

EFFECT OF PARTIAL SORGHUM INCLUSION IN FEED RATION OF DAIRY COWS ON MILK FATTY ACID PROFILE

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ABSTRACT

The aim of this study was to assess the effect of the inclusion of approximately 5 kg of sorghum silage into the feed ration of dairy cows instead of the same amount of legume-grass silages on the fatty acid (FA) profile of milk. The on-farm experiment was conducted on 120 mid-lactating Czech Fleckvieh cows (Agrospol a.d. Knínice, farm Vanovice) and was divided into two consecutive periods of 3 months each. In the first period, cows were fed a total mixed ration based on maize silage and legume-grass silage (Control), while in the second period, legume-grass silage was partially replaced by sorghum silage (Sorghum). In each period, samples of evening and morning milk were taken from ten cows and were analysed for the FA profile, which was determined using gas chromatography equipped with a flame ionization detector. After the sorghum inclusion, the content of palmitic acid (C16) lowered ($P < 0.05$), and the content of pentadecenoic (C15:1), stearic (C18), arachidic (C20) and behenic acid (C22) increased ($P < 0.05$). The diet change also tended to decrease the content of eicosapentaenoic (C20:5n3) and tricosanoic acid (C23) ($0.05 \leq P < 0.1$).

Keywords: alternative feed, eicosapentaenoic acid, palmitic acid, stearic acid

INTRODUCTION

Increasing temperatures and long periods of drought are making it harder for farmers to grow traditional crops for animal feeding. For this reason, alternative crops, that are more drought and heat tolerant compared to maize and grasses, such as sorghum, are beginning to be grown in our conditions. However, it is well known that sorghum contains tannins and cyanogenic glycosides, which are antinutrients (Wang et al. 2024; Suha and Babiker 2015). Furthermore, tannins can impact rumen microbiota, which is responsible for the main lipid metabolism pathways in rumens (biohydrogenation and lipolysis) (Makmur et al. 2022).



Additionally, around 50 % of fatty acids (FA) in milk originate from the diet of ruminants, therefore the change in the diet can cause major impacts on the resulting fat composition of milk (Mansbridge a Blake 1997). Previous research on sorghum inclusion (Khosravi et al. 2018; Tudisco et al. 2021; Cattani et al. 2017; Yang et al. 2019) are not consistent and report various changes (positive and negative) in the FA profile after sorghum inclusion into the feed ration of dairy cows. The amount of sorghum in our study differs compared to other works, which have a higher sorghum amount (in percentage). For this reason, this work aims to assess how lower sorghum inclusion (around 10% of dry matter) impacts the resulting FA profile of milk.

MATERIAL AND METHODS

Design of experiment, animals and feeding

The design of the experiment is the same as described in Malý et al. (2024) (this being the third experiment). The on-farm experiment was conducted on a group of 120 mid-lactating Czech Fleckvieh cows (Agrospol a.d. Knínice, farm Vanovice), from which 10 representative cows were chosen for a detailed study of milk composition. The trial was divided into two consecutive 3-month periods. Each period consisted of at least a 3-week adaptation period and a 56–60 day collection period in which samples of milk were taken three times in monthly interval. Cows were fed a total mixed ration once daily; during the day, the feed was pushed regularly six times per day using an automatic feed pusher. In the first period, the total mixed ration (TMR) diet was based on maize silage, legume-grass silage and a supplemental mixture (Control), while in the second period, legume-grass silage was partially replaced with sorghum silage (Sorghum). The composition of feed rations is given in Tables 1 and 2. Cows were milked twice daily (at 4 a.m. and 3 p.m.), and milk yield was recorded.

Tab. 1: *Composition of feed ration (in kg/d, on as fed basis)*

Component (kg/d, as fed)	Control	Sorghum
maize silage	20	20.5
legumes-grass silage	10.5	4.5
sorghum silage	-	5.3
sugar beet pulp	8	5.4
molasses	0.6	0.6
supplemental mixture	9.75	10.4
rapeseed meal	1.1	1.25
sum of diets	49.95	47.95

Tab. 2: *Composition of supplemental feeding mixture (%)*

Component	Content (%)
wheat	24.6
barley	10
maize	23
soybean meal	19
rapeseed cake	16
SM Production U ¹	3.7
limestone	1.7
salt	0.5
sodium bicarbonate	1.5

¹SM Production U – vitamin and mineral mixture

Sampling and analysis

The sampling was similar to Malý et al. (2024), as it was the same project, but the third experiment/year. Samples of evening and morning milk were taken from ten cows once per month during the regular milk recording. Samples for FA analysis were frozen (-20 °C) until analysis.

Before FA analysis evening and morning milk was pooled into one sample relative to milk yield. Milk fat was extracted using a modified Bligh and Dyer (1959) extraction procedure. Transesterification of triglycerides in extracted fat to FA methyl esters (FAMES) was done by adding hexane and 0.5M methanolic sodium methoxide solution in a volumetric ratio of 80:3. FAMES were analysed by gas chromatography with flame ionization detection using GC Agilent 8860 (Agilent, United States) under optimised conditions used in Mitchell et al. (2023) (oven program: 60 °C for 4 min to 140 °C @ 2 °C/min and held for 30 min to 160 °C @ 1 °C/min and held for 60 minutes to 190 °C @ 1 °C/min and held for 60 min, detector: FID @ 250 °C) using the ZB-FAME column (Phenomenex, United States) with dimensions 100 m x 0.25 mm x 0.20 µm. The identification of FAs was carried out using the analytical standards (Restek, United States). The FA profile was determined by calculating the ratio of each FA's peak area to the total peak area of all detected FAs.

Statistical analysis

Statistical analysis was done using Microsoft Excel (Microsoft). For testing the significance between the groups (Control, Sorghum), the T-test was used.

RESULTS AND DISCUSSION

The results shown here are preliminary, from one sampling term in each experimental group (n = 10).

The resulting FA profile of milk before and after sorghum inclusion is shown in Table 3.

The most abundant saturated fatty acid (SFA) was in both groups palmitic acid (C16), followed by myristic (C14) and stearic (C18) acids, respectively. This is in agreement with Yang et al. (2019) and Cattani et al. (2017). Other authors report slightly higher C14 content compared to C18 in the sorghum group. It is important to note that this is a numerical comparison only without any statistical test. Our results show that after the inclusion of sorghum into the diet of dairy cows, the concentration of palmitic acid has significantly decreased ($P < 0.05$). This is in contrast with Yang et al. (2019), Tudisco et al. (2021), Khosravi et al. (2018) and Cattani et al. (2017), who reported either no change in the content of C16 after the inclusion of sorghum or an increase (Cattani et al. 2017). Another SFA impacted by the inclusion was C18, whose content increased in Sorghum compared to Control ($P < 0.05$). This matches results reported in studies from Yang et al. (2019) and Cattani et al. (2017). Other authors reported no differences in the content of C18 after incorporation of sorghum (Khosravi et al. 2018; Tudisco et al. 2021). Arachidic acid (C20) and behenic acid (C22) were also higher in Sorghum in comparison with Control ($P < 0.05$). Yang et al. (2019) and Khosravi et al. (2018) also reported an increase in C20, but did not observe C22. Other SFA were not affected by the treatment. It should be taken into account that the TMR slightly differs in each work as well as the breed of the cows used compared to our work, so direct comparison with the literature is not possible. Another important factor is the amount of sorghum silage added to the feed ration, which is lower in our work compared to the work of other authors and also varies across studies. Diet and breed have a significant impact on the final FA composition (Hanuš et al. 2018), so this can further explain inconsistencies in scientific literature and also between it and our work.

The major unsaturated fatty acid in both experimental groups in our study is oleic acid (C18:1n9c), followed by linoleic acid (C18:2n6c) and palmitoleic acid (C16:1). This is the same as in work from Yang et al. (2019) and Khosravi et al. (2018). Regarding UFA, the dietary change affected only eicosapentaenoic acid (C20:5n3), whose levels tended to decrease ($0.05 \leq P < 0.1$).

Our results can be considered overall positive. A lower concentration of C16 in the human diet is health beneficial (Hanuš et al. 2018). Hanuš et al. (2018) mentions that C16 increases total blood cholesterol and cardiovascular disease risk. Another important aspect of our study is that incorporating sorghum silage didn't affect most FA, which is very good, so the farmers can include sorghum without it having a negative effect on the FA profile of milk.

Tab. 3: *The content of fatty acids (relative representation) in milk*

	Control ¹		Sorghum ²		P
	mean	SD	mean	SD	
C4	1.13	0.12	1.07	0.11	0.262
C6	1.11	0.10	1.08	0.13	0.554
C8	0.93	0.08	0.95	0.10	0.691
C10	2.90	0.32	3.07	0.39	0.321
C11	0.18	0.11	0.14	0.03	0.285
C12	4.42	0.52	4.53	0.54	0.659
C13	0.26	0.13	0.21	0.04	0.267
C14	13.83	1.06	14.25	0.89	0.349
C14:1	1.38	0.30	1.18	0.33	0.173
C15	2.13	0.85	1.69	0.24	0.149
C15:1	0.23	0.06	0.28	0.04	0.036
C16	35.94	1.52	33.48	2.13	0.008
C16:1	1.97	0.32	1.74	0.39	0.171
C17	0.74	0.16	0.67	0.04	0.180
C17:1	0.31	0.09	0.26	0.05	0.150
C18	7.18	1.37	8.73	1.15	0.014
C18:1n9c	21.16	1.83	22.49	1.87	0.124
C18:2n6t	0.07	0.11	0.03	0.00	0.337
C18:2n6c	2.51	0.32	2.54	0.26	0.795
C18:3n6	0.05	0.00	0.05	0.01	0.495
C18:3n3	0.44	0.05	0.43	0.05	0.783
CLA	0.50	0.09	0.46	0.14	0.495
C20	0.10	0.02	0.13	0.02	0.004
C20:1n9	0.06	0.02	0.05	0.01	0.398
C20:2	0.03	0.00	0.03	0.00	0.490
C20:3n6	0.10	0.02	0.11	0.02	0.331
C21	0.02	0.00	0.02	0.00	0.811
C20:4n6	0.15	0.02	0.15	0.02	0.762
C20:5n3	0.04	0.00	0.04	0.00	0.062
C22	0.03	0.01	0.04	0.00	0.024
C23	0.01	0.01	0.02	0.00	0.058
C24	0.02	0.01	0.02	0.00	0.204
C24:1n9	0.07	0.01	0.06	0.01	0.493

¹ diet based on maize silage and legume-grass silage² diet based on maize silage and legume-grass silage that was partially replaced by sorghum silage

CONCLUSION

Our results show that sorghum silage can be incorporated into the feed ration of dairy cows without major and negative changes in the fatty acid profile. After the 5 kg inclusion, the content of palmitic acid (C16) decreased ($P < 0.05$), and the content of stearic (C18), arachidic (C20) and behenic acids (C22) increased ($P < 0.05$), with the majority of fatty acids being unaffected by the treatment. These results suggest that sorghum incorporation, especially in regions with higher temperatures and limited rainfall, can be used as a replacement for legumes and grass, without ruining the nutritional value of the fatty acid profile in milk.

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