TECHNICAL NOTE

# Impacts of the diet on sheep milk quality under Mediterranean conditions

**Nikolaos Voutzourakis, Smaragda Sotiraki and Alexandros Stefanakis**

## About

Sheep and goat rearing has always been an important agricultural activity in countries of the Mediterranean basin. Professionalization of production and growing awareness of product quality have raised interest among sheep farmers in the relationship between feeding and product quality.

This technical note provides an overview on the interrelations between sheep diet and milk quality, based on research done in Greek sheep farms and other Mediterranean countries.

## Introduction

Milk and dairy products remain one of the main sources of protein, calcium, potassium, magnesium, and vitamin A in human diets all over the world and are also good sources of carotenoids and tocopherols, significant provitamins and natural antioxidants with several biological functions.

Additionally, several bioactive compounds contained in milk have been found to have positive health effects. The two major categories are the fatty acids contained in fat and the bioactive proteins and peptides, that originate from them and formed during milk fermentation by microbes, cheese ripening or digestion.

Milk composition is affected by several factors including the animals' feed, since it reflects not only their diet but also the local geographical, economical and climatic conditions. Milk quality can easily be controlled by the farmer with quick and obvious results, although it requires an understanding of the interactions between the composition of the diet and the quality criteria.

**Picture 1: During the last decades many farms have achieved higher production levels through modernization of their facilities. (Photo: Nikolaos Tzanidakis)**



Nikolaos Voutzourakis, Smaragda Sotiraki and Alexandros Stefanakis (2014): Impacts of the diet on sheep milk quality under Mediterranean conditions. LowInputBreeds technical note. Download at www.lowinputbreeds.org

**Table 1. Health effects of milk's bioactive compounds and recommendations for human consumption**

| Compound | Health effect | Recommendations[a] | g 100 ml$^{-1}$ sheep milk[b] |
|---|---|---|---|
| **Saturated FA (SFA)** | | | |
| **Lauric, myristic, palmitic acid** | Raises total LDLa and HDLb cholesterol and increases some hemostatic/thrombotic factors that promote thrombosis | 7–22 g | 50–70 g |
| **Monounsaturated FA (MUFA)** | | | |
| **Palmitoleic, oleic, acid** | Decreases total and LDL cholesterol when substituted for saturated fat and decreases total cholesterol compared with dietary carbohydrate | 18–56 g | 15–40 g |
| **Polyunsaturated FA (PUFA)** | | | |
| **n-6 fatty acids** | | 7–22 g | 3–10 g |
| **Linoleic acid** | Decreases total and LDL cholesterol | | |
| **Arachidonic acid** | Precursor for eicosanoids (prostaglandins, thromboxanes, leukotrienes) | | |
| **Conjugated linoleic acid (CLA)** | Has anti-cancer properties, decreases body fat in growing animals | | |
| **n-3 fatty acids** | | 1.3–2.7 g | 0.5–1.5 g |
| **a-linolenic acid** | Decreases cardiovascular risk through multiple mechanisms including platelet function, inflammation endothelial cell function, arterial compliance and arrhythmia | | |
| **Eicosapentaenoic acid (EPA), Docosapenteonoic acid (DPA), Docosahexaenoic acid (DHA)** | Decreases risk of sudden death through multiple mechanisms including platelet function, endothelial cell function, arterial compliance and arrhythmia and has beneficial effects on nervous system, development and health | 500 mg | 10–100 mg |
| **Bioactive proteins and peptides** | | | |
| **Immunoglobulins, lactoferrin** | Has anti-microbial activity, modulate of inflammatory response | n/a | |
| **Growth factors (EGF, TGF-b)** | Prevents development of inflammatory bowel disease | n/a | |
| **PP and VPP peptides (fermented milk)** | Antihypertensive activity | n/a | |
| **Casoxins: A, B, C and D** | Regulates appetite and reduces feeding | n/a | |
| **Caseinophosphopeptides** | Enhances calcium absorption | n/a | |
| **Milk basic protein (whey)** | Promotes bone formation and inhibit bone resorption | n/a | |

[a] Recommendations for daily consumoption based on a 2,000 calorie diet
[b] an average range as estimated from studies around the Mediterranean

## Impacts of the diet on milk yield, fat and protein content

Since most sheep milk is used for cheese production, cheese yield (gram of cheese per litre of milk) is an important quality characteristic, affected mostly by milk protein content, but also by the fat content. Of these two macro-nutrients, the milk protein content is harder to manipulate by nutrition than the fat content.

### Factors influencing the protein content of the milk

- Generally, by increasing the energy content of the diet, especially if adding starch or sugar, the percentage of milk protein increases, to a certain point.
- An increase in dietary crude protein (CP) may also increase protein content, but will mainly increase milk yield and thus protein yield. On the other hand, a diet low in crude protein will decrease the protein content of the milk. These effects are highly affected by the source of protein.

- Excessive protein in the ration, either as rumen-undegradable or degradable protein, will reduce the protein percentage in milk.
- The use of fat supplements may also reduce the percentage of protein in the milk although this effect can be balanced by increasing the rumen-undegradable protein content in the diet.

### Factors influencing the fat content of the milk

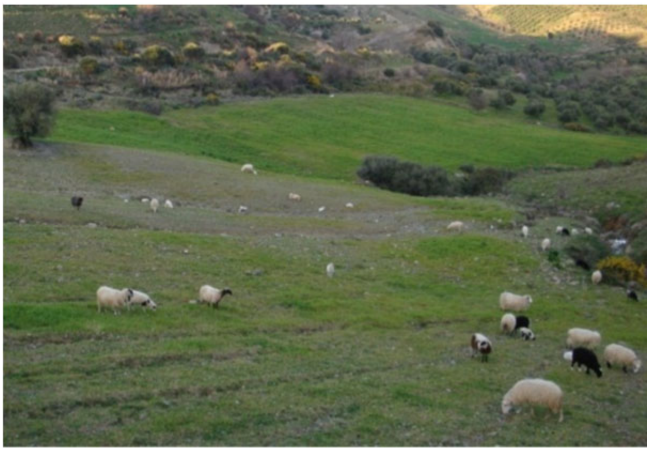
Compared to protein, the fat content and fatty acid profile of milk are more likely to be influenced by the diet.

- There is a high correlation between non-degradable fibre (NDF) in the diet and milk fat content; increasing the non-degradable fibre will increase the fat content of the milk. However, non-degradable fibre is also negatively correlated with milk yield. Nevertheless, an increase in the fat content of milk might well reflect a drop in milk production, rather than a direct effect of dietary fibre on milk fat. Many factors, such as energy balance, milk yield, availability and source of energy could influence this relationship. On the other hand, a low level of dietary fibre will result in a low milk yield and a low fat content. A non-degradable fibre level between 30 and 35 % of the dry matter in the ration seems to have the most beneficial effect on the fat concentration of the milk.
- Adding fat supplements to the diet will increase the fat percentage in the milk. But a high fat content (>6 %) in the ration will have the opposite effect.
- Finally, a diet of low energy content will impair productivity and reduce fat and milk secretion. On the other hand, if the energy intake is raised above optimal by increasing concentrate feed in the ration, an increase in milk yield will occur, while milk composition will be affected on later stage, depending on the breed.

## Impacts of the diet on the milk fatty acid profile

The fatty acid profile of sheep milk is affected in different ways and it is highly related with the fatty acid profile of the ration fed:

- Diets low in energy cause a mobilization of ewes' fat reserves and increase the concentration of long chain fatty acids (LCFA), particularly stearic, oleic and linoleic acid in blood and milk, for a short period of time.
- Milk from pasture fed ewes is known to have higher concentrations of conjugated linoleic acid (CLA), a-linolenic and linoleic acid, compared to milk from ewes fed with conserved hay and concentrate feed. This more preferable fatty acid profile is probably due to the higher content of polyunsaturated fatty acids (PUFA) in grass lipids.
- Feeding of leafy herbage from early growth stages increases concentration of a-linolenic, linoleic and conjugated linoleic acid in milk compared to grazing of late-growth, stemmy herbage or preserved forage.
- Different pasture mixtures result in different fatty acid profiles. Studies demonstrate higher levels of a-linolenic, conjugated linoleic acid and trans-11 oleic acid, when animals were grazed on pure legumes or grass–legume mixtures compared to grazing in pure grass pastures.
- The difference in plant populations (i.e species, composition) could explain the higher contents of conjugated linoleic acid and n-3 fatty acids in milk from ewes grazing at high altitudes compared to the milk from ewes grazing in lower altitudes.



**Picture 2. Sheep grazing on cultivated pasture on Crete. The composition of the pasture mixture has an influence on the fatty acid profile of the milk. (Photo: Nikos Voutzourakis)**

- Milk from diets with high forage to concentrate ratio exhibit a more preferable fatty acid profile than that from diets with a high intake of supplementary concentrates. Consumption of high-concentrate diets often reduces biohydrogenation, because of the lower ruminal pH, having a negative effect on conjugated linoleic acid and trans-11 oleic production.
- An increase in the fat content of the ration may also increase the concentration of conjugated linoleic acids and other fatty acids in milk depending on the fat source used. Animal fats in the diet reduce the short- and medium-chain fatty acids and increase unsaturated long-chain fatty acids, whereas opposite effects were observed when vegetable or fish oils were used.
- The use of rumen protected fat supplements with particular fatty acids can increase the concentration of the targeted fatty acids in the milk. For example, calcium soaps of palm oil will increase proportions of palmitic acid, whereas calcium soaps of olive oil increase proportions of oleic and stearic acids in sheep milk.

Most ovine milk is used for cheese production and the cheese fatty acid profile is positively correlated with the milk fat composition; the content of important fatty acids, such as conjugated linoleic acid, are not severely affected by the production process.

## Impacts of the diet on the content in vitamins, minerals and other compounds

The concentration of vitamin A, carotenoids and tocopherols in sheep milk is believed to be directly influenced by their presence in the ration. The best available source of these compounds is natural pasture at early growth whereas preserved forages and mature plants have significant lower concentrations. Thus, milk from pasture fed animals has higher concentrations of vitamins compared to the milk from sheep kept indoors.

The use of vitamin supplements to animals may increase milk concentration, but the scientific findings are not con-clusive.

The content of macro-element minerals in sheep milk is generally not affected by the diet, unless the fed ration lacks these minerals.

Finally, free grazing sheep, especially in mountainous and semi-mountainous areas, eat the local flora specific for each region, many containing various bioactive compounds such as the condensed tannins. These compounds have a beneficial effect on animal health and for some their contribution to the characteristic aroma in cheese has been identified. However, little is known about the effect on human health from the quantities found in milk and dairy produce.

## Outlook

Although many studies have been published on conjugated linoleic acid, eicosapentaenoic acid and other beneficial fatty acids in bovine milk, there is still little information available on ovine milk and dairy products, which describe the effect of the diet on the milk fatty acid profile.

Moreover, the relation between the milk fatty acid profile and biotic or/and abiotic stress factors has not been thor-oughly studied yet. It is the goal of the Lowinputbreeds project to close this gap.

## Further reading


Nudda, Anna, Gianni Battacone, Roberta Bencini, and Giuseppe Pulina. Nutrition and Milk Quality. in: Giuseppe Pulina, Editor(s), Dairy Sheep Nutrition, CABI Publishing, 2004, pages 129-150

Latha Sabikhi. Designer Milk. in: Steve L. Taylor, Editor(s), Advances in Food and Nutrition Research, Academic Press, 2007, volume 53, pages 161-198


## Imprint

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### Title photo

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### LowInputBreeds


LowInputBreeds is the acronym of the project 'Development of integrated livestock breeding and management strategies to improve animal health, product quality and performance in European organic and 'low input' milk, meat and egg production'. It is funded under the Seventh Framework Programme of the European Community for Research, Technological Development and Demonstration Activities (Contract No. 222623).


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### Editorial support

Gillian Butler, Newcastle Universty, UK

### Layout

Helga Willer and Gilles Weidmann, Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

### Publishers


Consortium of the LowInputBreeds project, c/ Newcastle University, UK, and Research Institute of Organic Agriculture (FiBL), Frick, Switzerland

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