Journal of Food Composition and Analysis 72 (2018) 122–131

Contents lists available at ScienceDirect

Journal of Food Composition and Analysis

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

Original Research Article

Fatty acid profile and vitamins A and E contents of milk in goat farms under Mediterranean wood pastures as affected by grazing conditions and seasons

Rosario Gutiérrez-Peña[a], Víctor M. Fernández-Cabanás[b], Yolanda Mena[b], Manuel Delgado-Pertíñez[b,*]

[a] Instituto de Investigación y Formación Agraria y Pesquera (IRFAP) del Gobierno de las Islas Baleares, C/ Eusebi Estada, 145, 07009, Palma de Mallorca, Spain
[b] Departamento de Ciencias Agroforestales, Escuela Técnica Superior de Ingeniería Agronómica, Universidad de Sevilla, "Agrifood Campus of International Excellence, ceiA3", Ctra. Utrera km 1, Sevilla, 41013, Spain

ARTICLE INFO

Keywords:
Food analysis
Food composition
Mountain goat herds
Milk quality
Conjugated linoleic acid
n-3 fatty acids
Retinol
Tocopherol

ABSTRACT

European small ruminant systems are mainly situated in mountain areas and for the production model to be sustainable, the quality of products and traceability should be analysed. Technical data and bulk milk samples (n = 48 for each season) from 16 goat farms were collected each month during the four seasons of the year. According to the indicator *Net energy provided by grazing* on shrublands (NERG), farms were separated in High (n = 3, 59% NERG), Medium (n = 9, 39%) and Low (n = 4, 16%) Grazing groups. Samples were analysed for fatty acid (FA) profile and vitamin A and E contents, and was evaluated its utility to discriminate milk samples. Few differences were found in the analyzed parameters between farm groups. However, important changes were reported according to season. Spring milk (46% NERG) showed significantly higher levels of some healthy FA (total polyunsaturated, 4.67 ± 0.044% of total FA; n-3, 0.94 ± 0.017; conjugated linoleic acid total, 0.51 ± 0.008), summer (37% NERG) and autumn (33% NERG) showed higher levels of α tocopherol (215.5 and 195.8 ± 6.54 μg/100 g, respectively) and winter (32% NERG) showed higher levels of retinol (85.0 ± 1.71 μg/100 g). The multivariate approach was able to discriminate milk from different seasons.

1. Introduction

At present, there is a growing interest in animal food products obtained from mountain pastures, recognised by nearly all consumers and farmers themselves as high-quality foods. European small ruminant production systems involve important socioeconomic and environmental issues in the Mediterranean region, mainly for the less favoured areas where small ruminants are adapted to grazing in marginal areas and where conditions for other agricultural production are inadequate (De Rancourt et al., 2006; Riedel et al., 2007). In these countries, many goat farms traditionally associated to grazing systems in mountain areas have specialized in milk production, particularly in economically developed countries such as Spain. This dairy specialization has brought about an increase in the use of concentrates (Castel et al., 2011) thus reducing or even eliminating pasture as a feed source. Despite the goat farming intensification process, there are still areas where farms depend on pastures, at least partly, to feed their animals. However for this production model to be sustainable, apart from being economically viable, the quality of their products should also be analysed and characterized.

Authentication of herbivore diet has become a target of scientific research, as consumer perception is being addressed to the mode of animal production. Due to the strong influence of animal feeding on the composition of milk fat, certain lipid molecules can be used to support the traceability of milk from grazing ruminants (Morand-Fehr et al., 2007; Povolo et al., 2012). In addition, intake of unsaturated fatty acids (FA), such as trans-vaccenic (VA), linoleic (LA), conjugated linoleic (CLA) and α-linolenic acids (α-LNA) or other n-3 FA, and fat-soluble antioxidants (e.g., α-tocopherol, carotenoids) are claimed to have possible benefits for human health (Connor, 2000; Willcox et al., 2004). However, studies on goats' intake of Mediterranean shrub and woody forages and its effect on fat composition of milk products are scarce in the scientific literature. On this point, studies conducted for a short period of time and few farms (Delgado-Pertíñez et al., 2013; Tsiplakou et al., 2006) reported that intake of woody forages increased the contents of α-LNA and other n-3 FA, while CLA content did not differ from those derived from non or low grazing animals. Only during the summer, the previous study of Delgado-Pertíñez et al. (2013) evaluated the effect of grazing level on milk α-tocopherol content, and concluded

* Corresponding author.
E-mail addresses: mrgutierrez@dgagric.caib.es (R. Gutiérrez-Peña), victorf@us.es (V.M. Fernández-Cabanás), yomena@us.es (Y. Mena), pertinez@us.es (M. Delgado-Pertíñez).

https://doi.org/10.1016/j.jfca.2018.07.003
Received 15 December 2017; Received in revised form 3 July 2018; Accepted 5 July 2018
Available online 05 July 2018

that contents were significantly higher in the high grazing farms. Moreover, there is no information on the composition of retinol and other tocopherol compounds in milk from goat farms grazing on Mediterranean woody pastures.

From the scientific literature available it is clear that the analysis of just one compound is not sufficient for the unequivocal verification of pasture grazing. Using the information contained in several biomarkers at once, i.e. a multivariate approach, seems a much more appealing strategy. Canonical Variate Analysis and Principal Component Analysis biplots have been applied for the discrimination of groups. The main advantage of the biplot methods is that it is possible not only to establish the differences between groups but also to characterize the variables responsible for them. Fat-soluble antioxidants (tocopherols and retinoids) and FAs compounds have been used with these multivariate approaches to authenticate production system (outdoor grazing vs. indoor feeding) of sheep (Valdivielso et al., 2015; Virto et al., 2012) and cow dairy products (Capuano et al., 2014). Nevertheless, no references have been found regarding its application to the characterization of goat dairy products.

Influence of feeding strategies on milk composition in commercial herds has not been frequently reported. On-farm studies contribute to the generation of valuable information from real commercial farms, where all factors cannot be controlled or even are inseparably associated (e.g., lactation, season and feeding management effects) in contrast to experimental farms or trials (Delgado-Pertíñez et al., 2013; Tsiplakou et al., 2006; Valdivielso et al., 2016,2015). This kind of research is indispensable in order to know how extensive grazing can affect to the quality of dairy products in farms located in mountain zones. Thus, the aim this study was focussed on the evaluation of the effect of seasonal feeding systems (winter, spring, summer and autumn) and grazing farm level on Mediterranean wood pastures (high, medium and low) on the milk FA profile, retinol and tocopherols contents from commercial herds of dairy goats. The study was conducted with a high number of farms and over a long period of time, so another objective was to evaluate the utility of all the analytical variables to discriminate milk samples according to the different grazing farm levels and the seasonal feeding groups. The work brings into focus the Payoya goat breed management system habitual in the mountain range in Cadiz (south-western Spain).

2. Materials and methods

2.1. Study area and characteristics of goat systems

The study was conducted in the mountain range of Cadiz (South of Spain). The Sierra de Cádiz district is located between parallels 36° 55´ and 36° 41´ (northern latitude) and between meridians 5° 35´ and 5° 11´ (western longitude). With a Mediterranean climate, with cool and wet winters (mean 8 °C) and warm and rainless summers (mean 25 °C). Mean annual rainfall is 960-2.220 mm. Plant communities are generally dominated by sclerophyllous woody plants with an herbaceous or shrubby understory. The understorey is mainly covered by bushes (60–80%) with 0.6–1.8 m height, being the most abundant species *Cistus albidus, Phomis purpurea, Genista hispanica, G. Scorpius, Rosmarinus officinalis, Thymus mastichina* and *Pistacia lentiscus* (Mata et al., 2004). Grass species, legumes and other families of dicots are also present in this kind of mid-mountain pastures.

Goats have one lactation per year, with an average length of 6–8 months. Most births are concentrated in October-November and in January-February of the following year, and lactation normally finishes during the summer, conducting to a high seasonality in milk production (more milk is sold in the first half of the year).

2.2. Selection of experimental farms, feeding management indicators, and sampling

All goats utilized in this study were of the Payoya breed. There are about 35 farms currently working with the Association of Payoya Breeders (unpublished data). Within those farms, non-*randomly* sixteen farms were selected based on three fundamental criteria (Gutierrez-Peña et al., 2016): (i) goat production was an important economic activity for the farm with a minimum herd size of 80 breeding goats as reported by Nahed et al. (2006), (ii) all farms belonged to the local cooperative "*Nuestra Señora de los Remedios*" that collaborated in this research project, in order to confirm technical and economic information and (iii) farms were representative of the variable management of the pastoral goat farming systems already existing in the area based on the researchers' previous experience (Ruiz et al., 2008). The selected farms were about 50% of census farms and will be representative of the study population. Across 2011 and according to a design of repeated measures, a set of indicators for the technical characterization of small ruminant rangeland systems was obtained from each farm monthly in order to characterize their feeding management (*Net energy requirements obtained from grazing*, NERG, %; *Concentrate supply per milking goat*, kg/day; *Forage supply per milking goat*, kg/day) following the methodology proposed by Ruiz et al. (2008) and previously described by Gutierrez-Peña et al. (2016). Other indicators were collected annually: *Total area* (ha/goat); *Natural pasture area* (ha/goat) differentiating between *Natural shrub pasture area* (ha/goat) and *Natural herbaceous pasture area* (ha/goat). The indicator NERG is one of the main factors that difference farms in the area of research and was computed once a month subtracting the net energy of concentrates and forages supplied indoors to milking goat's net energy requirements. Farms were classified in three categories depending on their grazing level (Nahed et al., 2006): High grazing (HG, n = 3; NERG > 55%), Medium grazing (MG, n = 9; NERG < 55% and > 25%) and Low grazing (LG, n = 4; NERG < 25%), as it was reported by Gutierrez-Peña, et al. (2016).

According to this previous study of Gutiérrez-Peña et al. (2016), there are differences in the types of concentrate and forage supplemented depending on the grazing level, being the most frequently utilised: compound feed and cereal straw (high grazing) and compound feed, a mixture of grains and alfalfa hay (medium and low grazing, respectively). Ingredients and proximal chemical composition of the three most frequent concentrates supplied indoor have also been published in Gutierrez-Peña et al. (2016). Briefly, the first is a grain mix composed mainly of corn (25% of the total ingredients), lima beans (22%) and oat and sunflower seeds (20% each). The second concentrate is a high fiber concentrate and contains both short fiber forage (25%) and a mixture of grains (corn and corn distillate, 36%; soybean hulls, 15%; granulated wheat bran, 12%). The third concentrate is a pelleted feed, that is composed mainly of malting barley and wheat feed (24% and 20%, respectively), and to a lesser extent corn distillate (15%), soybean hulls (10%) and soybean (10%). With regard to the FA profile (unpublished data), the unsaturated FA are majority in the three concentrates. However, the grain mix and high fiber concentrates present higher contents in C18:2 n-6 *cis* (41 and 48% of total FA, respectively) and PUFA (44 and 51%, respectively), compared to the pelleted feed (27 and 31% for C18:2 and PUFA, respectively). Regarding the use of vitamin supplements, differences between farms were not found, as most do not supplement throughout the year (unpublished data).

Collection of whole milk samples was performed monthly according to a design of repeated measures from each farm bulk tank (n = 192). Triplicates of milk samples were placed in 50 mL plastic bottles and wrapped with aluminium foil to preserve them from light. Azidiol was used as preservative in one of the samples utilized to analyse commercial traits and the FA profile of milk samples, whereas azidiol-free replicates were used for the analysis of vitamins. Finally, samples were