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β-carotene Supplementation Does Not Improve Milk Yield and Milk Components of Saanen Goats

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Abstract: We hypothesized that supplementing goats with β-carotene would increase milk yield and improve milk quality. Therefore, the current study aimed at evaluating the effect of supplemental β-carotene on milk yield and milk components. Goats were divided into two groups, one group received β-carotene 100 and 50 mg/head/day before and during the drying off period, respectively, while the second group received water as placebo with similar quantities. Colostrum samples were collected for three days and the milk samples were collected once a week for a month. Milk yield, protein%, fat%, lactose% and Somatic Cell Counts (SCC) were analysed. Milk fat, lactose and protein were analysed using Spectrometer and SCC was analysed using Cytometer. The data collected for milk yield, fat, protein and lactose and SCC were analysed using one-way analysis of variance for repeated measures with PROC GLM procedure of SAS (version 9.4). The study found no effect of supplemental β-carotene on milk yield and milk composition. Therefore, it can be concluded that supplemental β-carotene does not influence milk yield and milk composition of Saanen goats during the drying off period.

Keywords: Goat, Colostrum, Protein, Lactose, Somatic Cells Count

Introduction

Feed supplements such vitamin E, vitamin C, carotene, selenium, zinc, vitamin A and manganese are considered to have antioxidant activities (Mardalena *et al*., 2011; Torsein *et al*., 2018). These antioxidants could improve health protection against free radicals as an attempt to prevent damage caused by oxidation process (Mardalena *et al*., 2011). As a result, causes improvement in protein, fat, somatic cell count and udder health (Sretenovic *et al*., 2007; Pulido *et al*., 2012).

Dairy products such as milk have high contents of vitamin-A and β-carotene which are stored in form of retinol in animals (Ullah *et al*., 2017). β-carotene with its function as an antioxidant can directly play a role in reduction of oxidative stress thus improving products quality and health status of animals (Castillo *et al*., 2005; 2006). Therefore, addition of β-carotene can play a crucial role in goat nutrition to enhance milk performance.

In ruminant animals, however, there is species difference in terms of β-carotene transformation. β-carotene is adequately converted in animals like sheep and goats, while in cattle, they have inadequate capability in converting β-carotene (McDowell, 2000). Despite these species differences, however, most studies in the literature which examined influence of β-carotene on milk and quality were done in dairy cattle. There are however, limited studies in goats on the influence of β-carotene supplementation on milk yield and milk composition. Therefore, the current study aimed at evaluating the effect of supplemental β-carotene on milk yield and milk composition for Saanen goats.

Materials and Methods

Ethical Approval

This study was conducted with approval by the University of Pretoria animal ethics committee (Project no.EC108-14).

Experimental Site

The study was carried out at the University of Pretoria experimental farm, South Africa. The coordinates of the farm at latitude 25°44’30” S and longitude 28°15’30” E, with an elevation of 1360 m above sea level. The area is characterised by warm and humid condition in summer and dry, cold and sunny in winter with an average rainfall of 650 mm in summer (Van Niekerk *et al*., 2009).

Table 1: Feed ingredients for the total mixed ration

Ingredients	Dry matter%	Quantity in kg/animal
Lucerne hay	43.81	1.600
Eragrostis curvula hay	24.10	0.900
Maize meal	16.06	0.600
Molasses	9.05	0.350
Protein concentrate	6.98	0.250
Total	100.00	3.700

Experimental Animals, Feeding and Management System

Sixty (60) females Saanen goats between one and six years and also of parity between one and four were used in this experiment. The animals were kept under intensive system and were fed on total mixed ration as shown in (Table 1). The protein concentrate was sourced from a commercial company. Throughout the duration of the experiment water was given at free access. The mastitis test was done daily as a routine husbandry practices using California Mastitis Test (CMT) and ranked according to increase in viscosity from 1 to 5. The highest viscosity CMT 5) is more or less correlated to the highest SCC. The animals that were used for the experiment had acceptable values.

Experimental Design and Treatments

The does were assigned in to two groups of β-carotene supplemented and non-supplemented considering their weight and parity in a completely randomised design and each group comprised thirty (30) does. The average body weight and parity for control and supplemented groups were 47.10±3.07 Kg and 46.67±3.07 Kg and 2.50±0.23 and 2.56±0.23, respectively and did not differ significantly.

β-carotene Supplementation

Animals in supplemented group were orally administered β-carotene (100 mg/head/day) (Pennville Pty Ltd, South Africa) for a duration of 58 days which commenced four (4) weeks prior to synchronisation of oestrus. Again, following the drying off period, animals were given β-carotene (50 mg/head/day) for a duration of approximately 40 days. The company indicated that each 10 g paste contained 100 mg β-carotene. The control group received water as placebo with similar quantities as in the treatment group.

Oestrus Synchronisation Protocols

All does were kept away from bucks for a period of one (1) month prior to the onset of the experiment. All does were synchronised using Controlled Internal Drug Releasing device (CIDR) containing 0.3 g progesterone (Pfizer, New Zealand). The device was implanted intravaginal and allowed for a duration of 11 days. At CIDR removal, all does were injected with 150 µg cloprostenol and one group injected 300 IU of equine Chorionic Gonadotropin (eCG) (Intervet Schering-Plough Animal Health, South Africa) while another group introduce to Male effect.

Semen Collection and Artificial Insemination (AI)

Semen Collection

An electro ejaculator (Ramsem, South Africa) was used to collect semen from bucks as described by Sundararaman *et al*. (2007) with few modifications. Briefly, after the probe was inserted inside the rectum, the buck was massaged and the machine button was pressed producing a voltage of 3-5 volts. After pressing the button, it was held for 4-5 sec and again returned to 0. Semen mass motility was analysed according to the procedures by Dogan *et al*. (2005). From each semen sample collected, 10 µL semen on was put on glass slide and then examined on a microscope (Olympus C×21). Semen samples with motility score of three (3) and above were used.

Artificial Insemination

The procedures for artificial insemination followed were as described by (Steyn, 2005). Each doe was inseminated with fresh undiluted semen of 0.2 mL with a concentration of 300-800×106 sperm. Cervical insemination was carried out in all does twice at fixed times of 48 h and 60 h after CIDR removal (Motlomelo *et al*., 2002).

Milk Collection and Analysis

Milk Collection

Milking of all goats was done daily (morning and evening) using milking machine. Following kidding, five (5) does in each group were selected and milk colostrum samples were taken once a day in the morning for duration of three (3) days. Similarly, milk samples were taken once a week for a duration of four (4) weeks from the same five does used for colostrum collection. Milk from each goat was analysed separately to have 5 values per collection and therefore, milk samples were not pooled. Daily milk yield was collected for a period of over 30 days starting 5 days after kidding from all the goats leading to four collections. The milk samples were kept in vials (Lactolab Pty Ltd). The vials contained a Broad Spectrum Microtabs II tablet (Advanced Instruments, Massachusetts, USA), a preservative preventing growth of bacteria, mold and yeast.

Milk Analysis

Milk fat%, protein%, lactose% and Somatic Cell Counts (SCC) were analysed in both the colostrum and

milk samples by Lactolab Pty Ltd laboratory at the Agricultural Research Council, Irene, South Africa. The somatic cell count was analysed using Cytometer while protein, fat and lactose were analysed using Spectrometer (Minnesota, USA)**.**

Statistical Analysis

The data collected for milk yield, fat, protein and lactose and SCC were analysed with one-way analysis of variance for repeated measures using PROC GLM procedure of SAS (version 9.4).

The model fitted was:

$$Y_{ij} = \mu + T_i + E_{ij}$$

Where:

Y_{ij} = Observation on the dependent variables
μ = Overall mean
T_i = Treatment effect
e_{ijk} = Random error

Results

Supplemental β-carotene did not influence milk yield, protein%, lactose%, fat% and SCC. The result showing the influence of β-carotene supplementation on milk yield, protein%, lactose%, fat% and SCC is shown as in (Table 2).

Supplemental β-carotene did not significantly (P>0.05) influence the average daily and total milk yield over 30-day period during early lactation. However, numerically, the total milk yield and daily milk yield tended to be higher in the treatment group compared to the control group but not significant. Milk fat, protein, lactose and the SCC did not differ significantly (P>0.05) between β-carotene supplemented group and non-supplemented group. Similarly, colostral fat, protein, lactose and the SCC did not differ significantly (P>0.05) between β-carotene supplemented group and non-supplemented group (Table 3). Similarly, milk lactose percentage tended to be higher in β-carotene supplemented group than in non-supplemented group but not significant. Moreover, numerically, the treatment group tended to have lower SCC in β-carotene supplemented group than in non-supplemented group.

Milk colostrum fat, protein, lactose and SCC did not differ significantly between β-carotene supplemented group and non-supplemented group (Table 2). However, numerically, protein and fat and somatic cell counts tended to be higher in the β-carotene supplemented than in the non-supplemented group but the differences were not statistically significant.

Table 2: Milk yield and composition (Mean ± SE**)** of Saanen goats supplemented with β-carotene

Parameters	Treatment	Control
Milk yield (30 days period), kg	108.78±5.48[a]	107.30±6.13[a]
Milk yield, kg/day	3.63±0.18[a]	3.58±0.20[a]
Milk fat%	3.76±0.23[a]	4.06±0.23[a]
Milk protein%	3.29±0.08[a]	3.39±0.08[a]
Milk lactose%	4.57±0.05[a]	4.54±0.05[a]
Milk SCC, ×1000 cells/mL	881.55±207.50[a]	930.53±207.50[a]

Means with similar letters do not differ significantly

Table 3: Colostrum composition **(**Mean ± SE**)** of Saanen goats supplemented with β-carotene

Parameters	Treatment	Control
Colostral fat%	6.89±0.47[a]	6.56±0.45[a]
Colostral protein%	7.33±0.54[a]	6.30±0.52[a]
Colostral lactose%	3.62±0.14[a]	3.73±0.14[a]
Colostral SCC, ×1000 cells/mL	2213.86±344.33[a]	2030.10±332.66[a]

Means with similar letters do not differ significantly

Discussion

β-carotene is among antioxidants that have been shown to play important role in improving milk composition and health status of udder. The present study hypothesised that that supplementing goats with β-carotene would increase milk yield and improve milk composition and quality of Saanen goats. However, supplemental β-carotene did not improved milk yield, milk composition and quality of Saanen goats during drying off period.

With few previous studies on the influence of β-carotene on milk yield, milk composition and quality in goats, the current study could not compare or contrast its findings with findings from similar species. Similar studies, however, have been done in other ruminant species. In sheep, supplemental β-carotene did not influence milk yield (Brozos *et al*., 2007). In addition, dairy cows supplemented with β-carotene did not affected milk yield (Bindas *et al*., 1984; Rakes *et al*., 1985; Wang *et al*., 1988; De Ondarza *et al*., 2009; De Ondarza and Engstrom, 2009; Kaewlamun *et al*., 2011; 2012; Oliveira *et al*., 2015). These studies are consistent with the finding of the present study with regard to milk yield. Contrarily, some studies reported that β-carotene supplementation has a positive effect on milk production in heat stress cows (Arechiga *et al*., 1998; Chawla and Kaur, 2004). These disparities between studies on the effect of supplemental β-carotene on milk yield could be ascribed to differences in amount of β-carotene in the diet and blood and level, time and period of β-carotene supplementation (Kaewlamun *et al*., 2011). It is imperative that sheep and goats adequately convert dietary β-carotene (McDowell, 2000). Therefore, the ineffectiveness of supplemental β-carotene in improving milk yield from the

current study could be ascribed to insufficient amount of β-carotene in the mammary gland and thus led to lack of its antioxidant influence.

For the milk composition, previous studies with dairy cows reported conflicting results on the influence of β-carotene on milk components. In line with the current study, it was reported that supplemental β-carotene has no positive effect on milk fat, protein and lactose (Kaewlamun *et al*., 2011; 2012; Machpesh, 2013; Oliveira *et al*., 2015). Also, it has been noted that supplemental β-carotene did not influence milk protein but increase milk fat% in cows (De Ondarza *et al*., 2009). Conversely, supplemental β-carotene reduced milk fat% (Oldham *et al*., 1991).

In agreement with the current study, supplemental β-carotene did not influence milk SCC in cattle (Wang *et al*., 1988; Oldham *et al*., 1991; De Ondarza *et al*., 2009; Kaewlamun *et al*., 2011; 2012; Oliveira *et al*., 2015). In disagreement with the current finding, other studies had reported that supplemental β-carotene reduced milk SCC in cattle (Rakes *et al*., 1985; Wang *et al*., 1988). Ineffectiveness of supplemental β-carotene in reducing SCC in the current study could be due to the fact that goats convert β-carotene adequately and as a result mammary glands did not absorb enough β-carotene to exert its antioxidant activity. This could be ascribed to levels of supplemental β-carotene in the current study.

Although β-carotene supplementation did not improved milk yield and milk components in the current study, other antioxidants however, have been reported to affect milk yield and milk components. Milk yield, protein and fat were increased and somatic cell counts were reduced in goats supplemented with Se-VitE (Tufarelli and Laudadio, 2011; Zhang *et al*., 2018). Additionally, milk yield and fat were improved in goats supplemented with fat with exception of protein (Al-Dabbas and Hawari, 2011). Moreover, the combined supplementation of α-tocopherol plus selenium decreased the relative proportions of short chain fatty acids and medium-chain fatty acids and increased that of long chain fatty acids in milk fat (Pulido *et al*., 2012).

Conclusion

Supplemental β-carotene did not influence milk yield and composition of Saanen goats during the drying off period. Further research is warranted on the effect of different levels of β-carotene on milk yield and composition and on concentration of β-carotene and vitamin A in blood and milk at different stages of lactation in goats.

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Author's Contributions

Dominic Lado Marino Gore: Contributed on the original ideas of the manuscript, data collection, analysis and interpretation and manuscript write up.

Khoboso Christina Lehloenya: Contributed on the original ideas and preparation of the manuscript.

Ethics

The authors confirm that the manuscript has not been published or not under consideration for publication in other journals. We also confirm that there is no conflict of interest and that all the authors have agreed on the order of authors listed in the manuscript.

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