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ANTIOXIDANT ACTIVITY AND SENSORY EVALUATION OF COMMERCIAL GOAT MILK CHEESES

ACTIVIDAD ANTIOXIDANTE Y EVALUACIÓN SENSORIAL DE QUESOS COMERCIALES DE LECHE DE CABRA

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ABSTRACT

The aim of this study was to evaluate the antioxidant activity and the sensory preference of commercial goat milk cheeses. Different brands (N=6) of commercial goat milk (i.e., white, fresh and Feta-type cheeses) were evaluated for their antioxidant activity using the DPPH method. Sensory evaluation was conducted to determine the preference of the cheeses. Overall, the antioxidant activity of cheeses ranged from 158 to 233 μM of Trolox/mL. Particularly, it was observed that the Feta-type cheeses exhibited the lowest antioxidant activities, whereas white fresh-cheeses were those with highest antioxidant activities. The sensory preference of the cheeses was variable, being the most preferred a sample representative of each cheese type. This study demonstrates that these commercial goat milk cheeses are sources of potential antioxidant compounds.

Keywords: Goat Milk; Antioxidant; Commercial Cheese; Sensory Preference.

RESUMEN

El objetivo de este estudio fue evaluar la actividad antioxidante y la aceptación sensorial de quesos comerciales de leche de cabra. Se evaluaron diferentes marcas (N=6) de quesos comerciales de leche de cabra (i.e., quesos frescos blancos y tipos Feta) para determinar su actividad antioxidante utilizando el método DPPH. Se realizó una prueba de evaluación sensorial para determinar la preferencia de los quesos. En general, la actividad antioxidante de los quesos osciló entre 158 y 233 μM de Trolox/mL. En particular, se observó que los quesos tipo Feta presentaban las actividades antioxidantes más bajas,

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mientras que los frescos blancos eran los que mostraban las actividades más altas. Además, la preferencia sensorial de los quesos fue variable, siendo la muestra más preferida una de cada tipo de queso. Este estudio demostró que los quesos comerciales de leche de cabra son fuentes de potenciales compuestos antioxidantes.

Palabras clave: Leche de Cabra; Antioxidante; Queso Comercial; Preferencia Sensorial.

1. INTRODUCTION

In recent years, there has been a growing interest in the nutritional composition of goat milk and its derived products, which are not only appreciated for their distinct sensory profiles but also for their potential health benefits (Nayik et al., 2022). Besides, it has been reported that these goat milk products can exhibit some better qualities over cow's milk in several aspects including decreased allergenicity of their proteins, enhanced digestibility, and a higher presence of bioactive components (dos Santos et al., 2023; Nayik et al., 2022). From this perspective, several biologically active compounds occurring naturally or as a result of microbial activities during the fermentation process, have been described in goat milk and its derived products (e.g., bioactive peptides, polyphenols, fatty acids, γ-aminobutyric acid, and exopolysaccharides, among others) (Chávez-Servín et al., 2018; Hilario, Puga, Ocaña, & Romo, 2010; Kocak, Sanli, Anli, & Hayaloglu, 2020; Redruello, Szwengiel, Ladero, del Rio, & Alvarez, 2022).

In this context, goat cheese is one of the most significant dairy products worldwide and it has been recognized as a health food because of its profile of the aforementioned bioactive compounds and its nutritional composition (Nayik et al., 2022; Santiago-López et al., 2018). Particularly, these bioactive compounds can exhibit diverse health benefits including antihypertensive, anti-inflammatory, antimicrobial, antidiabetic, and antioxidant (dos Santos et al., 2023; Nayik et al., 2022). However, while several studies have explored the bioactivity of goat cheese, its antioxidant activity remains largely underexplored (Barac et al., 2016; Chávez-Servín et al., 2018; Hernández-Galán et al., 2017; Hilario et al., 2010). Given that antioxidants play a crucial role in prolonging cheese shelf-life and mitigating oxidative stress in the human body, understanding the antioxidant potential of goat cheese could provide valuable insights into its health-promoting properties. Furthermore, as consumer demand for antioxidant-rich foods grows, assessing the antioxidant activity of goat cheese is essential for producers to meet market expectations and differentiate their products. Despite the increasing recognition of goat cheese as a functional food, studies evaluating both its antioxidant properties and sensory acceptance in commercial varieties are still limited. Therefore, this study aims to bridge this gap by evaluating the antioxidant activity of commercial goat milk cheeses and their overall sensory preference, thus contributing to a better understanding of their health benefits and market potential.

2. MATERIALS AND METHODS

2.1. Materials

Commercial goat milk cheeses were obtained from at local store in Lerma de Villada, state of Mexico, Mexico. Feta (i.e., Laclette and Lyncott) and white, fresh (i.e., Laclette, Carol, Flaveur and Extra Special) goat cheeses were sampled three times. Chemicals used for the analysis were of analytical grade obtained from Sigma-Aldrich (St. Louis, MO, USA). The cheese brands and their proximate composition are shown in Table 1.

Table 1. Proximate composition of commercial goat milk cheeses.

Component	Cheese types					
	Laclette Feta	Lyncott Feta	Flaveur white fresh	Laclette white fresh	Carol white fresh	Extra Special white fresh
Protein (g/100 g)	21	21	14.1	15	15	15.3
Fat (g/100 g)	20	20	18.1	24	24	19.7
Carbohydrate (g/100 g)	9	9	7.2	9	9	8
Sodium (mg/100 g)	560	560	344.6	510	510	510
Energy (kcal/100 g)	300	300	248.5	312	312	270.5

Data obtained from the nutrition facts label of each goat milk cheese. In all the cheeses the dietetic fiber, trans fat, and added sugar values were zero.

2.2. Preparation of water-soluble extracts of peptides

Water-soluble extracts (WSE) of peptides present in the cheeses were prepared according to Aguilar-Toalá et al. (2022) with some modifications. Cheese samples (60 g) were thoroughly homogenized in 120 mL of distilled water by magnetic stirring (Stable Temp Cole-Parmer IL, USA) (5 ºC, 300 rpm for 15 min). The resulting homogenates were held at 4 ºC for 1 h. The insoluble material was then separated by centrifugation at 5000 x *g* (Sorvall Lynx, Thermo Fisher Scientific) for 10 min at 4 ºC. Finally, the supernatants were filtered using a Whatman No. 42 filter paper, to remove residual-suspended fat and residual solids/ impurities, and stored in the dark at -20 °C until further use.

2.3. Determination of antioxidant activity

The antioxidant activity of WSE based on their radical scavenging properties was carried out by using the DPPH method according to Centenaro et al. (2014). Briefly, a working solution of DPPH (0.1 mM) was prepared in ethanol (80%) and Trolox (6-hydroxy-2,3,7,8-tetramethylchroman-2-carboxylic acid) was used as a standard to prepare a reference curve (20 to 250 µM). Next, 1 mL of DPPH in ethanol was mixed with 2 mL of WSE (1 %) or deionized water (for blank). The absorbance was measured in triplicate spectrophotometrically at 517 nm.

2.4. Sensory evaluation

Regular consumers of fermented dairy products were recruited at the Metropolitan Autonomous University – Lerma Campus. Panelist pool (N=20) consisted of university students, lecturers, and employees (ages ranging from 18 to 50 years). Selection was based on voluntary participation and basic consumer profiling through a brief questionnaire, which confirmed that participants consumed fermented dairy products at least once a week. For the sensory test, a preference ranking test was applied in order to select the most preferred cheese. Panelists were given the six cheese samples served in 3-digit coded cups,

in monadic, sequential order and asked to rank the samples from most preferred to least preferred. Panelists were given water and unsalted crackers to cleanse their palate in between samples.

2.5. Statistical analysis

The statistical analysis of experimental data was made using ANOVA followed by Turkey's test to compare the results among treatments. Differences were considered to be significant when $P<0.05$. The sensory data was analyzed using the Friedman test. All analyses were performed using the Minitab software version 19.1 (Minitab Inc., Pennsylvania, USA).

3. RESULTS AND DISCUSSION

Overall, the presence of antioxidants in foods is vital for maintaining both food quality and human health. A variety of antioxidant-rich foods incorporated in the diet can help promote overall well-being and lower the risk of some chronic diseases (Ponnampalam et al., 2022). Our results show that all commercial goat milk cheeses exhibited antioxidant activity ranging from 158 to 228 μM of Trolox/mL. Interestingly, it was observed that the Feta-type cheeses exhibited the lowest antioxidant activities (<200 μM of Trolox/mL) among all the samples analyzed. On the other hand, all the white, fresh goat cheeses showed the highest antioxidant activities (>214 μM of Trolox/mL). This difference in antioxidant activity can be attributed to the extent of proteolysis during cheese ripening. Feta and other brined cheeses undergo lower proteolysis compared to other cheese types, resulting in a reduced release of bioactive peptides with antioxidant properties. For example, Nega and Moatsou (2012) found that the proteolysis in Feta cheese was the lowest (*ca*. 13.8%) among different Greek cheese varieties such as Gruyere-type (i.e., graviera kritis and naxou), hard type (i.e., kefalograviera, san michali), and pasta filata type (i.e. kasseri, metsovone), which are reported to have more than 17% proteolysis.. Similarly, these authors found the same behavior for the peptide profiles, where those in Feta cheese was those with the lowest content of peptides. Thus, with this in mind it is plausible that the lower presence of antioxidant bioactive peptides in Feta cheese analyzed in our study is due to this phenomenon, and therefore, they showed lower antioxidant activity. In a similar study, it was observed that among six different cheese varieties (e.g., Karish, Feta, Domiati, Ras, Gouda, Edam) evaluated for their antioxidant activity, Feta cheese was one of those that showed lower antioxidant activity, as well as exhibited the lowest protein content (Helal & Tagliazucchi, 2023). In this context, Meira et al. (2012) reported similar findings about the antioxidant activity of Feta cheese, which exhibited lower activity compared with Roquefort, Pecorino, Pecoridno-sardo, and Cerrillano cheeses.

Our findings contribute to the current understanding of the relationship between cheese type, proteolysis, and antioxidant activity (see Table 2), reinforcing the idea that fresh, non-brined goat cheeses may be a better dietary source of antioxidant compounds. This knowledge can be valuable for cheese producers aiming to develop functional dairy products with enhanced health benefits.

It has been reported that certain components, mainly generated during the fermentation process in cheese are responsible for their antioxidant activity. Some examples of bioactive compounds found in cheese are peptides, exopolysaccharides, fatty acids, organic acids, vitamins, γ-aminobutyric acid, and conjugated linoleic acid, which are reported to have antioxidant properties (Fardet & Rock, 2018; Santiago-López et al., 2018; Stobiecka, Król, & Brodziak, 2022). However, further studies are necessary to identify which of these bioactive compounds are responsible for the antioxidant activity exhibited by the cheeses analyzed in the present study.

Table 2. Antioxidant activity (μM of Trolox/mL) of water-soluble extracts from commercial goat milk cheeses

Cheese	*DPPH method*
Laclette Feta	195.63 ± 9.41 b
Flaveur white fresh	227.24 ± 11.07 a
Laclette white fresh	214.47 ± 14.66 ab
Carol white fresh	233.33 ± 10.84 a
Lyncott Feta	158.57 ± 20.41 c
Extra Special white fresh	228.04 ± 20.18 a

Values are mean ± standard deviation of triplicate determinations. Different lowercase letters indicate statistical difference (P<0.05) among cheeses.

On the other hand, according to our preference-ranking test, the results of total rank sum obtained by Friedman´s test show that the Carol white fresh cheese was the most preferred (P<0.05), followed by Laclette Feta and Extra Special white fresh. Interestingly, two of the most preferred samples (i.e., Carol and Extra Special white fresh) are among those cheeses that exhibited highest antioxidant activity. This finding is significant because it suggests that cheeses with high antioxidant activity are not only beneficial from a functional perspective but are also well-accepted by consumers. These results reinforce the potential of fresh goat cheeses as functional foods, offering both health benefits and desirable sensory attributes. Given the increasing consumer interest in antioxidant-rich foods, this study provides useful insights for cheese manufacturers aiming to develop and market products with enhanced bioactivity and consumer appeal.

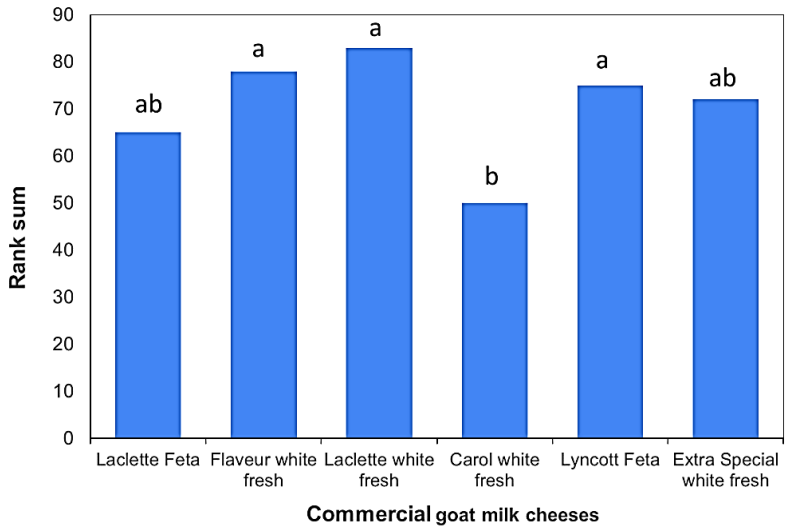

Figure 1. Preference ranking scores (N=20) of six commercial goat milk cheeses. Lower rank sum indicated higher preference and higher rank sum indicated lower preference. Different letters on top of the bars indicate significant differences (P<0.05) according to Friedman´s test.

4. CONCLUSIONS

This study highlights the antioxidant potential of six commercial goat milk cheeses, which are also very appreciated by consumers because of their sensory properties. The antioxidant activity, measured using the DPPH method, varied among different type of cheeses, being the white, fresh type cheeses those with the highest activity; whereas the feta-type cheeses showed the lowest antioxidant activity. These findings demonstrate a link between cheese type, proteolysis, and antioxidant activity, reinforcing that fresh, non-

brined goat cheeses may serve as better dietary sources of antioxidants than Feta-type cheeses. Notably, two of the most preferred cheeses also exhibited high antioxidant activity, highlighting the dual importance of antioxidant-rich cheeses for both health benefits and consumer acceptance. This insight is valuable for product development and marketing strategies, as it suggests that antioxidant content may enhance consumer appeal. Furthermore, this study provides new evidence on the antioxidant potential of commercial goat cheeses, addressing a research gap in the bioactivity of these dairy products. However, further studies are needed to identify the specific bioactive compounds responsible for their antioxidant properties. It is also important to evaluate these properties using additional *in vitro* antioxidant methods and conduct sensory acceptability tests to determine the degree of liking and acceptance of different sensory attributes in each cheese type.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Conceptualization: José Eleazar Aguilar-Toalá; methodology: Montserrat Arroyo-Rodeo, Jessica Gutiérrez-Salazar; validation: José Mariano García-Garibay, Judith Jiménez-Guzmán, María de la Luz Zambrano-Zaragoza; Formal analysis: Montserrat Arroyo-Rodeo, Jessica Gutiérrez-Salazar, José Eleazar Aguilar-Toalá, Andrea Liceaga; research: Montserrat Arroyo-Rodeo, Jessica Gutiérrez-Salazar; resources: José Mariano García-Garibay, Judith Jiménez-Guzmán, María de la Luz Zambrano-Zaragoza; writing - Original Draft: Montserrat Arroyo-Rodeo, Jessica Gutiérrez-Salazar, Andrea Liceaga, José Eleazar Aguilar-Toalá; writing - Review and Editing: María de la Luz Zambrano-Zaragoza, Andrea Liceaga, Ildefonso Guerrero-Encinas, Rosy Gabriela Cruz-Monterrosa; supervision: Rosy Gabriela Cruz-Monterrosa, Monzerrat Rosas-Espejel, María de la Luz Zambrano-Zaragoza, Andrea Liceaga, Ildefonso Guerrero-Encinas; funding Acquisition: José Eleazar Aguilar-Toalá, Rosy Gabriela Cruz-Monterrosa.

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The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

DATA AVAILABILITY

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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