1
		25	QF2
	Dry sample	5	QF3
		25	QF4
Culantro (*Eryngium foetidum*)	Ethanolic extract	5	QF5
		25	QF6
	Dry sample	5	QF7
		25	QF8

Finally, the cheese was turned (3 times/20 min), entangled and pressed for two (2) hours, and stored in polyethylene bags at 5°C for five days. A total of 24 cheeses were made with an average mass of 454 g each. Samples of each formulation were analyzed in triplicate.

Physicochemical analysis

The physicochemical parameters established in the NTE INEN 1528 Standard were evaluated, according to the AOAC methods (AOAC, 1995). The moisture content was determined by the gravimetric method (AOAC, 925.09), as well as the ash content (AOAC, 923.03), and proteins were evaluated using the Kjeldahl method (AOAC, 920.105). The Werner-Schmid technique (ISO 1735:2004) (ISO, 2004) was used for fat content. For total solids content, the same sample from the moisture measurement was used (AOAC, 1995). For ionic acidity (pH), a potentiometer (Orion brand) was used with direct immersion of the electrode in the cheese (Covenin, 1977). The lactose concentration was determined using the Lane-Eynon volumetric method, the lactic acid content by direct titration with a titrated sodium hydroxide solution (AOAC, 1995), the

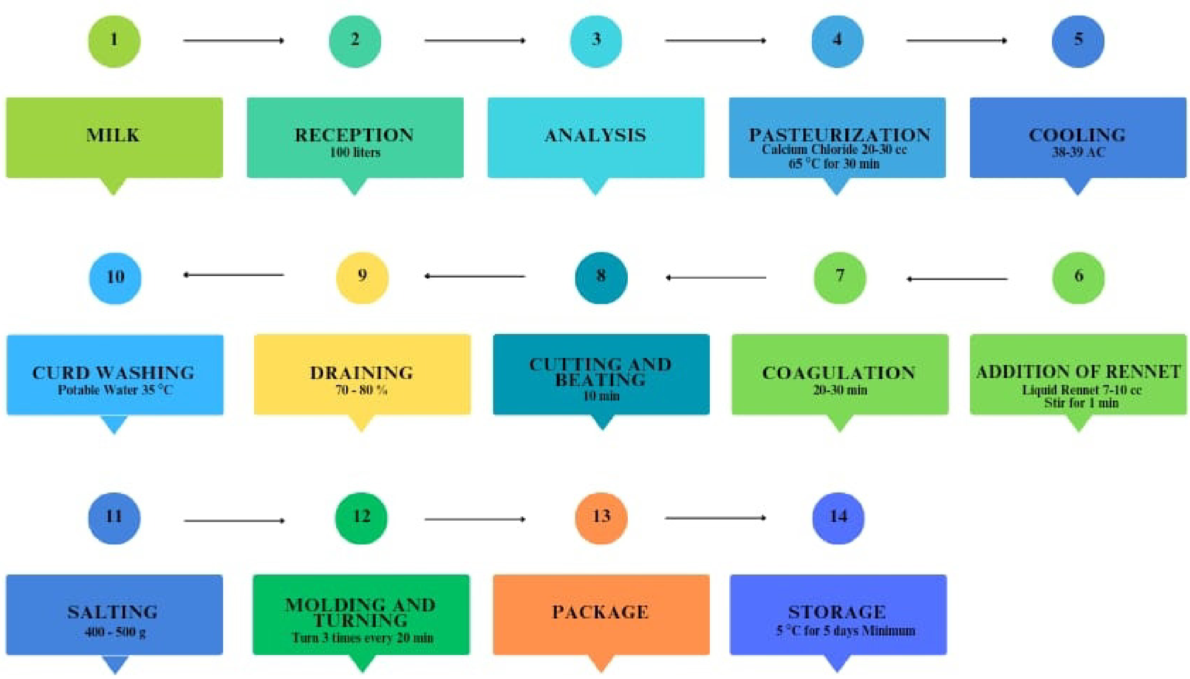

Figure 1. Flowchart of the production stages of fresh cheese made from cow's milk (*Bos taurus*) fortified with *Mansoa alliacea* (Lam.), A.H. Gentry (wild garlic) and *Eryngium foetidum* L. (culantro).

chloride content was evaluated using Mohr's direct titration method (Fischer and Peters, 1971), and the calcium content was evaluated from the ashes obtained by titration with potassium permanganate ($KMnO_4$) (AOAC, 2012).

Sensory Evaluation

A randomly selected untrained sensory panel (100 judges) was used to determine sensory acceptance and preference of fresh cheese (QF1, QF2, QF3, QF4, QF5, QF6, QF7, and QF8). Samples from each treatment were randomly coded with three digits and presented individually to the untrained sensory panel (Watts *et al*., 1992); the analysis was carried out over three days. A 10-point hedonic scale (ranging from 10, I like it extremely, to 1 I dislike it extremely) was used for the quantitative evaluation of the sensory attributes of taste, color, smell, and texture (Saltos-Saltos, 2010) and general acceptance. On the other hand, preference was evaluated at different times and only the two best fresh cheeses obtained from the combination of the treatments evaluated were used. The untrained sensory panel responded to the question "Which of the two samples do you prefer?", and also commented on the sensory attributes of the product (Saltos-Saltos, 2010).

Microbiological evaluation

The microbiological quality was assessed in the fresh cheese selected in the preference test, following the provisions of the Ecuadorian standard for fresh unripened cheeses (NTE INEN 1528, 2012). The sample of each treatment was subjected to serial dilution (10-3); in three previously sterilized Petri dishes, one (1) mL per plate of each dilution was added and then 20 mL of culture medium (potato dextrose agar, Bioxon brand) was added, and incubated at 25 ± 1 °C, for 72 ± 2 h (NTE INEN 1529-10; INEN, 2013) for one, two or three days in the case of molds and yeasts. Samples were cultured on nutrient agar medium (Bioxon brand) to allow the proliferation of aerobic mesophilic bacteria, at 35 ± 2 °C, for 48 ± 2 h and counted at 24 and 48 h (NOM-092-SSA-1994).

For the determination of coliforms, samples were incubated on crystal violet, neutral red, and bile agar with glucose (VRBG), and incubated at 37 ± 1 ºC for 24 ± 2 h (NTE INEN 1529-13; INEN, 2013). For the determination of *Escherichia coli,* 3M Petrifilm *E. coli* plates were incubated at 48 °C, for 4 h, counting was performed after 24 ± 2 h, then an additional 24 ± 2 h were incubated for counting (AOAC 991.14). The growth of *Salmonella* was carried out following the methodology described by the Ecuadorian technical standards INEN 1529-15 (INEN, 2013).

Experimental design and statistical analysis

The experimental design was totally randomized with factorial arrangement 2^3, with three replications and 24 experimental units. According to the Shapiro-Wilk test, variables with non-normal distributions were transformed with natural logarithm; homogeneous variables were transformed using Levene's test. ANOVA and Tukey's test were used for multiple comparisons of means at 5 % for treatments that had statistically significant differences in their means. In the sensory analysis, the medians of the ranges were compared using Friedman's non-parametric test during the three days. Two treatments with the highest median (scale, 1 to 10) were selected, and the one with the highest percentage was selected in the preference test. The SPSS software, version 24, was used to analyze the data.

Results and discussion

Physicochemical properties

The results of the physicochemical analysis (table 2) in the cheese samples, in relation to moisture content, total soluble solids, calcium, protein, and fat, did not follow a normal distribution (Shapiro-Wilk; $p<0.05$), so they were transformed into logarithmic form and subsequent analysis of variance (ANOVA).

Highly significant differences ($p<0.001$) were found between the treatments for the variables ash, pH, moisture, total solids, and protein. The protein content, total solids, and pH were higher for QF8, concerning the other treatments (table 2), while the highest ash and total solids content, as well as the lowest moisture content, were for QF4. The moisture content of fresh cheeses such as QF4, QF8, QF7, and QF3 was low (Table 2) but higher than the range reported by Guzmán *et al*. (2015) and by Bermudez-Beltrán *et al*. (2020). These cheeses themselves are among those classified as semi-soft (65 %) by Díaz *et al*. (2017) in their study on fresh cheeses from Toluca, Mexico. The moisture content in cheeses with ethanolic extract can affect shelf life and storage due to the possible loss of protein hydration water and firmness due to compaction and interaction of protein micelles (Castro *et al*., 2016). The moisture content of fresh cheeses is within the limits established by the INEN Standards (2012).

Compared to the other treatments, QF4 had the highest mean ash concentration (table 2). The lowest mean ash content in QF2 (table 2) was lower than the value reported by Díaz *et al*. (2017), with 3.30 % ash, determined in cheeses marketed in fixed and popular markets in Toluca in Mexico, but was higher than the ash content reported by

Table 2. Physicochemical analysis of fresh cheese made with wild garlic (*Mansoa alliacea*) and culantro (*Eryngium foetidum*), added as ethanolic extract and dry sample at different concentrations (5 and 25 %).

Parameter	Treatment							
	QF1	QF2	QF3	QF4	QF5	QF6	QF7	QF8
pH	5.81^{b}	5.80^{b}	5.88^{bc}	5.52^{a}	5.79^{b}	5.71^{b}	5.95^{bc}	5.93^{bc}
Chlorides (%)	1.60	1.60	1.70	1.72	1.67	1.61	1.75	1.75
Lactose (%)	1.83	1.81	1.90	1.92	1.84	1.84	1.90	1.90
Lactic acid	0.23	0.21	0.23	0.24	0.23	0.24	0.26	0.27
Tot Solids. (%)	40.91^{a}	40.84^{a}	42.00^{b}	42.03^{b}	40.88^{a}	40.90^{a}	42.05^{b}	42.20^{b}
Calcium (%)	1.93	1.90	2.10	2.11	1.95	1.88	2.11	2.13

QF: treatment. Different letters in the row show significant differences ($p\leq0.05$), means according to Tuckey's test. Each value represents 3 evaluations.

Anchundia *et al*. (2019) for kneaded cheese (2.52 to 2.91 %) from Ecuador and the one reported by Bermudez-Beltrán *et al*. (2020) in Swiss cheese made from the fruit of the plant *Physalis peruviana* L., fortified with moringa leaves (*Moringa oleifera*) in powder and gelatin form.

The higher the concentration of ash in QF4 cheese, the higher the overall mineral and organic matter content (Komansilan *et al*., 2021). This variable is frequently used to determine the mineral content of milk and dairy products (Himed-Idir *et al*., 2021); indicates that the minerals of the finished product may be affected by the brine used (Komansilan *et al*., 2021). In this regard, Pulido *et al*. (2018), noted that the main components are calcium, as well as phosphorus, and traces of iron.

The protein content in fresh cheese ranged from 20.10 to 20.84 %, with higher values in QF8 and QF7. This is consistent with previous studies (Pulido *et al*., 2018), but differs from Ecuadorian kneaded cheese (Anchundia *et al*., 2019). Cheeses with rosemary (*R. officinalis*) powder (Himed-Idir *et al*., 2021) or *A. unedo* extract (Masmoudi *et al*., 2020) had higher protein content. As well as in the Swiss cheese made by Bermudez-Beltrán *et al*. (2020) with the fruit of the plant *P. peruviana*, fortified with moringa (*M. oleifera*) leaves in powder and gelatin form (41.06 % - 41.83 %). The Ecuadorian technical requirements for protein content are 18%, so the samples evaluated meet these requirements (INEN, 2012).

There were no significant differences in fat content (table 2). However, it was between 20.11 and 20.84 %, so it can be categorized as semi-skimmed or low-fat fresh cheese because its fat level is higher than 20 and less than 45 %, according to the INEN 1528 standard (INEN, 2012), which defines it based on the crude fat content. Bermudez-Beltrán *et al*. (2020) reported lower fat content (3.85 - 4.10 %) in Swiss cheese made from the fruit of the plant *P. peruviana*, fortified with moringa leaves (*M. oleifera*) in powder and gelatin form.

The ionic acidity (pH) of the cheese samples depended on the type of plant with which it was fortified. QF7, QF8, and QF3 had the highest ionic acidity values (table 2), while QF4 had the lowest. These values are higher than those of cheese made from cow's milk (Diaz *et al*., 2017). Conversely, studies conducted by Himed-Idir *et al*. (2021) did not find significant differences in pH between the analyzed samples of fresh cheese fortified with ethanolic extract and the dry sample of *R. officinalis*. The pH of cheese affects the microbiological quality and texture since a pH close to neutrality affects the degradation and proliferation of bacteria.

A pH higher than the isoelectric point favors cheeses with higher moisture (Castro *et al*., 2016), as observed in the present study (table 2). The addition of ethanolic extract resulted in a lower pH for the ethanolic extract compared to the dry sample (table 2). El-Bialy *et al*. (2016) did not find differences between the aqueous extract and the oil of *O. basilicum*, but they did find a decrease in the pH value during the storage time.

In terms of total solids content, the highest mean corresponded to QF8, QF7, QF4, and QF3, treatments that included the addition of dry samples (table 2) for both concentrations and species evaluated, which in turn corresponded to the lowest moisture content (Tunick, 2023). Likewise, it was observed that the highest content of total solids (table 2) corresponded to the highest content of protein and fat in QF8 and QF7 (Felix *et al*., 2021).

Affective test of acceptance

Sensory analysis, according to the application of the Friedman test of median ranks, showed highly significant differences ($p<0.001$) between the treatments for all the attributes evaluated table 3).

Table 3. Sensory analysis of fresh cheese made with wild garlic (*Mansoa alliacea*) and culantro (*Eryngium foetidum*).

Treatment	Taste	Smell	Color	Texture	General Acceptance
QF1	6.00	6.00	6.00	6.00	6.00
QF2	6.00	5.00	5.50	5.00	5.25
QF3	9.00	9.00	9.00	9.00	9.00
QF4	6.00	6.00	5.00	5.00	5.50
QF5	6.00	6.00	6.00	6.00	6.00
QF6	6.00	6.00	6.00	6.00	6.00
QF7	9.00	9.00	9.00	9.00	9.00
QF8	6.00	6.00	6.00	6.00	6.00

aNote: Sensory scores according to the 10-point hedonic scale, where 1: I dislike it extremely, 2: I dislike it very much, 3: I dislike it moderately, 4: I dislike it slightly, 5: I neither like it nor dislike it, 6: I like it slightly, 7: I like it moderately, 8: I like it a lot, 9: I like it very much, and 10: I like it extremely. Treatments with the same letter are not statistically different for each sensory feature, according to Friedman test of median ranks at the significance level of $p<0.001$. Each value represents 100 assessments.

The highest median acceptance for flavor was for QF7 and QF3 (table 3), equivalent on the hedonic scale "I like it very much". It is important to note that fresh cheeses with QF7, QF8, and QF3 were the ones with the highest pH values (table 2), and therefore the lowest acid taste, which could explain the greater acceptance of QF7 and QF3 cheeses (Da Conceicao *et al*., 2007).

One of the scopes of this research was to obtain a distinctive taste and smell after the supplementation of fresh cheeses with wild garlic and culantro, as well as to provide a better taste for better acceptance by consumers. The general preferences (acceptability) for smell were for QF7 and QF3 (9, 9, respectively), equivalent on the hedonic scale "I like it very much".

According to Waizel-Bucay and Waizel-Haiat (2019), odor is directly related to the secondary metabolites that plants produce, including flavonoids. On the other hand, Dwivedi *et al.* (1973) asserted that some minor precursors of taste, such as polyphenols, nucleotides, and carotenoid pigments, contribute to flavor.

In relation to color, QF7 and QF3 had the highest median acceptance score (table 3), equivalent on the hedonic scale "I like it very much". The parameters considered influenced the color of the product and, consequently, the level of acceptability of the panelists. The appearance of the final product was not pleasant for the panelists when a higher concentration (QF8) was added, possibly due to the green color produced by the incorporation of the plants (Kuikman and O'Connor, 2015).

The QF7 and QF3 cheeses had the highest median acceptance scores (Table 3) for texture, equivalent on the hedonic scale "I like it very much". QF7 and QF3 had lower moisture content and higher total solids, pH, and fat content (table 2); texture factors that support the increased acceptance of QF7 and QF3 by panelists. The lowest median acceptance of the texture attribute by the tasting panel (table 3) was for treatments with ethanolic extract, due to the higher moisture content (Ruvalcaba-Gómez *et al*., 2020) and lower pH (table 2).

Regarding general acceptance, the evaluated treatments presented a positive sensory acceptance concerning this attribute, with QF7 and QF3 standing out with the highest median acceptance score, while for QF2 and QF4 it was lower (mean sensory score: 5.25 and 5.50, respectively). Conversely, Kuikman and O'Connor (2015) found greater sensory acceptance of control than treatments incorporated with moringa (*M. oleifera*).

Affective test of preference

Of the 100 panelists who participated in the preference test, 71 % of participants selected QF7, compared to QF3 (29 %). The use of Amazonian plants had a very good acceptance, and the most successful way of incorporating them was as a 5 % dry extract.

Microbiological analysis of the fresh cheese selected in the preference test

The results of the microbiological evaluation carried out on the cheese selected in the sensory analysis are presented in table 4.

The results obtained were compared with the Ecuadorian Technical Standard NTE INEN 1528 (INEN, 2012), observing that the cheese of the QF7 treatment met the food safety parameters for human consumption. Considering the results, the main foodborne pathogens, such as *Salmonella* spp., were absent in the processed product; similarly, *E. coli*., Enterobacteriaceae, yeasts, and bacteria are below the permitted limit, indicating that the processed product is suitable for human consumption. Similar results were reported by Bermudez-Beltrán *et al*. (2020) who determined total coliforms, *E. coli*, molds and yeasts, *E. Aureos*, *Salmonella* spp., and *Listeria monocytogenes* in Swiss cheese with *uchuva*, a fruit of the plant *P. peruviana*, supplemented with moringa leaves (*M. oleifera*) in powder and gelatin form, the authors indicated that the products developed met food safety requirements.

Conclusion

The fresh cheese produced is high in protein, fat, and calcium, which makes it a caloric and nutritionally dense product. This, together with the management of good manufacturing practices and a high level of acceptance among tasters, makes fresh cheese with culantro, added as a 5 % dry sample, a necessary product within Ecuador's food strategies, allowing the potential of Amazonian resources to be valued.

Literature cited

Anchundia, M.A., Jácome, C., Domínguez, F., & Torres, F. (2019). Evaluación nutricional y fisicoquímica del queso amasado fabricado en la provincia del Carchi, Ecuador. *Revista Bases de la Ciencia, 4*(3), 55-66. Doi:10.33936/rev_bas_de_la_ciencia.v4i3.1857

AOAC. (1995). Official Methods of Analysis: Association of Official Analytical Chemists.15th Edition. Washington, USA.

AOAC. (2012). Official Method of Analysis: Association of Official Analytical Chemists. 19th Edition. Washington, USA.

Bermudez-Beltrán, K. A., Marzal-Bolaño, J.K., Olivera-Martínez, A.B., & Espitia, J.P. (2020). Cape Gooseberry Petit Suisse Chee incorporated with moringa leaf powder and gelatin. *LWT-Food Science and Technology, 123,* 109101. Doi:10.1016/j.lwt.2020.109101

Bezerra, M.L., Pontes, R.B., Oliveira, B., & Goncalves, T. (2022). Influencia del método de extracción en la actividad antioxidante del extracto acuoso de *Punica granatum* (granada). *Revista Cubana de Farmacia, 55*(1), 1-18. https://revfarmacia.sld.cu/index.php/far/article/view/582

Castro, A., Porras Atencia, O.O., Bermúdez, S.C., Velasco Sánchez, N.J., & Osorio Padilla, M.L. (2016). Detección de *Listeria* ssp. y *Salmonella* spp. en queso y su relación con las caraterísticas fisicoquímicas. *Revista Politécnica, 12*(23), 91-98. https://revistas.elpoli.edu.co/index.php/pol/article/view/903

Cenobio-Galindo, A.J., Rodriguez-Diaz, I., Salcedo-Hernandez, R., Hernandez-Fuentes, A.D., Quintero-Lira, A., & Campos-Montiel, R.G. (2017). Efecto de un microencapsulado con capacidad antioxidante en un queso funcional tipo oaxaca en su vida de anaquel. *Investigación y Desarrollo en Ciencia y Tecnología de Alimentos, 2*, 474–480. http://www.fcb.uanl.mx/IDCyTA/files/volume2/3/9/78.pdf

Comisión Venezolana de Normas Industriales Ministerio de Fomento (COVENIN). (1977). Determinación de acidez iónica (pH). Norma venezolana COVENIN 1151. Comisión Venezolana de Normas Industriales Ministerio de Fomento. Caracas. Venezuela. 8 pp.

Da Conceicao, E.R., Johanningsmeier, S.D., Drake, M.A., & McFeeters, R.F. (2007). A chemical basis for sour taste perception of acid solutions and fresh-pack dill pickles. *Journal of Food Science, 72*(6), S352-S359. Doi:10.1111/j.1750-3841.2007.00400.x

Díaz, E., Valladares, B., Gutiérrez, A., Arriaga, M., Quintero, B., Cervantes, P., & Velázquez, V. (2017). Caracterización de queso fresco comercializado en mercados fijos y populares de Toluca, Estado de México. *Revista Mexicana de Ciencias Pecuarias, 8*(2), 139-146. Doi:10.22319/rmcp.v8i2.4419

Dwivedi, B.K., Shahani, K.M., & Arnold, R.G. (1973). The role of enzymes in food flavors part I: dairy products. *Critical Reviews in Food Science & Nutrition, 3*(4), 457-478.Doi:10.1080/10408397309527150

El-Bialy, A.R., Gab-Allah, R.H., & El-Dardiry, A.I. (2016). Effect of adding water extract and essential oil of sweet basil on quality and different properties of soft cheese. *Journal of Food and Dairy Sciences, 7*(4), 239-246. Doi:10.21608/jfds.2016.42976

El-Sayed, S.M., & Youssef, A.M. (2019). Potential application of herbs and spices and their effects in functional dairy products. *Heliyon, 5*(6), e01989. Doi:10.1016/j.heliyon.2019.e01989

Felix, D., Wang, H., Czaja, T.P., van den Berg, F., Kirkensgaard, J.J.K., Ipsen, R., & Hougaard, A.B. (2021). Effects of homogenization and pH adjustment of cheese feed without emulsifying salt on the physical properties of high-fat cheese powder. *Powder Technology, 378*, 227-236. Doi:10.1016/j.powtec.2020.10.004

Table 4. Microbiological quality of the fresh cheese selected in the preference test.

Requirements	QF7	Reference data. NTE INEN 1528				
		n	m	M	c	Test method
Enterobacteriaceae, CFU.g-¹	6x10^{-3}	5	2x10^{2}	10^{3}	1	NTE INEN 1529-13
***Escherichia coli*, CFU.g-¹**	4x10^{-3}	5	<10	10	1	AOAC 991.14
***Salmonella*, 25 g**	Absence	5	Absence	-	0	NTE INEN 1529-15
Yeasts	Countless		-	-	-	-
Bacteria	17x10^{-3}		-	-	-	-

n: number of samples to be examined, m: maximum permissible index to identify the level of good quality, M: permissible index to identify the acceptable level of quality, c: number of permissible samples with results between m and M. Source: INEN (2012).

Fischer, R.B., & Peters, D.G. (1971). Valoraciones de precipitación: Valoración de Mohr. *In* R. B. Fischer y D. G. Peters (Eds.),*Compendio de Análisis Químico Cuantitativo* (pp. 228-229). México: Interamericana.

González, M. (2002). Tecnología para la elaboración de queso blanco, amarillo y yogurt. *Ciencia y Tecnologías de Alimentos Secretaria Nacional de Ciencias, Tecnología e Innovación Veraguas, Panamá*. 1-16. https://goo.su/VNTr99

Guzmán, L., Tejada, C., De la Ossa, Y., & Rivera, C. (2015). Análisis comparativo de perfiles de textura de quesos frescos de leche de cabra y vaca. *Biotecnología en el Sector Agropecuario y Agroindustrial, 13*(1), 139-147. https://revistas.unicauca.edu.co/index.php/biotecnologia/article/view/359

Himed-Idir, H., Mouhoubi, K., Siar, E.H., Halim, B., Mansouri, H., Adjeroud, N., Madani, J., & Boulekbache-Makhlouf, L. (2021). Effect of rosemary (*Rosmarinus officinalis* L.) supplementation on fresh cheese: Physicochemical properties, antioxidant potential, and sensory attributes. *Journal of Food Processing and Preservation, 45*(1), e15057. Doi:10.1111/jfpp.15057

Instituto Ecuatoriano de Normalización (INEN). (2012). Norma Técnica Ecuatoriana NTE INEN 1528:2012. Quesos frescos no madurados. Requisitos.

Instituto Ecuatoriano de Normalización (INEN). (2013). Norma Técnica Ecuatoriana NTE INEN 1529-7:2013. Control microbiológico de los alimentos. Determinación de microorganismos coliformes por la tecnica de recuento de colonias.

Instituto Ecuatoriano de Normalización (INEN). (2013). Norma Técnica Ecuatoriana NTE INEN 1529-15:2013. Control microbiológico de los alimentos. Salmonella. Método de detección.

Instituto Ecuatoriano de Normalización (INEN). (2014). Norma Técnica Ecuatoriana NTE INEN-ISO 166-49-2. Microbiología de productos alimenticios y alimentos para animales - Método horizontal para el conteo de Escherichia coli positiva a la β-glucuronidasa –Parte 2: Técnica de recuento de colonias a 44 °C usando 5 bromo-4-cloro-3-indolil β-d-glucurónido (ISO 16649- 2:2001, IDT).

Instituto Nacional de Estadísticas y Censos (INEC). *Fichas Tecnicas de Bienes y Servicios.*Https://aplicaciones2.ecuadorencifras.gob.ec/SIN/co_alimentos.php?id=22251.00.08

ISO 1735:2004. (2004). Cheese and processed cheese products. Determination of fat content. Gravimetric method (Reference method).

Komansilan, S., Rosyidi, D., Radiati, L.E., Purwadi, P., & Evanuarini, H. (2021). The physicochemical characteristics and protein profile of cottage cheese produced by using crude bromelain enzyme extracted from *Ananas comosus*. *Current Research in Nutrition and Food Science Journal, 9*(2), 578-587. Doi:10.12944/CRNFSJ.9.2.21

Kuikman, M., & O'Connor, C.P. (2015). Sensory evaluation of Moringa-probiotic yogurt containing banana, sweet potato or avocado. *Journal of Food Research, 4*(5), 165-171. Doi:10.5539/jfr.v4n5p165

Lalama, J., Montes, S., & Zaldumbide, M. (2016). Etnobotanica de las plantas medicinales en el cantón Tena para contribuir al conocimiento, conservación de la biodiversidad vegetal en la región Amazónica. *Revista Científica Dominio de la Ciencia, 2*(2), 26-48. https://dialnet.unirioja.es/servlet/articulo?codigo=5761575

Masmoudi, M., Ammar, I., Ghribi, H., & Attia, H. (2020). Physicochemical, radical scavenging activity and sensory properties of a soft cheese fortified with *Arbutus unedo* L. extract. *Food Bioscience, 35*, 100579. Doi:10.1016/j.fbio.2020.100579

Nieto, C., & Caicedo, C. (2012). Análisis reflexivo sobre el desarrollo agropecuario sostenible en la Amazonía Ecuatoriana INIAP-EECA. INIAP, 127. http://repositorio.iniap.gob.ec/handle/41000/3791

Nogueira, E.B., Costa-Lima, B.R.C., Torres, F., Regazone, A.V., Melo, L., Franco, R.M., & Cortez, M.A.S. (2018). Effect of potassium-based emulsifying salts on the sensory and physicochemical parameters of low-sodium spreadable processed cheese. *International Journal of Dairy Technology, 71*(3), 717-722. Doi:10.1111/1471-0307.12519

Norma Oficial Mexicana NOM-092-SSA-1994, bienes y servicios. Conteo de bacterias mesófilas aerobias. http://www.salud.gob.mx/unidades/ cdi/nom/092ssa14.html

Palmarola, A. (2012). Boletín de la Sociedad Latinoamericana y del Caribe de Cactáceas y otras Suculentas. *Sociedad Latinoamericana y del Caribe, 9*(1), 45.

Pulido, R., Pinzón, D.M., & Tarazona Díaz, M.P. (2018). Caracterización nutricional, microbiológica y sensorial de queso fresco. *Nutrición Clínica y Dietética Hospitalaria, 38*(3), 74-9.Doi:10.12873/383tarazona

Ruvalcaba-Gómez, J.M., Ruiz-Espinosa, H., Arteaga-Garibay, R.I., Rojas-López, M., Amador-Espejo, G.G., Anaya-Esparza, L.M., & Delgado-Macuil, R.J. (2020). Texture, physicochemical and sensory properties of artisanal Adobera cheese from Los Altos de Jalisco, a genuine Mexican cheese. *International Journal of Dairy Technology, 73*(2), 411-420. Doi:10.1111/1471-0307.12676

Saltos-Saltos, H.A. (2010). *Sensometría; Análisis en el desarrollo de alimentos procesados*. 1ra. Edición. Editorial Pedagógica Freire.

Sánchez, E. (2015). Estudio del ajo de monte (*Mansoa allicea*) y sus propiedades: su uso gastronómico y medicinal en la comuna Chiguilpe de Santo Domingo de los Tsáchilas. *Revista de Ciencia, Tecnología e Innovación, 2*(2), 185-193. https://www.redalyc.org/pdf/5646/564660011009.pdf

Talbot-Walsh, G., Kannar, D., & Selomulya, C. (2018). A review on technological parameters and recent advances in the fortification of processed cheese. *Trends in Food Science & Technology, 81*, 193-202. Doi:10.1016/j.tifs.2018.09.023

Tunick, M. H. (2023). Cheese Rheology and Texture. Chapter 9. *Handbook of Cheese Chemistry*. Doi:10.1039/BK9781839169908-00202

Watts, B.M., Ylimaki, G.L., Jeffery, L.E., & Elías, L.G. (1992). *Métodos sensoriales básicos para la evaluación de alimentos* (pp. 66-86). Centro Internacional de Investigación para el Desarrollo. Ottawa, Canadá. ISBN:0-88936-564-4. https://filadd.com/doc/metodos-sensoriales-basicos-para-la-eval-pdf

Waizel-Bucay, J., & Waizel-Haiat, S. (2019). Las plantas con principios amargos y su uso medicinal. ¿Un futuro dulce?. *Anales de Otorrinolaringología Mexicana, 64*(4), 202 - 228.https://otorrino.org.mx/ingresar-app/?download-id=2240

Yang, L., He, Q.S., Corscadden, K., & Udenigwe, C.C. (2015). The prospects of Jerusalem artichoke in functional food ingredients and bioenergy production. *Biotechnology Reports, 5*(1), 77–88. Doi:10.1016/j.btre.2014.12.004

Younesi, E., & Ayseli, M.T. (2015). An integrated systems-based model for substantiation of health claims in functional food development. *Trends in Food Science & Technology, 44*, 95-100. Doi:10.1016/j.tifs.2014.09.006