MEDDOCS Open Access Publisher

Journal of Veterinary Medicine and Animal Sciences

Open Access | Research Article

Partial replacement of alfalfa hay by wheat straw improves milk oxidative stability without negative effects on milk yield and composition in sheep

PE Simitzis*; A Chazlari; MA Charismiadou; M Goliomytis; SG Deligeorgis

Department of Animal Breeding and Husbandry, Faculty of Animal Science and Aquaculture, Agricultural University of Athens, 75 Iera Odos, Athens, 11855, Greece

***Corresponding Author(s): PE Simitzis**

Department of Animal Breeding and Husbandry, Faculty of Animal Science and Aquaculture, Agricultural University of Athens, 75 Iera Odos, Athens, 11855, Greece

Email: pansimitzis@aua.gr

Received: Aug 20, 2018

Accepted: Sept 10, 2018

Published Online: Sept 13, 2018

Journal: Journal of Veterinary Medicine and Animal Sciences

Publisher: MedDocs Publishers LLC

Online edition: http://meddocsonline.org/

Keywords: Sheep; Alfalfa hay; Wheat straw; Milk oxidative stability; Milk yield; Milk composition

Abstract

Objective: Milk is susceptible to oxidation and the products of this process may be harmful for living organisms. Diet composition of dairy animals can influence milk fatty acid profile and therefore milk vulnerability to oxidation. The aim of the present study was to highlight the effects of partial replacement of alfalfa hay by wheat straw on milk yield, composition and oxidative stability in sheep.

Methods: Eighteen Karagouniko ewes were allocated into two homogeneous groups (n = 9). Each ewe was then individually fed with forage (100% alfalfa hay - C or 65% alfalfa hay: 35% wheat straw - S) and concentrates during the experimental period that lasted 28 days. Individual milk samples were collected at 0, 7, 14, 21 and 28 days of the experiment for chemical composition (IR spectrometry) and oxidative stability (MDA concentration) analyses.

Results: Partial replacement of alfalfa hay by wheat straw improved milk oxidative stability (decreased malondialdehyde - MDA values) without negative implications on milk yield and composition (fat, protein, lactose) in sheep.

Conclusion: Wheat straw can replace alfalfa hay up to the level of 35% in the diets of ewes with positive effects on milk characteristics observed after 14 days.

Introduction

The oxidative stability of milk and the derived dairy products plays a major role in the dairy industry. Milk lipid oxidation is highly influenced by long chain unsaturated fatty acids, which are particularly susceptible to this biological process and can give rise to the development of off-flavor that leads to milk quality deterioration [1]. The composition of the milk is affected by several factors, such as breed, management, stage of lactation, health status and nutrition. Diet components and certain feeding regimes provided to the dairy animals can therefore increase the content of polyunsaturated lipids of milk and its susceptibility to oxidation [2] or offer additional protection against oxidation procedures [3,4].

Among the factors that affect milk composition is the forage type [5,6]. As already shown, milk from cows fed fresh green forage had a much higher unsaturated: saturated Fatty Acids (FA) proportion, with increased levels of polyunsaturated FA and Conjugated Linoleic Acid (CLA) (in particular C18:2 cis-9,

Cite this article: Simitzis PE, Chazlari A, Charismiadou MA, Goliomytis M, Deligeorgis SG. Partial replacement of alfalfa hay by wheat straw improves milk oxidative stability without negative effects on milk yield and composition in sheep. J Vet Med Animal Sci. 2018; 2: 1006.

trans-11), compared to the milk produced by silage-fed cows [7]. Moreover, according to a previous study [8], molar proportions of acetate, butyrate and valerate decreased linearly, whereas that of propionate and 2-methyl butyrate increased linearly with the increase of wheat straw levels as a replacer of alfalfa hay in the diet of cows.

Part-time grazing with indoor supplementation is the predominant, most frequently used, sheep flock management system during the main period of lactation in Greece [9]. The two main sources of supplemental forage used in the diets of small ruminants are alfalfa hay and wheat straw. However, recent literature is mainly focused on the effects of concentrate/forage ratios and little information is available on the effect of the nature of forage on milk composition in dairy animals others than dairy cows. The aim of the present study was therefore to examine the impact of partial replacement of alfalfa hay by wheat straw without changing concentrate/forage ratio on milk yield, composition and oxidative stability in sheep.

Materials and methods

Eighteen 3-year-old Karagouniko dairy ewes at the mid lactation (100–105th day after parturition) and at their second parity were used in the present experiment. Animals were fed with alfalfa hay and concentrates, were housed at the premises of the Agricultural University of Athens and handled according to the Ethical Committee guidelines of the Faculty of Animal Science and Aquaculture. The ewes were allocated into two homogeneous sub-groups (n = 9) based on their mean body weight (46.3 ± 2.4 kg) and milk yield (1.11 ± 0.15 L). Each ewe of control and straw groups was individually fed with forage (100% alfalfa hayor alfalfa hay: 35% wheat straw, respectively) and concentrates (Table 1) for a period of 28 days. The quantities of feed provided to the animals were adjusted according to their individual requirements, based on their body weight and milk yield. All animals had ad libitum access to fresh water. Diet selectivity did not occur, and no refusals of forage and/or concentrates were observed. Individual samples from control and straw groups were collected at the beginning of the experiment. These samples were analyzed for organic matter (OM; Official Method 7.009), dry matter (DM; Official Method 7.007) crude protein (CP; Official Method 7.016) and ether extract (EE; Official Method 7.060), according to the Association of Official Analytical Chemists International [10]. Composition and analysis of the concentrates (Viozokat S. A., Katerini, Greece) are presented in Table 1.

Table 1: Composition and analysis of concentrates, alfalfa hay and wheat straw

Components (g kg^{-1})	Concentrates	Alfalfa hay	Wheat straw
Corn	465		
Wheat	120		
Soybean Meal (47%)	210		
Sunflower Meal (33%)	50		
Alfalfa meal	30		
Wheat Bran	40		
Palm oil	25		
Molasses	15		
Salt (NaCl)	9		
Monocalcium Phosphate	14		
Limestone	18		
Vitamins & Trace elements Premix*	4		
Analysis			
Dry Matter – DM (g kg^{-1})	880	935	952
Crude protein – CP (g kg^{-1})	170	102	34
Crude Fiber (g kg^{-1})	54	342	517
Ash (g kg^{-1})	80	74	72
Fat (g kg^{-1})	50	23	10
Calcium (g kg^{-1})	10	-	-
Phosphorus (g kg^{-1})	7	-	-

*Premix provided per kg: 50 mg Fe, 60 mg Zn, 0.76 Se, 0.75 mg Co, 1.25 mg I, 35 mg Mn, 150 mg Mg, 15 kIU vitamin A, 2 kIU vitamin D3, 25 mg vitamin E, 0.63 mg vitamin B1, 0.50 mg vitamin B2, 0.13 mg vitamin B6, 12.5 mg niacin, 1.6 mg pantothenic acid, 0.15 folic acid, 0.15 mg biotin (kIU: 1000 International Units).

Animals were milked twice a day at 6 am and 6 pm by a milking machine. Individual milk samples were collected at 0, 7, 14, 21 and 28 days of the experiment for chemical composition and oxidative stability analyses. Milk sample was obtained after mixing the volume of milk collected during the morning and evening milking and was analyzed for fat, protein and lactose by IR spectrometry (Milkoscan 133; Foss Electric, Hllerod, Demark), after calibration according to Gerber [11] and Kjeldahl [12]. Oxidative stability of ewe milk was evaluated by measuring the levels of Malondialdehyde (MDA), a secondary lipid oxidation product formed by hydrolysis of lipid hydroperoxides. MDA concentration was determined by applying a selective third-order derivative spectrophotometric method, previously developed by Botsoglou et al [13].

Data were subjected to ANOVA with the nutritional treatment as the fixed effect. Ewe was considered as the experimental unit. The level of significance was set at 0.05. Results are presented as least square means ± SEM. All analyses were performed by SAS/STAT Version 9.1.3 (2011).

Results and discussion

As illustrated in Table 2, partial replacement of alfalfa hay by wheat straw (35%) did not have a significant effect on milk yield and composition (fat, protein, lactose) during the experimental period. No effect on milk yield, fat, protein and lactose content was also found in cows after the partial replacement (30%) of alfalfa hay by wheat straw [8]. On the other hand, MDA content of milk was decreased after 14 days of wheat straw supplementation indicating an improvement in milk oxidative stability (Table 2). Milk MDA values remained lower in S compared to C group till the end of the experiment. However, milk malondialdehyde levels of S group were similar on days 14, 21 and 28. A possible explanation for the improved milk oxidative stability is that ewes fed with the wheat straw produced milk with lower levels of polyunsaturated fatty acids. This hypothesis is supported by the fact that alfalfa hay contains higher levels of polyunsaturated and lower levels of saturated fatty acids compared to wheat straw (Tsiplakou, personal communication).

Table 2: Effect of forage (100% alfalfa hay - C or 65% alfalfa hay: 35% wheat straw – S) on milk yield (L), composition (fat, protein, lactose - %) and MDA content (ng mL-1)

Milk Parameter	Day	Group		P-value
		Control (C)	Straw (S)	
Yield (L)	0	1.15 ± 0.16	1.08 ± 0.14	0.72
	7	1.24 ± 0.14	1.05 ± 0.13	0.32
	14	1.16 ± 0.13	0.93 ± 0.12	0.19
	21	1.03 ± 0.11	0.84 ± 0.11	0.21
	28	1.02 ± 0.11	0.83 ± 0.11	0.09
Fat (%)	0	4.72 ± 0.46	4.78 ± 0.41	0.85
	7	5.54 ± 0.34	5.15 ± 0.33	0.37
	14	5.71 ± 0.32	5.71 ± 0.33	0.99
	21	5.81 ± 0.26	5.73 ± 0.25	0.81
	28	5.74 ± 0.26	5.43 ± 0.23	0.39
Protein (%)	0	5.39 ± 0.15	5.17 ± 0.13	0.18
	7	5.31 ± 0.11	5.18 ± 0.09	0.33
	14	5.17 ± 0.09	5.05 ± 0.08	0.34
	21	5.33 ± 0.09	5.09 ± 0.08	0.07
	28	5.21 ± 0.11	4.93 ± 0.11	0.09
Lactose (%)	0	5.43 ± 0.18	5.63 ± 0.16	0.30
	7	5.69 ± 0.07	5.68 ± 0.06	0.91
	14	5.61 ± 0.07	5.64 ± 0.06	0.76
	21	5.46 ± 0.09	5.53 ± 0.08	0.58
	28	5.48 ± 0.09	5.46 ± 0.08	0.82
MDA (ng mL^{-1})	0	4.85 ± 0.31	4.82 ± 0.28	0.93
	7	3.52 ± 0.23	3.22 ± 0.21	0.33
	14	3.84 ± 0.30	2.51 ± 0.30	<0.01
	21	3.85 ± 0.30	2.39 ± 0.30	<0.01
	28	3.83 ± 0.37	2.40 ± 0.36	<0.01

The significant effect of forage type on milk oxidative stability has already been shown in previous studies. Increased levels of lipid hydroperoxides in milk were observed from cows fed grass-clover silage compared to that fed meadow hay, possibly due to the significantly higher concentration of linolenic acid [14,15]. Singlet oxygen attacks the double bonds of the unsaturated fatty acids that are responsible for the amount of lipid hydroperoxides [16]. Moreover, diets based on red clover and alfalfa silages are susceptible to a rapid loss of α-tocopherol and increased production of oxidation products, such as Thiobarbituric Acid Reactive Substances (TBARS) during the storage of cow milk in comparison with the milk produced by cows fed diets based on grass silage [17]. Finally, water-soluble Total Antioxidant Capacity (TAC) of milk appears to increase when the ewes consume fresh grass mainly through grazing instead of alfalfa hay [18].

Conclusions

Partial replacement of alfalfa hay by wheat straw improves milk oxidative stability without negative effects on milk yield and composition in sheep. This effect was evident after two weeks of wheat straw dietary inclusion and is possibly associated with the lower concentration of polyunsaturated fatty acids in wheat straw than alfalfa hay.

Acknowledgement

The authors would like to thank the Department of Nutritional Physiology and Feeding in Agricultural University of Athens and especially Mrs M. Georgiadou for forage analyses and the Department of Dairy Research in Agricultural University of Athens for milk composition analyses.

References

1. Timmons JS, Weiss WP, Palmquist DL, Harper WJ. Relationships among dietary roasted soybeans, milk components, and spontaneous oxidized flavor of milk. J Dairy Sci. 2001; 84: 2440–2449.

2. Stockdale CR, Walker GP, Wales WJ, Dalley DE, Birkett A, et al. Influence of pasture and concentrates in the diet of grazing dairy cows on the fatty acid composition of milk. J Dairy Sci. 2003; 70: 267–276.

3. Correddu F, Nudda A, Manca MG, Pulina G, Dalsgaard TK. Light-Induced Lipid Oxidation in Sheep Milk: Effects of Dietary Grape Seed and Linseed, Alone or in Combination, on Milk Oxidative Stability. J Agric and Food Chem. 2015; 63: 3980-3986.

4. Di Trana A, Bonanno A, Cecchini S, Giorgio D, Di Grigoli A, et al. Effects of Sulla forage (Sulla coronarium L.) on the oxidative status and milk polyphenol content in goats. J Dairy Sci. 2015; 98: 37-46.

5. Vlaeminck B, Fievez V, Carbita ARJ, Fonseca AJM, Dewhurst RJ. Factors affecting odd- and branched-chain fatty acids in milk: A review. Animal Feed Science and Technology. 2006; 131: 389-417.

6. Nicholson JWG, St-Laurent AM. Effect of forage type and supplemental dietary vitamin E on milk oxidative stability. Canadian Journal of Animal Science. 1991; 71: 1181-1186.

7. Elgersma A, Tamminga S, Ellen G. Modifying milk composition through forage. Animal Feed Science and Technology. 2006; 131: 207-225.

8. Poore MH, Moore JA, Swingle RS, Eck TP, Brown WH. Wheat straw or alfalfa hay in diets with 30% neutral detergent fiber for lactating cows. Journal of Dairy Science. 1991; 74: 3152-3159.

9. Sossidou E, Ligda C, Mastranestasis I, Tsiokos D, Samartzi F. Sheep and Goat Farming in Greece: Implications and Challenges for the Sustainable Development of Less Favoured Areas. Animal Science and Biotechnologies. 2013; 46: 446-449.

10. Association of Official Analytical Chemists International. Official Methods of Analysis, 14th Edition. 1984.

11. British Standards Institution. Gerber Method for the Determination of Fat in Milk Products. 1955.

12. International Dairy Federation. Determination of the Nitrogen Content of Milk, Kjeldahl Method, Inter. Standard FID-IDF 20b, Part 1. International Dairy Federation, Brussels. 1993.

13. Botsoglou NA, Fletouris DJ, Papageorgiou GE, Vassilopoulos VN, Mantis AJ, Trakatellis AG. A rapid, sensitive and specific thiobarbituric acid method for measuring lipid peroxidation in animal tissues, food and feedstuff samples. J Agric and Food Chem.

1994; 42: 1931-1937.

14. Havemose MS, Weisbjerg MR, Bredie WLP, Poulsen HD, Nielsen JH. Oxidative stability of milk influenced by fatty acids, antioxidants, and copper derived from feed.Journal of Dairy Science. 2006; 89: 1970–1980.

15. Havemose MS, Weisbjerg MR, Bredie WLP, Nielsen JH. Influence of feeding different types of roughage on the oxidative stability of milk. International Dairy Journal. 2004; 14: 563–570.

16. Halliwell B, Gutteridge JMC. Free Radicals in Biology and Medicine, second ed. Clarendon Press, Oxford. 1996.

17. Al-Mabruk RM, Beck NFG, Dewhurst RJ. Effects of Silage Species and Supplemental Vitamin E on the Oxidative Stability of Milk. Journal of Dairy Science. 2004; 87: 406-412.

18. Ruiz de Gordoa JC, Bustamante M, Arranz J, Virto M, Barron LJR, et al. Increase in water- soluble total antioxidant capacity of sheep's milk as a result of increased grazing time. In: Challenging strategies to promote the sheep and goat sector in the current global context.

19. Ranilla MJ, Carro MD, Ben Salem H, Morand-Fehr P. CIHEAM, Options Méditerranéennes : Série A. Séminaires Méditerranéens. 2011; 99:267-271.