The comparison of the lactation and milk yield and composition of selected breeds of sheep and goats

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<td>Ferro, Mariane; Universidade Federal de Mato Grosso, Departamento de Zootecnia Tedeschi, Luis; Texas A&amp;M University, Animal Science; Atzori, Alberto; Universita degli Studi di Sassari Dipartimento di Agraria, Sezione di Scienze Zootecniche</td>
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<td>dairy, energy, fat, lactation lenght, lactose, protein</td>
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</table>
The comparison of the lactation and milk yield and composition of selected breeds of sheep and goats

M. M. Ferro*,†; L. O. Tedeschi*; A. S. Atzori‡

* Department of Animal Science, Texas A&M University, College Station 77843, USA;
† Departamento de Zootecnia, Universidade Federal de Mato Grosso, Cuiabá 78020, Brazil;
‡ Sezione di Scienze Zootecniche, Dipartimento di Agraria, Università di Sassari, Sassari 07100, Italy

ABSTRACT: The objective of this study was to characterize the milk yield (MY) and milk composition of relevant sheep and goat breeds raised around the world to be used with nutrition models for diet formulation and nutrient balancing. A database developed by the Food and Agriculture Organization was used to identify relevant breeds (i.e., frequently raised) by comparing the occurrence of transboundary breed names across countries. Transboundary breeds that occurred more than three times and had milk production information (lactation length, total MY, days in milk, MY, and milk fat, protein, lactose) were pre-selected. Additional relevant breeds and information were obtained from specialized literature. The majority of sheep breeds were classified as nondairy (76%) because they lacked milk production information. Karakul and Merino accounted for up to 2.4% of sheep breeds raised around the world, whereas the other individual breeds accounted for less than 1%. In contrast, nondairy breeds of goats accounted for 46.3% and of the remaining 53.7%, Saanen, Boer, Anglo-Nubian, Toggenburg, and Alpine accounted for 6.5, 5, 4.4, 4, and 3%, respectively, of the transboundary breeds. A database compiled from published studies for the selected sheep (n = 65) and goats (n = 78) breeds were analyzed using a random coefficients model (studies and treatments within studies as random
For sheep breeds, the average and SD were 1.1 ± 0.3 kg/d for MY, 6.9 ± 1% for milk fat, 5.4 ± 0.4% for milk protein, 5 ± 0.3% for milk lactose, 17.7 ± 1.4% for milk total solids, and 1,073 ± 91 kcal/kg for milk energy. Lacaune had the greatest MY compared to Comisana and Tsigai (1.65 versus 0.83 and 0.62 kg/d; respectively, $P < 0.05$), but milk components were not different among breeds. For goats breeds, the average and SD across breeds were 1.7 ± 0.6 kg/d for MY, 4.2 ± 0.9% for milk fat, 3.3 ± 0.4% for milk protein, 4.4 ± 0.4% for milk lactose, 12.7 ± 1.1% for milk total solids, and 750 ± 75 kcal/kg for milk energy. Alpine had similar MY to Saanen (2.66 versus 2.55 kg/d, respectively; $P > 0.05$), but greater ($P < 0.05$) than other breeds. The Boer breed had the greatest milk fat, protein, lactose, and total solids than several other breeds, leading to the greatest milk energy content (907 kcal/kg). Because there are many factors that can alter MY and milk composition, averages provided in this study serve as guidelines, and nutritionists must obtain observed values when using nutrition models.

**Key Words:** dairy; energy; fat; lactation length; lactose; protein

**INTRODUCTION**

Small ruminants (sheep—*Ovis aries* and goats—*Capra hircus*) accounts for about 56.9% of the global ruminant domestic population (cattle, buffalo, sheep and goats) with 3,876 million heads in 2014, but their milk production constitutes a relatively small share of globally-produced ruminant milk, about 1.3% and 2.3%, respectively, when compared with dairy cattle (82.9%) and buffalo (13.4%); goats milk represent 63.5% whereas sheep milk accounts for only 36.5% of milk produced by small ruminants (Food and Agriculture Organization, FAO, 2017). Despite their small contribution to global milk output, sheep and goat farming plays a large socio-
economic role in some specific economies, especially in developing countries (subsistence) or in Europe and Oceania (market trade).

The chemical composition of milk differs among animal species (Rezaei et al., 2016), but information such as milk yield (MY) and composition are fundamental to adequately meet the requirements for energy and nutrients of lactating animals when using nutrition models to formulate diets or supplements to achieve optimum production (Tedeschi et al., 2010). While actual or observed information is needed to use modern nutrition models, tabular values provide means to compare different breeds and to complete gaps when such information is not available. The National Research Council (NRC, 1996, 2000) and the most recent National Academies of Sciences, Engineering, and Medicine (NASEM, 2016) provided tabular values for critical inputs needed to characterize the lactation of relevant beef cattle breeds, but the NRC (2007) did not include such table for small ruminants despite their requirement to proper formulate diets for lactating animals. Few publications have comparative values of milk composition for different breeds of sheep and goats. Therefore, the objective of this paper was to provide critical lactation information for selected most relevant domestic breeds of sheep and goats to be used in nutrition models.

MATERIAL AND METHODS

Identification of Relevant Breeds

The Domestic Animal Diversity Information System (DAD-IS; http://dad.fao.org/) developed by the FAO (2001) contains critical information about animal genetic resources around the world. The DAD-IS is a combination of two large databases: one that was originally developed by the European Federation for Animal Science Animal Genetic Data Bank (EAAP-
AGDB) program and the other one that was initially developed by the Animal Genetic Resources
Group of FAO (Bittante, 2011). Unfortunately, some of the breeds listed in the DAD-IS are
extinct and the DAD-IS database is not fully searchable and custom queries are not allowed at
this time. The transboundary breed names from the DAD-IS database were used to identify
relevant breeds. The transboundary breeds that were listed more than three times across countries
and had milk production information were selected. Additionally, we included sheep and goat
breeds listed by Haenlein (2007) that had the highest total milk yield and the breed descriptions
of Porter et al. (2016) for high production importance based. Some breeds, however, have
synonyms or different names within the same region. The selected relevant breeds of sheep and
goats, including their synonyms and diffusion level, are listed in
Table 1.

**Database Development**

A literature review was conducted to gather lactation information and characteristics of the selected breeds of goats and sheep. The criteria for inclusion in the database were the existence of sample size, average, and SD for the following independent variables: lactation length (days), total milk yield throughout the lactation (kd), days in milk (DIM), MY (kg/d), milk fat (%), milk protein (%), milk lactose (%), and milk total solids (%). The milk energy content for sheep was computed as described by Cannas et al. (2004) and for goats as described by Tedeschi et al. (2010) using the equations proposed by Pulina et al. (1992).

**Sheep breeds publications.** A total of 65 publications (Appendix 1) were included in the database, as follows: Agriculture and Forestry (n = 1), Animal Production Science (n = 2), Animal Science (n = 1), Annales de Zootechnie (n = 1), Asian Journal of Animal and Veterinary Advances (n = 1), Australian Journal of Agricultural Research (n = 2), Canadian Journal of Animal Science (n = 1), Ciência Rural (n = 1), Czech Journal of Animal Science (n = 3), International Dairy Journal (n = 1), International Journal of Dairy Technology (n = 1), The Journal of Agricultural Science (n = 1), Journal of Applied Animal Research (n = 1), Journal Dairy Science (n = 14), Journal of Central European Agriculture (n = 1), Journal of Dairy Research (n = 4), Livestock Production Science (n = 2), Mljekarstvo (n = 2), New Zealand Journal of Agricultural Research (n = 4), Australian Society of Animal Production (n = 1), Small Ruminant Research (n = 17), Tropical Animal Health Production (n = 2), and Veterinaria (n = 1).

**Goat breeds publications.** A total of 78 publications (Appendix 1) were included in the database, as follows: Acta Scientiarum (n = 1), Agronomía Mesoamericana (n = 1), Animal
production (n = 1), Animal (n = 2), Animal Feed Science and Technology (n = 2), Arquivos Brasileiro Medicina Veterinaria Zootecnia (n = 1), British Journal of Nutrition (n = 2), Ciência Agrotecnologia (n = 1), International Journal of ChemTech Research (n = 1), Italian Journal Animal Science (n = 1), Journal Animal Breeding and Genetics (n = 1), Journal Animal Physiology and Animal Nutrition (n = 1), Journal Dairy Science (n = 12), Journal of Agricultural and Food Chemistry (n = 1), Journal of Dairy Research (n = 4), Livestock Production Science (n = 2), Livestock Production Science (n = 2), Revista Brasileira de Saúde e Produção Animal (n = 1), Revista Brasileira de Zootecnia (n = 15), Revista Ciência Agronômica (n = 1), Revista de la Facultad de Ciencias Veterinarias (n = 1), South African Journal of Animal Science (n = 1), Small Ruminant Research (n = 19), Tropical Animal Health Production (n = 3), and Turk Journal Veterinary Animal Science (n = 2).

**Statistical Analyses**

All statistical analyses were conducted with SAS version 9.4 (SAS Inst. Inc, Cary, NC). A random coefficients model, using the PROC GLIMMIX, assumed the fixed effect of breeds and the random effect of studies and treatments within studies. The sample size divided by the SD (n/SD) of each independent variable served as a weight for all analysis. The DIM was used as a covariate, but preliminary analyses indicated that when n/SD was used as a weight, DIM did not affect the independent variables significantly (P > 0.05); therefore, the covariate DIM was removed from the statistical models.

**RESULTS AND DISCUSSION**

**Identification of Relevant Breeds**
Based on the DAD-IS database, there are 1,096 breeds of goats (55% are local breeds) and 2,156 breeds of sheep (61% are local breeds). Local breeds occur only in one country. For local breeds, about 40% (n = 237) and 31% (n = 185) of the goat breeds are localized in Europe and Asia, respectively, while for sheep breeds about 58% (n = 757) and 20% (n = 268) are localized in Europe and Asia, respectively (FAO, 2001). Transboundary breeds, on the other hand, occur in more than one country, but they are the same breed with regionalized naming. Figure 1 has the occurrence proportion of transboundary breeds of sheep and goats.

Sheep and goats adapt very easily to different production conditions, from arid to humid areas and from poor extensive production systems to intensive ones. In particular, in the Mediterranean region, the majority of sheep and all goats belong to dairy breeds, for which milk is the main product and meat is a secondary product (Gerber et al., 2013). Due to high specialization of breeds and farming systems in Western Europe, small ruminants reach higher production levels and efficiency, and higher economic importance than in other temperate areas or in most developing countries (Opio et al., 2013). Among the Mediterranean countries that included the most part of the top 10 world sheep producers, Italy in particular plays an important role being one of the first world sheep milk producers and the top world sheep cheese exporter. In contrast, goat milk production in Italy is less important than in other European countries, such as Greece, Spain and France, even though goat milk production is continuously growing and that of sheep is declining (FAO, 2017).

The Mason’s World Encyclopedia of Breeds (Porter et al., 2016) lists 238 breeds (regional or native breeds) of goats of which 71 (30%) were classified as dairy breeds, 55 (23%) were allocated as meat breeds, 105 (44%) were assigned to dual-purpose breeds, and the remaining 7 (3%) were designated adequate for coat or cashmere production. Similarly, Porter et
al. (2016) also registered 1,311 breeds of sheep of which 80 (6%) were classified as dairy breeds, 247 (19%) were allocated as meat breeds, 192 (15%) were ideal for dual-purposes, 223 (17%) were designated wool breeds, and the remaining 569 (43%) did not have a clear classification.

As shown in Figure 1, the majority of sheep breeds were classified as nondairy (76%) because they lacked adequate MY information. This is similar to the 21% of dairy and dual-purpose sheep breeds reported by Porter et al. (2016). Figure 1 indicates that Karakul and Merino each accounted for up to 1.2% of sheep breeds raised around the world; the other breeds accounted for less than 1%, suggesting that transboundary sheep breeds are evenly distributed worldwide. In contrast, nondairy breeds of goats accounted for only 46.3% and of the remaining 53.7% (dairy and dual-purpose breeds), Saanen, Boer, Anglo-Nubian, Toggenburg, and Alpine accounted for 6.5, 5, 4.4, 4, and 3%, respectively, of the transboundary breeds. Porter et al. (2016), on the other hand, indicated that about 74% of goat breeds were classified either as dairy or dual-purpose breeds. Five sheep breeds and six goat breeds from Figure 1 were selected; the remaining selected breeds (Table 2 for sheep and Table 3 for goats) were based on Haenlein (2007).

Analysis of the Literature Data

Park et al. (2007) suggested that the composition and physico-chemical characteristics of sheep and goats milk is essential for successful development of dairy industries as well as for the marketing of their products (e.g., fluid milk, cheese). There are distinct differences in the physico-chemical characteristics of milk from goats, sheep and cows. Barłowska et al. (2011) performed a meta-analysis of milk composition of five species (n = 30 studies/species), and provided descriptive statistics for milk CP, fat, and lactose, as follows: cattle (3.42% CP, 4.09% fat, and 4.82% lactose), water buffalo (4.38% CP, 7.73% fat, and 4.79% lactose), sheep (5.73%
CP, 6.99% fat, and 4.75% lactose), goat (3.26% CP, 4.07% fat, and 4.51% lactose), and camel
(3.26% CP, 3.8% fat, and 4.3% lactose). These authors also indicated that sheep’s milk had the
greatest energy content (1,417 kcal/kg), followed by cattle (891 kcal/kg), water buffalo (825
kcal/kg), and goat (721 kcal/kg). Major differences in the AA profile of the milk protein, the FA
of the milk fat, and the minerals and vitamins exist (Barłowska et al., 2011; Haenlein and Anke,
2010). Furthermore, the composition of cow’s milk is expected to have minimal changes
throughout the year, whereas changes in the composition of sheep and goats milk occur naturally
by seasons because towards the end of the lactation, the contents of milk fat, protein, solids, and
minerals increase while milk lactose content decreases.

The variation in MY and milk composition among different breeds of sheep and goats has
been observed by several authors. Such factors include genetics (Clark and Sherbon, 2000;
Greyling et al., 2004; Koutsouli et al., 2017; Lóbo et al., 2017; Montaldo et al., 2010; Salvador et
al., 2016); nutrition (Baldin et al., 2014; Bernard et al., 2009; Bernard et al., 2012; Carnicella et
al., 2008; Catunda et al., 2016); parity and number of lambs born (Ahuya et al., 2009; Carnicella
et al., 2008; Salvador et al., 2016); days after parturition (Koutsouli et al., 2017); milking
frequency (Koutsouli et al., 2017; Kremer and Rosés, 2016; Torres et al., 2014); environmental
conditions (Arias et al., 2012; Peana et al., 2017); and other physiological status (Caroprese et
al., 2010).

There is a tremendous genetic diversity within breeds of sheep and goats, but few
publications have documented their production aptitude and expected productivity. While
genetic differentiation of breeds has been conducted for many Asian countries (Periasamy et al.,
2017), basic production characterization is rare or incomplete for the most important breeds of
sheep and goats that are used in different regions of the world. In agreement, Raynal-Ljutovac et
al. (2008) indicated that milk composition varies according to animal breed, feed and feeding conditions, and environment. They reported the average composition of total solids of sheep milk varies between 14.4 to 20.7% with mean of 18.1%, milk fat content varies from 3.60 to 9.97% with mean of 6.82%, milk protein content varies from 4.75 to 7.20% with mean of 5.59%, and milk lactose varies from 4.11 to 5.51% with mean 4.88%.

**Sheep Breeds**

Table 2 has the average of lactation length, total milk yield, MY, milk composition, and milk energy of selected breeds of sheep. The average and SD across breeds were $1.1 \pm 0.3$ kg/d for MY, $6.9 \pm 1\%$ for milk fat, $5.4 \pm 0.4\%$ for milk protein, $5 \pm 0.3\%$ for milk lactose, $17.7 \pm 1.4\%$ for milk total solids, and $1,073 \pm 91$ kcal/kg for milk energy. Lacaune had the greatest MY compared to Comisana and Tsigai ($1.65$ versus $0.83$ and $0.62$ kg/d; respectively, $P < 0.05$), but milk components were not different among breeds. Dorset had the greatest milk energy content ($1,201$ kcal/kg) and Fat Tailed had the least one (918 kcal/kg). There was a moderate correlation of milk fat ($r = 0.55$) but low correlations of milk protein ($r = 0.24$) and milk lactose ($r = 0.17$) with the values reported by Haenlein and Wendorff (2008). Studies had incomplete data, leading to some breeds with missing values; thus, the missing values were populated with those reported by Haenlein and Wendorff (2008).

Nudda et al. (2002) evaluated three breeds and reported differences in MY: the Sarda breed had greater MY ($0.58$ kg/d) than Awassi ($0.36$ kg/d) and Merino ($0.16$ kg/d), and their MY is less than the MY presented in Table 2 for the same breeds: the average MY for Sarda ewes was $1.36$ kg/d followed by Awassi ($1.11$ kg/d) and Merino ($1.23$ kg/d). However, in agreement with Table 2, their Sarda ewes had lower milk fat ($6.56\%$) and protein ($5.75\%$) contents.
compared to their Merino ewes (7.99 and 5.99%, respectively). In contrast, Tsiplakou et al. (2006) compared four sheep breeds (Awassi, Lacaune, Friesland, and Chios) and indicated that the average daily MY, milk composition (protein, lactose) and yield of protein and fat were not different among them (1.6 kg/d; 5.72 and 4.92%; and 90.5 and 119 g/d, respectively). Nonetheless, the milk fat content was greater for Awassi ewes and total solids content was less for Chios ewes when compared to the other breeds. Selvaggi et al. (2016) studied three sheep breeds (Comisana, Leccese, and Sarda) and reported differences in MY and lactation length in which Leccese ewes produced less total MY per lactation (84.9 kg) compared to Comisana (112 kg) and Sarda (116 kg), and had shorter duration of lactation (156 d) versus Comisana (182 d) and Sarda (178 d), but Leccese ewes had greater milk fat (7.75%), protein (5.13%), and lactose (5.06%) contents than Comisana and Sarda (7.27%, 4.96%, and 4.89%, respectively).

Nowadays, dairy sheep farming systems vary from extensive (marked seasonal milk production, dual-purpose breeds, low feed supplementation, hand milking, absence of farm facilities, farm-made cheese) to intensive (seasonal or continuous milk production, improved local breeds or crosses, exploitation of forage crops, high feed supplementation, milking machine and housing facilities, industrial cheese) according to economic relevance of the production chain and the specific environmental and breed (Carta et al., 2009). In agreement, dairy sheep management varies greatly with breed, production system and country, where the most important dairy sheep in the European Mediterranean countries produce 65% of the total European sheep milk and raise most dairy sheep under extensive and semi-extensive systems (Sitzia et al., 2015).

Carta et al. (2009) indicated that another factor of variation between sheep breeds are breeding strategy to improve dairy traits that may involve either crossbreeding or purebreeding selection programs. Several comparisons between local and exotic breeds were done to
determine whether local dairy breeds could be used successfully under the improved conditions or whether it would have been better to replace them with more productive genotypes.

**Goats Breeds**

Table 3 has the average of lactation length, total milk yield, MY, milk composition, and milk energy of selected breeds of goats. The average and SD across breeds were 1.7 ± 0.6 kg/d for MY, 4.2 ± 0.9% for milk fat, 3.3 ± 0.4% for milk protein, 4.4 ± 0.4% for milk lactose, 12.7 ± 1.1% for milk total solids, and 750 ± 75 kcal/kg for milk energy. Alpine had similar MY to Saanen (2.66 versus 2.55 kg/d, respectively; $P > 0.05$), but greater than the other breeds ($P < 0.05$). The Boer breed had the greatest milk fat, protein, lactose, and total solids than several other breeds, leading to the greatest milk energy content (907 kcal/kg). There was a moderate correlation of MY ($r = 0.42$) and milk fat ($r = 0.66$) with the values reported by Haenlein (2007).

Studies had incomplete data, leading to some breeds with missing values; thus, the missing values were populated with those reported by Haenlein (2007) or Haenlein (2008).

Mestawet et al. (2012) reported differences between breeds of goats: Boer breed produced the highest average MY (1.41 kg/d) followed by Arsi-Bale (1.13 kg/d) and Toggenburg x Somali and Arsi-Bale x Somali crossbreds (0.89 kg/d). Their reported MY for Boer is identical to that reported in Table 2 (1.72 kg/d). Similarly, Lôbo et al. (2017) compared breeds of Alpine, Saanen, and Toggenburg raised in the Southeast of Brazil with breeds of Anglo-Nubian and Saanen raised in the Northeast of Brazil. They reported that genetics and environmental conditions (i.e., geolocations) could alter MY, lactation length, and milk composition. Thus, the values reported in Table 3 must be used with caution and adjustments when raising goats outside of the conditions used in the literature dataset studies might be necessary.
In agreement with Table 3, Soryal et al. (2005) reported similar values for milk composition for Nubian breed, which had the greatest fat (4.37%), total protein (3.87%) and total solids (13.5%) contents, when compared to Alpine breed, which had the least fat (2.7%), total protein (2.53%), and total solids (10.1%) contents. Mestawet et al. (2012) also found differences between Boer, Ars-Bale purebred and crossbreds, and Toggenburg crossbreds in which Boer had the greatest fat (4.92%) and total solids (15.9%) contents. A greater variation in milk composition was also reported by Lôbo et al. (2017) in which the Anglo-Nubian breed presented greater fat (4.25%), protein (3.4%), and total solids (12.5%) contents, followed by Saanen raised in Southeastern of Brazil and Alpine breeds with an average of 3.7% for fat, 2.95% for protein, and 11.8% for total solids contents. In their comparison, Saanen raised in the Northeastern of Brazil and Toggenburg had the least milk components: 3.3% for fat, 2.73% for protein, and 11.2% for total solids contents. Contrary to these findings, Mayer and Fiechter (2012) compared six goat dairy breeds (Coloured, Pinzgau, Saanen, Strahlen, Toggenburg, and White) and reported similar chemical composition (3.67% for fat, 3.35% for protein, 12.2% for total solids, and 4.23% for lactose contents). Their results is in contrast to those listed in Table 3 in which Saanen breed had less fat, protein, and total solids contents than Toggenburg.

Table 2 and Table 3 provided average MY and milk composition for relevant breeds of sheep and goats, respectively. However, as indicated above, these values are will certainly vary depending on plane of nutrition, animal management, and environmental conditions. Ideal environmental conditions may vary across different breeds, but as a rule of thumb, temperature humidity index (THI; Tedeschi and Fox (2016)) below 68, wind speed below 4 m/s, and solar radiation below 24 MJ/m² are usually ideal for dairy sheep in the Mediterranean region (Peana et al., 2017).


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Figure 1. Frequency of occurrence of transboundary breeds of (A) sheep and (B) goats around the world based on the Domestic Animal Diversity Information System (DAD-IS) from the Food and Agriculture Organization (FAO, 2001)
Table 1. Most relevant breeds of sheep and goats based on the frequency of occurrence of transboundary names across countries

<table>
<thead>
<tr>
<th>Sheep breed</th>
<th>Synonyms</th>
<th>Diffusion level</th>
<th>Goat breed</th>
<th>Synonyms</th>
<th>Diffusion level</th>
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<td>Alpine</td>
<td>Cosmopolite</td>
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<td>Fat Tailed</td>
<td>Norduz, Mehraban, Ghezel, Rahmani, Barki, Naeini</td>
<td>Anglo Nubian</td>
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<td>Canaria</td>
<td>Majorera, Palmera</td>
<td>Local</td>
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<td>Tsigai</td>
<td>Tigai, Cigaja, Zigaja, Tzigaqa</td>
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Table 2. Lactation length and milk yield and composition for selected breeds of sheep

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<th>Total milk</th>
<th>Milk yield</th>
<th>Milk fat</th>
<th>Milk protein</th>
<th>Milk lactose</th>
<th>Milk total solid, %</th>
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<td>120-300&lt;sup&gt;2&lt;/sup&gt;</td>
<td>130-550&lt;sup&gt;2&lt;/sup&gt;</td>
<td>1.11</td>
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<td>135-300&lt;sup&gt;2&lt;/sup&gt;</td>
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<td>East Friesian</td>
<td>21</td>
<td>300-365&lt;sup&gt;2&lt;/sup&gt;</td>
<td>500-900&lt;sup&gt;2&lt;/sup&gt;</td>
<td>1.16</td>
<td>ab</td>
<td>5.95</td>
<td>a</td>
<td>5.22</td>
<td>a</td>
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<tr>
<td>Fat Tailed</td>
<td>11</td>
<td>—</td>
<td>161&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.84</td>
<td>ab</td>
<td>5.26</td>
<td>a</td>
<td>5.15</td>
<td>a</td>
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<td>—</td>
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<td>8.05</td>
<td>a</td>
<td>4.96</td>
<td>a</td>
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<td>ab</td>
<td>6.85</td>
<td>a</td>
<td>5.53</td>
<td>a</td>
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<tr>
<td>Lacaune</td>
<td>28</td>
<td>160-170&lt;sup&gt;2&lt;/sup&gt;</td>
<td>434</td>
<td>1.65</td>
<td>a</td>
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<td>a</td>
<td>4.72</td>
<td>a</td>
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<tr>
<td>Manchega</td>
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<td>150-270&lt;sup&gt;2&lt;/sup&gt;</td>
<td>80-250&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.89</td>
<td>ab</td>
<td>7.05</td>
<td>a</td>
<td>5.81</td>
<td>a</td>
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<td>Merino</td>
<td>41</td>
<td>—</td>
<td>—</td>
<td>1.23</td>
<td>ab</td>
<td>8.21</td>
<td>a</td>
<td>5.59</td>
<td>a</td>
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<tr>
<td>Sarda</td>
<td>27</td>
<td>168&lt;sup&gt;3&lt;/sup&gt;</td>
<td>116</td>
<td>1.36</td>
<td>ab</td>
<td>6.11</td>
<td>a</td>
<td>5.22</td>
<td>a</td>
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<tr>
<td>Tsigai</td>
<td>31</td>
<td>—</td>
<td>—</td>
<td>0.62</td>
<td>b</td>
<td>7.73</td>
<td>a</td>
<td>5.99</td>
<td>a</td>
</tr>
</tbody>
</table>

<sup>1</sup> Within a column, superscripts of different letters differ at \( P < 0.05 \).

<sup>2</sup> Adapted from Haenlein and Wendorff (2008). Ranges reflect the minimum and maximum across different countries.

<sup>3</sup> Adapted Carta et al (2009).

<sup>4</sup> Number of animals.
Table 3. Lactation length and milk yield and composition for selected breeds of goats

<table>
<thead>
<tr>
<th>Breeds</th>
<th>n&lt;sup&gt;4&lt;/sup&gt;</th>
<th>Length</th>
<th>Total milk</th>
<th>Milk yield</th>
<th>Milk fat</th>
<th>Milk protein</th>
<th>Milk lactose</th>
<th>Milk total</th>
<th>Energy solid, %</th>
<th>Energy kcal/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alpine</td>
<td>68</td>
<td>248</td>
<td>601</td>
<td>2.66</td>
<td>a 3.33</td>
<td>c 3.10</td>
<td>ab 4.53</td>
<td>ab 11.05</td>
<td>c 679</td>
<td></td>
</tr>
<tr>
<td>Anglo-Nubian</td>
<td>18</td>
<td>270-305&lt;sup&gt;2&lt;/sup&gt;</td>
<td>592</td>
<td>0.90</td>
<td>de 3.71</td>
<td>bc 3.29</td>
<td>bc 4.23</td>
<td>bc 12.10</td>
<td>bc 716</td>
<td></td>
</tr>
<tr>
<td>Boer</td>
<td>8</td>
<td>—</td>
<td>—</td>
<td>1.72</td>
<td>bcd 5.88</td>
<td>a 4.02</td>
<td>a 4.95</td>
<td>a 14.73</td>
<td>a 907</td>
<td></td>
</tr>
<tr>
<td>Canaria (Canary)</td>
<td>47</td>
<td>251</td>
<td>183</td>
<td>0.79</td>
<td>e 3.96</td>
<td>bc 3.72</td>
<td>ab 4.66</td>
<td>ab 12.77</td>
<td>bc 754</td>
<td></td>
</tr>
<tr>
<td>Damascus</td>
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<td>270</td>
<td>378</td>
<td>1.88</td>
<td>bc 4.46</td>
<td>b 3.82</td>
<td>ab 3.60</td>
<td>c 12.94</td>
<td>bc 795</td>
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<tr>
<td>La Mancha</td>
<td>4</td>
<td>270-305&lt;sup&gt;2&lt;/sup&gt;</td>
<td>720-800&lt;sup&gt;3&lt;/sup&gt;</td>
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<td>4.95</td>
<td>ab 3.34</td>
<td>abc —</td>
<td>13.67</td>
<td>ab 807</td>
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<tr>
<td>Malagueña</td>
<td>20</td>
<td>240-270&lt;sup&gt;2&lt;/sup&gt;</td>
<td>500-700&lt;sup&gt;3&lt;/sup&gt;</td>
<td>1.47&lt;sup&gt;3&lt;/sup&gt;</td>
<td>5.49</td>
<td>a 3.40</td>
<td>ab 4.53</td>
<td>ab 13.64</td>
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<td>Maltese</td>
<td>16</td>
<td>250</td>
<td>283</td>
<td>2.23&lt;sup&gt;3&lt;/sup&gt;</td>
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<td>bc 3.14</td>
<td>bc 4.60</td>
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<td>Murciana-Granadina</td>
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<td>b 3.48</td>
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<td>a 13.01</td>
<td>bc 788</td>
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<tr>
<td>Nordic</td>
<td>32</td>
<td>250-300&lt;sup&gt;2&lt;/sup&gt;</td>
<td>600-700&lt;sup&gt;2&lt;/sup&gt;</td>
<td>1.92&lt;sup&gt;bc&lt;/sup&gt;</td>
<td>4.28</td>
<td>b 2.87</td>
<td>c 4.29</td>
<td>ab 11.25</td>
<td>c 736</td>
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<tr>
<td>Saanen</td>
<td>62</td>
<td>250</td>
<td>615</td>
<td>2.55&lt;sup&gt;ab&lt;/sup&gt;</td>
<td>3.28</td>
<td>c 2.94</td>
<td>be 4.28</td>
<td>bc 11.52</td>
<td>c 667</td>
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<tr>
<td>Charmoisée</td>
<td>2</td>
<td>265-290&lt;sup&gt;2&lt;/sup&gt;</td>
<td>645</td>
<td>2.55&lt;sup&gt;3&lt;/sup&gt;</td>
<td>3.40</td>
<td>bc 2.84</td>
<td>bc —</td>
<td>—</td>
<td>671</td>
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<td>Toggenburg</td>
<td>10</td>
<td>245</td>
<td>424</td>
<td>1.82</td>
<td>bcd 3.37</td>
<td>bc 2.96</td>
<td>bc 4.26</td>
<td>bc 13.14</td>
<td>abc 675</td>
<td></td>
</tr>
</tbody>
</table>

1. Within a column, superscripts of different letters differ at $P < 0.05$.
2. Adapted from Haenlein (2008). Ranges reflect the minimum and maximum across different countries.
3. Calculated from Haenlein (2007) as the reported total milk yield divided by the reported lactation length.
4. Number of animals.
Appendix 1. References used to develop the database.

Sheep Breeds


Goat Breeds


Paraskevakis, N. 2015. Effects of dietary dried Greek Oregano (Origanum vulgare ssp hirtum) supplementation on blood and milk enzymatic antioxidant indices, on milk total antioxidant capacity and on productivity in goats. Animal Feed Science and Technology. 209:90-97.


(A)
(B)

- Nubian breeds: 319
- Other dairy breeds: 139
- Boer: 34
- Angora: 14
- Alpine: 20
- Anglo-Nubian: 30
- Russian Coarse-Haired: 5
- Small East African: 5
- Soviet Mohair: 5
- Somali: 4
- Sahelian: 9
- Saanen: 44
- Red Sokoto: 4
- Crinlin: 6
- Damascus: 6
- Beetal: 5

400x249mm (96 x 96 DPI)