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Seasonal variation in retinol concentration of goat milk associated with grazing compared to indoor feeding

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Abstract

Forty-five Siriana dairy goats were divided into three groups and assigned to three feeding treatments: i) grazing (G), ii) grazing plus 600 g of mixed barley and chickpeas grain per day (GBC), iii) grazing plus 600 g of mixed maize and broad beans per day (GMB). These grazing groups were compared to a control group (I) of 15 Siriana goats fed indoors a pasture hay plus 600 g of a commercial concentrate per day. Retinol concentrations of milk samples were determined and correlated with the herbage intake. Feeding treatments influenced all trans and total retinol concentrations significantly. Milk from treatment G contained the highest all-trans and total retinol concentrations, while milk from treatment I had the lowest values. The increase in total retinol concentration in milk of 20% and 30%, respectively, corresponded with the increase in green herbage intake, from zero in the I treatment to 381.7 g DM/day in the GBC and GMB treatments and 568.7 g DM/day in G treatment. From spring to winter the ratio between total retinol concentration and milk production (R/MP) showed an opposite trend in comparison to milk production: the more the milk production decreased, the more the R/MP ratio increased. The differences observed in summer and winter between grazing treatments were probably due to different herbage intake. The mean ingested herbage intake of the GMB group was 28% less than that of the G group, and 36% less than the GBC group. This low intake caused the R/MP ratio to decrease by 41% and 62% in the G and the GBC groups, respectively. In the spring the herbage intake was higher (*ca.* 39%) than in the other two seasons, but no differences were observed between treatments. The influence of feeding treatment observed on milk retinol concentration could be due to a difference in retinol precursor concentration in the animal diet and/or a difference in bioavailability of the precursors in the animal body.

Keywords: Retinol, dairy goat, feeding treatment
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Introduction

All-transretinol, the main form of vitamin A, is found in animal products such as milk, meat and eggs, while provitamin A (carotenoids) may be found in fruits, vegetable oils and other vegetables (Scott *et al*., 2000). Carotenoids, which include, amongst many others, β- and α-carotene and β-cryptoxanthin are converted with different degrees of efficiency to vitamin A. The most potent retinol precursor is β-carotene. The vitamin A level in milk may be influenced by the animal diet. In forages, β-carotene is degraded during drying and preservation as a consequence of exposure to light (Park *et al*., 1983) and milk from grazing animals or those fed pasture herbage contains a higher level of vitamin A than milk from animals fed diets consisting of hay and concentrates (Pizzoferrato *et al*., 2000; Martin *et al*., 2002).

In the Mediterranean area, goat feeding systems are based on rangeland or natural pasture resources, but in some countries, specifically France, preserved feeds are used extensively. Grazing animals, in particular goats, prefer to browse the green parts of plants, especially in the summer when a large part of the vegetation is dry (Fedele *et al*., 1993). The aim of the present study was to investigate the seasonal variation of retinol levels in milk from grazing goats with or without concentrate supplementations, compared with a diet containing no fresh herbage (control).

Materials and Methods

A native herbaceous pasture in a Basilicata valley (Southern Italy) at 360 m above sea level was used for this experiment. According to climatic conditions, which are cold in winter (from –6 to 8 °C), temperate in spring (from 16 to 23 °C) and hot in summer (from 26 to 32 °C), the botanical composition of pastures changes considerably. Grasses, in particular *Lolium perenne, Dactylis glomerata* and *Bromus* spp. grow in

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winter, while legumes (*Medicago polimorpha*, *Trifolium repens*, *Vicia* spp.) and certain forbs (*Ranunculus bulbosus*, *Asperula odorosa*, *Daucus carota*, *Geranium molle*, etc.) grow in the spring and forbs such as *Galium verum*, *Rumex* spp., *Cichorium intybus*, *Plantago* spp. in summer. Forty-five Siriana dairy goats in their third lactation were divided into three groups and offered one of the following treatments: G - grazing only, for 8 hours/day; GBC - grazing plus 600 g of a mixture of barley and chickpeas grain (140 g CP and 180 g NDF/kg) per day; GMB: grazing plus 600 g of a mixture of maize and broad beans (140 g CP and 180 g NDF/kg) per day. The grazing consisted of an area of 6 ha which was divided into six equal-sized paddocks, two of which were alternately grazed by each group. These grazing groups were compared to a control group (I) of 15 goats fed indoors on a pasture hay plus 600 g of commercial concentrate (150 g CP and 180 g NDF/kg feed) per day. Herbage intake was estimated by difference between the herbage mass measured in a 2x2 m of ungrazed pasture and five 2x2 m post-grazing areas per treatment. During winter (from March to middle April), spring (from middle April to early June) and summer (from early June to middle July), three milk samples were collected per season from each goat. The samples per season per goat were mixed and stored for analyses. Retinol isomers were determined by HPLC after saponification and extraction according to the method of Panfili *et al*. (1996). Results standardized for dry matter and individual milk goat production were statistically evaluated using SAS GLM procedure (1990). Effects of feeding treatment and season were tested for each studied variable.

Results and Discussion

All-trans, 13-cis, all-trans plus 13-cis (total) concentrations, and the cis/trans retinol ratio of the milk samples are reported in Table 1. Feeding treatments had an influence on all-trans and total retinol concentrations ($P > 0.05$). Milk from unsupplemented grazing goats (G treatment) contained the highest all-trans and total retinol concentration (633.01 and 650.48 μg/100 DM, respectively) while milk from the I treatment had the lowest values (481.57 and 498.60 μg/100 DM, respectively).

Table 1 Retinol concentration (μg/100 DM) in milk samples (mean ± s.d.)

Retinol	Dietary treatments				F
	Hay + Concentrate (I)	Grazing (G)	GBC	GMB	
All-Trans	481.6 ± 51.8^{b}	633.0 ± 132.0^{a}	566.6 ± 124.9^{b}	591.5 ± 100.3^{ab}	*
13-Cis	17.0 ± 6.9	17.5 ± 14.2	14.5 ± 9.1	18.6 ± 14.4	NS
Total	498.6 ± 49.9^{b}	650.5 ± 133.9^{a}	581.0 ± 129.4^{b}	610.1 ± 102.9^{ab}	*
Cis/trans	3.53 ± 1.7	2.76 ± 2.1	2.55 ± 1.5	3.15 ± 2.5	NS

a,b -values with the same letter are not statistically different ($P > 0.05$)
GBC – Grazing + barley and chickpeas grain; GMB – Grazing + maize and broad beans

From these results, green herbage intake influenced trans retinol levels in milk positively. Compared to the zero green herbage intake (I) treatment, the total retinol concentration in the milk increased by 20% in the GBC and GMB treatments where green herbage intakes were 381.7 ± 96.5 g/day DM, and by 30% in the G treatment where green herbage intake was 568.7 ± 69.4 g/day DM (Figure 1).

While the ratio total retinol concentration/milk production (R/MP) increased from spring to winter, the milk production (MP) values showed an opposite trend, in agreement with the observation by Jensen *et al*. (1999) in dairy cows. The R/MP value increased more in the unsupplemented grazing goats (G) from spring to winter than in indoor goats (I). The herbage contribution to the diet seemed to influence the retinol content in milk. In fact, the differences between grazing treatments in summer and winter could be explained by the different levels of herbage intake. The respective herbage ingestions of the GMB and GBC groups were 28% and 36% less than in G group. The relevant decrease of R/MP ratio was 41% and 62% respectively.

In spring the green herbage intake was the highest and no differences were observed in the milk production between the different feeding treatments. During this season, vegetation growth is the highest and goats browse preferably the floral shoots and flowers. During this phase, plants tend to synthesize defensive secondary compounds (Strauss *et al*., 2004), probably decreasing vitamin synthesis. They may also

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synthesize compounds not completely bio-available to ruminal microflora. As a consequence, the vitamin concentration in milk decreases.

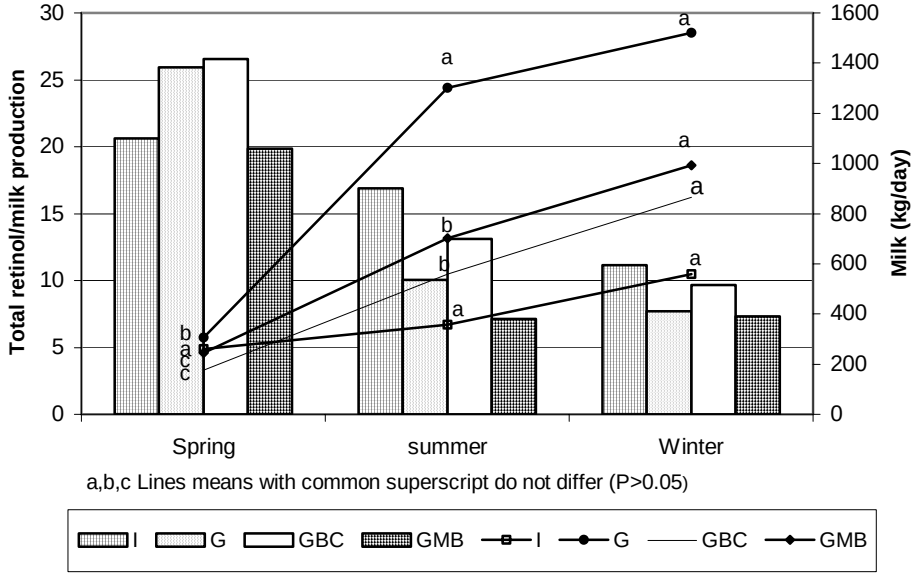

Figure 1 Seasonal variation of total retinol/milk production ratio (—) in relation to milk production ( )

Conclusions

This study suggests that the influence of feeding treatment on milk retinol concentration may be explained on the basis of differences in retinol precursor concentrations in the diet, and/or differences in bioavailability of precursors for vitamin A synthesis in the animal. The grazing herbage positively influences the trans retinol level in milk and seems to be the most critical factor, *viz*. the higher the herbage intake, the higher the retinol concentration in milk in summer and winter. The exception is in spring, when this relationship was apparently not valid.

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