Small Ruminant Research 124 (2015) 95–100

Contents lists available at ScienceDirect

Small Ruminant Research

journal homepage: www.elsevier.com/locate/smallrumres

Short communication

# Influence of milk ultrafiltration on Ca, Mg, Zn and P levels in fermented goats' milk

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ARTICLE INFO

*Article history:*
Received 4 December 2014
Received in revised form 8 January 2015
Accepted 9 January 2015
Available online 17 January 2015

*Keywords:*
Minerals
Milk ultrafiltration
Fermented goats' milk

ABSTRACT

The application of ultrafiltration process has been proposed and used as an alternative to the addition of powdered milk in the production of fermented goats' milk. However, data about the effects of this process on nutritional properties of the final products are scarce. We evaluated the influence of milk ultrafiltration on Ca, Mg, Zn and P levels in experimental fermented goats' milks, in comparison to the raw milk and commercial fermented goats' milks. Inductively coupled plasma optical emission spectrometry (ICP-OES) was used as analytical technique for Ca, Mg and Zn, and UV/VIS spectrophotometry for P. Ca and Mg levels in our experimental fermented products were significantly higher than in raw milk. In addition, higher contents of Ca, Zn and P were observed in the experimental ultrafiltered fermented goats' milk, in comparison to the commercial ones. Significant linear correlations among Ca, Mg, Zn and P levels demonstrated the existence of important similarities in their behaviours in these products. It was concluded that ultrafiltration increases Ca, Zn and P concentrations and our products may constitute a better source of minerals compared to other products already on the market. Ultrafiltration could represent a great advance to concentrate milk for higher nutritional values fermented products manufacture.


## 1. Introduction

Goat milk has gained an increasingly important role in the human diet, since it possesses certain properties which distinguishes it from cow milk and makes it a valuable alternative (Bergillos-Meca et al., 2013a; Navarro-Alarcón et al., 2011). Goat milk provides more short- and medium-chain fatty acids (i.e. caproic, caprylic and capric acids) and high-quality absorbable proteins than are to be found in cow milk (López-Aliaga et al., 2010; Olalla et al., 2009). The larger amounts of some minerals, such as calcium (Ca), zinc (Zn) and magnesium (Mg), in goat milk may influence the growth of lactic acid bacteria since they are a normal part of some enzymatic complexes involved in lactose fermentation (Slacanac et al., 2010). It affords highly available Ca and phosphorus (P), favours iron (Fe) absorption and its deposition in target organs (López-Aliaga et al., 2009). Apart from this, goat milk is a good source of several vitamins and other minor components and it has been found to have oligosaccharides similar to human milk

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http://dx.doi.org/10.1016/j.smallrumres.2015.01.005
0921-4488/

(Bergillos-Meca et al., 2013a; Hijano, 2010; Jennes, 1980; Martínez-Férez et al., 2005; Park, 2006).

The world production of fermented goat milk has been increased in the last decade (Barbaros and Huseyin, 2010) and probiotic fermented goats' milk has been attributed with certain therapeutic values in human nutrition (Domagala, 2009; Martín-Diana et al., 2003). Unfortunately, there are certain technological difficulties to obtain a product with good organoleptic properties, most of them related to the goat milk composition (Domagala, 2009); the αs1-casein in goat milk contributes to a softer curd than does that in cow milk (Jennes, 1980; Kondyli et al., 2007; Park and Guo, 2006). In order to improve the texture quality, total solids are increased through addition of evaporated milk, powdered milk and protein concentrates (Stack et al., 2010; Tratnik et al., 2006) and enzymatic crosslinking (Park and Guo, 2006) and a notable increase of minerals such as Ca, Mg and Zn in the obtained fermented milk has been reported (Closa et al., 2003; De la Fuente et al., 2003; Güler, 2007; Martín-Diana et al., 2003; Navarro-Alarcón et al., 2011; Park, 2000; Quintana, 2011; Slacanac et al., 2010). However, the main disadvantage of these conventional concentration methods is the heat treatment during the manufacturing, which can change the characteristics of whey components, mainly the proteins, as they are thermolabile and can lose their nutritional and functional properties during heating. Ultrafiltration is a very attractive alternative method to concentrate milk for fermented products manufacture, as it does not use heat and as a consequence does not involve a phase change, which makes the concentration process more economical (Baldasso et al., 2011). Therefore, in the last several years, the application of ultrafiltration process to concentrate milk constituents and increase the total solid fraction has been tested. It could be an important processing step in cheese and other dairy products manufacturing (Gésan-Guiziou, 2013). Thus, it has been published that probiotic yoghurts prepared from goat milk concentrated by ultrafiltration have better sensory properties and a good texture (Domagala et al., 2012; Domagala and Wszolek, 2008).

The aim of this study was to evaluate the influence of an ultrafiltration process during the production of different fermented goats' milks on the presence of Ca, Mg, Zn and P in the final product, by comparing them with the starting milk and commercial fermented goats' milks manufactured with other milk concentration methods.

## 2. Materials and methods

### 2.1. Milk and fermented milk samples

A total of 10 skimmed fermented goats' milks manufactured with the traditional starters used in yoghurt manufacturing *Lactobacillus delbrueckii* ssp. *bulgaricus* and *Streptococcus salivarius* ssp. *thermophilus* (group A) and other 10 skimmed fermented goats' milks manufactured with these starters and *Lactobacillus plantarum* C4 (group B), a putative probiotic strain previously isolated and tested (Bujalance et al., 2007; Fuentes et al., 2008; Puertollano et al., 2008), were analyzed. The production process of these fermented goats' milks has been previously published (Bergillos-Meca et al., 2013b; Moreno-Montoro et al., 2013) and it is detailed in the next section. The raw skimmed milk used for the manufacture of all the fermented milks was analyzed in parallel. In addition, the 5 commercial whole and skimmed fermented goats' milks available in the Spanish market were also analyzed (group C). All samples were carefully handled to avoid contamination, and the appropriate quality-assurance procedures and precautions were followed to ensure the reliability of the results.

### 2.2. Instrumentation for mineral analysis

Raw milk was skimmed with a centrifuge containing stainless steel plates (S.Q. Arroyo, Santander, Spain) and ultrafiltered using a membrane with a cut-off of 50 kDa (Sartorius Stedim Biotech, Madrid, Spain). Fermentation was carried out in an incubator (Selecta SA, Barcelona, Spain). Ca, Mg and Zn were determined with a Perkin–Elmer Optima 8300 ICP-OES (Perkin–Elmer, Inc., MA, USA). P was determined at 750 nm with a UV/VIS spectrophotometer. A Selecta multiplace digestion block (Selecta SA, Barcelona, Spain) and Pyrex tubes were used for previous milk and fermented milk samples mineralization. Bidistilled deionized water with a specific resistivity of 18 MΩ cm from a Milli-Q system (Millipore, Milford, MA) was always used.

### 2.3. Supplies

To decrease the risk of contamination, polypropylene vessels and plastic pipette tips were used, and glassware being reduced to a minimum. All the material was washed in $HNO_3$ 30% (w/v) and rinsed several times with bidistilled deionized water.

### 2.4. Chemicals

Starter cultures *L. bulgaricus* and *S. thermophilus* YO-MIX 495 LYO 100 DCU (Danisco, France) were used for milk fermentation. Lactobacilli MRS agar and broth (Difco™, Becton, Dickinson and Company, Sparks, USA) were used as culture media for these starters, whereas LPSM (*L. plantarum* selective medium) was used for the probiotic *L. plantarum* C4. A multielement calibration standard (N.3, Perkin–Elmer, Inc., MA, USA) was used and diluted as necessary to obtain working standards. $HNO_3$ 65% (w/v), $HClO_4$ 65% (w/v) and $V_2O_5$ (Merck, Darmstadt, Germany) were used for sample mineralization. All reagents were of analytical grade (Suprapur, Merck, Germany).

### 2.5. Manufacturing of experimental fermented goats' milks

Fermented milks of the groups A and B were manufactured as previously reported (Bergillos-Meca et al., 2013b; Moreno-Montoro et al., 2013). For this purpose, raw milk was skimmed by centrifugation to obtain a 0.1% fat content. After that, milk was concentrated by ultrafiltration, which was carried out as usual by continuously removing the permeate stream, using a membrane with a cut-off of 50 kDa. Applied transmembrane pressure and re-circulation rate were controlled by valves and the feed rate, supplied by a variable speed pump. The pressure applied through the membrane was measured with a manometer and the permeate flow was determined by measuring the filtrate volume collected during a certain period of time. The solids content was measured in the concentrate stream and the process was stopped when the desired concentration was achieved. It was selected to operate approximately at room temperature (25 ± 2 °C) and low pressure, 1.5 bar approximately, thus a good permeate flux evading thermal contamination was obtained. The degree of concentration reached through an ultrafiltration process is usually expressed as volume concentration ratio (VCR), defined as the quotient between initial feed volume and concentrate volume. For the manufacturing of our products, the ultrafiltration process was set up to reach a VCR = 1.7, so that the total solid content of the concentrated milk was 13.4%. These data were previously detailed (Moreno-Montoro et al., 2013).

Concentrated milk obtained was subjected to a heat treatment at 80 °C for 30 min, and left for cooling to 37 °C. The starter culture was added to the milk for the manufacturing of fermented milks of group A, whereas the fermentation of group B was conducted by the starters and *L. plantarum* C4. Both products were then incubated at 37 °C for 6 h. After fermentation and gel formation, fermented milks were cooled down to 4 °C and stored at 4–8 °C. Samples were then stored at −20 °C until used in mineralization.

### 2.6. Sample mineralization

A 2 g portion of each milk and fermented milk sample was treated with 8 mL of $HNO_3$–$HClO_4$ (4:1) and a few micrograms of $V_2O_5$ (as a catalyst)