Fatty acid composition of goat milk produced under different feeding regimens and the impact on Goat Cheese

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Abstract

Ruminants and their great ability to live and produce on a diet rich in fibre have a great potential to contribute to a healthy and sustainable human nutrition (Hofmann 1989). Sadly, only in times of rising energy prices the following question is asked: How much food can we afford to feed to animals? Taking this aspect into account considerably more research is necessary on the topic "Feed no Food in ruminant nutrition". In 2009 the Thuenen-Institute of Organic Farming in Trenthorst, Germany, started the project "Feed less Food" with the dairy goats on the organic experimental station in Trenthorst, Holstein, Northern Germany.

The main questions focused on the impact of reduced concentrate use on animal welfare, milk yield and quality. In 2012, the focus was laid on lactation performance and the occurrence of fatty acids in milk essential to humans. In 2012 two feeding groups were formed and dairy goats received either an estimated 10% or 40% of the total feed intake (dry matter basis) as concentrates (KF 10 and KF 40).

Goats in group KF 40 showed a significantly higher lactation performance (P < 0.05) regarding milk kg, fat kg and protein kg. No significant difference between groups was found for fat and protein content. Furthermore, no significant difference occurred in fatty acid pattern of milk. Short and medium chain fatty acids turned out to be significantly increased in cheese from group KF 40. Content of long chain and polyunsaturated fatty acids as well as rumenic acid (CLA) and Ω-3 fatty acids was significantly higher in cheese from goats of group KF 10,. Ratio of Ω-6:Ω-3 proved to be significantly lower in cheese from group KF 10.

Introduction

Ruminants and their great ability to live and produce on a diet rich in fibre have a great potential to contribute to a healthy and sustainable human nutrition (Hofmann 1989). Sadly, only in times of rising energy prices the following question is asked: How much food can we afford to feed to animals? Taking this aspect into account considerably more research is necessary on the topic "Feed no Food in ruminant nutrition".

In 2009 the Thuenen-Institute of Organic Farming (TI) has started the project "Feed less Food" using dairy goats on the organic experimental station in Trenthorst, Schleswig-Holstein, Northern Germany.

The main questions focused on the impact of reduced concentrate feed on animal welfare, milk yield and quality. Similar studies have already beenconducted by Sporkmann (2011), Rahmann (2011), Muzzulini (2010) and Aschenbach (2009).

In 2012, the focus was laid on lactation performance and milk quality traits essential in human nutrition.

For this purpose dairy goats from the research station of the Thuenen-Institute were split into two treatment groups. Group KF 10 received an estimated 10% of concentrates and group KF 40 received an estimated 40% of concentrates in their ration dry matter. As most of the goat milk produced in Europe is processed into fermented products, mainly cheese (Monrad-Fehr et al. 2007), the relevant quality aspects were considered in this experiment: milk from both groups was processed individually into a six weeks aged, semi-hard cheese.

The aim of this experiment was to answer the following questions: Do fatty acid(FA) patterns of milk and cheese differ between KF 10 and KF 40 groups? This question was investigated with special regard to some essential fatty acids such as Ω-6 and Ω-3, their ratio and conjugated linoleic acids (CLA). Even though knowledge about Ω-6 and Ω-3 FAs appears to be controversial, scientist seem to agree that the ratio of Ω-6:Ω-3 FAs in consumed human food has changed within the past 10,000 years from 1.5:1 to 20:1 in modern Western societies (DeFilipps and Sperling 2006; Simopoulos 2002). These very same authors furthermore agree that the increase in intake of Ω-6 FA , and therewith the relative decrease in intake of Ω-3 FA are seen as responsible factors for an increase of various diseases, particularly cardiovascular diseases (DeFilipps

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and Sperling 2006; Psota et al 2006; Simopoulos 2002) as well as cancer and inflammatory and autoimmune diseases (Simpoulos 2002). Most studies investigating effects of Ω-3 FAintake on human health were carried out using marine sources (fish). Fewer studies dealt with Ω-3 FAs that originate from plants. Nevertheless, it is assumed that those Ω-3 fatty acids have at least a similar effect (DeFilipps 2002).

Animals, material and methods

- **Animals:** In 2012 the trial started with 58 dairy goats, all of which belonged to the BDE breed (Bunte Deutsche Edelziege, German Alpine dairy goat). The trial began with the kidding in spring 2012 and ended with the drying off in November 2012. The whole farm of the research station is certified according to the guidelines of the European Union for organic agriculture (834/2007/EC). The flock was divided into two groups (28 and 26 goats): One group received approximately 10% of the total feed intake in the form of concentrates (KF10) (dry matter basis, explored in feeding trials, in which the lactating goats did not lose any live weight). For the other group concentrate was included at a level of about 40% of the total dry matter intake (KF40). Cracked wheat was pressed into pellets and fed as concentrate. Four weeks before kidding started each goat received 50 g per day of concentrate in the milking parlour, during milking. The amount of concentrate was successively increased to 500 g per day which was handed out in two portions, for the morning and evening milking. This level was maintained until weaning. Depending on the group concentrates were either further increased by 100 g per week until 1,000 g per day were reached (KF 40), or concentrates were decreased until 100 g per day were reached (KF 10). Grazing started on April 19. Altogether, a grazing area of 13,3 ha was available. Beyond grazing season hay was offered in the morning after the milking, and after the milking in the evening. During grazing season hay was given just once after the evening milking. In order to allow the goats to make use of their selective feed intake, 50% of the offered hay was tolerated as residual. The goats were milked twice a day and milk was stored in separate tanks for each group. The milk of each group was processed into semi-soft cheese according to the same log but with or without the addition of herbs (Volkmann 2012).
- **Feed:** Beginning July 6, feedstuff samples were taken on four different days between July and October (July 6, July 13, August 31 and September 7). Hay samples were collected from the hay bale on the feed bunk. In orer to make assure the samples were representative, the hay was taken from at least five different spots of the bale. Concentrate samples were taken from the bucket in the milking parlour or the hand barrow storing it. For sampling the rangeland a frame of 1x1m in size was put on five different spots of the pasture, the dairy goats were gazing on. Crop on pasture was cut at a height of approximately five centimetres using grass scissors. The height of the remaining crop should represent the approximate pasture refusal caused by goats. The cut of each square metre was collected and weighed. The samples were put in a drier for 72 hours at 60°C. The dried material was mixed and a part of it was ground (particle size: 1 mm) in order to make further analyses possible. All feedstuff samples were taken on Fridays from batches that were expected to be fed to the dairy goats until Monday, when milk samples were taken. **Nutrient contents** (g/kg dry matter): Hay: crude protein (CP) 143, ether extract (EE) 23, crude fibre (CF) 278, crude ash (CA) 86; Pasture**:** CP 143, EE 43, CF 228, CA 88; Concentrate**:** CP 135, EE 27, CF 38, CA 31.
- **Milk quality:** In addition to the individual milk yield monitoring and sampling conducted monthly separate pooled samples from the storage tank were taken weekly. Sampling began on March 20 and latest until October 24 (Volkmann 2012). Milk was analysed for fat, protein and lactose content and the somatic cell count. As a standardised milk yield was needed for further statistical analysis,the 240-day yield performance was calculated.
- **240-day milk yield (kg)**: **KF10:** milk: 514.4, fat: 14.8, protein: 14.4; KF40: milk: 641.5, fat: 19.1, protein: 18.2. (MSE root milk: 83.9, fat: 2.6, protein: 2.2; P-values <0.001)
- **Cheese qualities:** After six weeks of ageing samples were taken. Using a drill, small pieces of cheese were taken from five different spots of the brick shaped cheese wheels. Each cheese wheel was marked with the date of manufacture and the milk it was made of (KF 10 or KF 40). They were put in a plastic bag, one bag per wheel, and frozen at the Thuenen-Institute. Six of the deep-frozen samples of each group (KF 10 and KF 40) were brought to the University of Natural Resources and Life Sciences, Vienna, Department of Food Science and Technology, and analysed via gas-phase chromatograph for their fatty acid pattern.

Statistical analysis: All statistical tests were performed using SAS 9.1. Descriptive analysis was drawn in Microsoft Excel, using the Pivot function. Treatment effects were considered significant at $P<0.05$.

- **240-day yield and milk contents:** PROCEDURE GLM (General Linear Model) (ANOVA). The model used was: $Y = \mu$ + group + number of lactations + day of drying off + ε, whereas Y is the dependent variable (kg milk, kg fat, kg protein), μ = overall mean and ε = random error.
- **Fatty acid pattern:** Differences amongst groups of fatty acids spectrum of milk and cheese were analysed using PROCEDURE GLM: $Y = \mu$ + group + day + ε, with Y = dependent variable (e.g. sum of short chain fatty acids, sum of polyunsaturated fatty acids, sum of Ω - 3 fatty acids), μ = overall means and ε = random error.

Results

Milk: Table **1** gives an overview of the content of milk regarding the most important groups of fatty acids (FA). No significant differences were observed between group KF10 and KF40.

Table 1 : Fatty acid pattern of milk (g/100g FA)

Fatty acids	KF 10	KF 40	Root MSE	P-Value
SCFA[1]	8.4	8.5	0.4	0.537
MCFA[2]	25.9	26.6	1.6	0.453
LCFA[3]	62.7	62.2	1.6	0.574
SAFA[4]	73.4	73.7	1.5	0.744
MUFA[5]	19.5	19.5	0.8	0.945
PUFA[6]	4.1	4.1	0.3	0.935
Ω-3-FA	1.1	0.9	0.2	0.225
Ω-6-FA	1.5	1.9	0.4	0.100
Rumenic acid (CLA)	1.0	0.8	0.2	0.311

[1] Short Chain Fatty Acids, sums up C4 – C8 FA, [2] Medium Chain Fatty Acids, sums up C8 – C14 FA, [3] Long Chain Fatty Acids, sums up C15 – C22 FA, [4] Saturated Fatty Acids, [5] Monounsaturated Fatty Acids, [6] Polyunsaturated Fatty Acids.

Cheese: As Table 2 points out SCFA content was significantly higher in cheese of KF40 than in cheese from goats of KF10. The same can be said for the content of MCFA. An inverse result is given for LCFA ($P<0.001$). No statistical difference was noted for SCFA and MUFA. In contrary, the level of PUFA was significantly higher in cheese from goats of KF10. The content of Ω-3- FA and CLA was significantly higher in KF 10. An inverse result is given for Ω-6-FA

Table 2 : Fatty acid pattern of cheese (g/100g FA)

Fatty acids	KF 10	KF 40	Root MSE	P - Value
SCFA[1]	8.7	9.0	0.2	0.040
MCFA[2]	26.5	28.0	0.8	0.018
LCFA[3]	64.0	62.1	0.8	0.001
SAFA[4]	75.1	75.8	0.9	0.241
MUFA[5]	20.0	19.7	0.7	0.393
PUFA[6]	4.0	3.8	0.2	0.048
Ω-3-FA	1.1	0.8	< 0.1	< 0.001
Ω-6-FA	1.4	1.8	< 0.1	< 0.001
Rumenic acid (CLA)	1.0	0.8	0.1	0.012

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Omega 3:6 ratio:. No significant difference between groups regarding the Ω-6:Ω-3 ratio was observed in milk whereas in cheese it was markedly reduced in group KF10 (Table 3).

Table 3: Ω-6:Ω-3 ratio in milk and cheese

Item	KF 10	KF 40	Root MSE	P - Value
Milk	1.4	2.1	0.8	0.200
Cheese	1.3	2.2	0.1	< 0.001

Conclusions

With regard to the above findings, it can be concluded that a reduced use of concentrates presents a possible feeding strategy in (organic) dairy goat husbandry. A significant lower milk performance has to be accepted. Therefore, the decision for a minimised inclusion of concentrates has to be made very consciously. Results are indicating that reducing the concentrate supplementation has some potential of a higher product quality. Further research is needed and should include more detailed analysis of feedstuffs,e.g. fatty acid pattern, and detailed information about feed intake.
Assuming that a reduced omega 6:3 ratio has a positive effect on human health, there is evidence that a lower concentrate intake in dairy goats kept on pasture leads to “healthier” dairy foods.

The long-term health effects of a reduced concentrate feeding strategy on goats kept on pasture remain to be explored.

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