Original study

Effect of rumen-protected methionine on production and composition of early lactating Shami goats milk and growth performance of their kids

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Abstract

This study was conducted at the Agricultural Research Station of the University of Jordan in the Jordan valley to evaluate the effect of supplementing rumen-protected methionine to early lactating Shami goats on milk production, composition, fatty acid profile, and growth performance of their kids. Twenty-four fresh lactating Shami goats were randomly assigned into three dietary treatment groups (eight each) in a completely randomized design. Diets were a control with no supplements or supplemented with either 2.5, or 5.0 g/head/d rumen-protected methionine. The experiment started exactly after kidding and lasted for 60 days thereafter. Production variables studied were milk production, milk composition, body weights, feed intake, kids weaning weight, and milk fatty acids.

Daily milk production and energy corrected milk were not affected by protected methionine supplementation. Milk Percentages of fat, protein, total solids, and casein were also not affected by protected methionine supplementation. Likewise, fat and protein yields were not different among dietary treatments of protected methionine. No differences in milk fatty acids composition were observed by supplementing rumen protected methionine in the experiment.

Feed intake, feed to milk ratio, and final body weight of dams were not changed among treatments. No differences were observed in weaning weights, average daily gain, and milk to gain ratio of kids born to dams in the experiment regardless to sex of kids.

In conclusion, results indicated that supplementing rumen protected methionine to dairy goats diet did not improve their milking performance, the composition of their milk, or growth performance of their kids.

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Abbreviations: DM: dry matter, ECM: energy corrected milk, RPM: rumen-protected methionine

Introduction

Growing trend in consumption of goat milk and its products has initiated the modern dairy industry to improve goat milk production and change the milk composition by dietary means (Poljičak Milas & Marenjak 2007). Goat milk has been identified as an alternative for infants and adults who are either sensitive or allergic to cow milk. The nutritional advantage of goat's milk has been attributed to the small size of fat globules, hence making the product more easily digestible (Mir *et al.* 1999).

Shami goat is the most important improved native breed, with a genetic potential to produce an average of 475 kg of milk (range of 350-650 kg) in a lactation period of about 205 days under improved management (Mavrogenis 2005).

On the other hand, protein is an important limiting nutrient in ruminant animals. Supplementation of rumen degradable protein, rumen undegradable protein or amino acid is considered important to satisfy requirements and increases the proportion of dietary amino acid absorbed from the intestine (Ali *et al.* 2009).

Several studies have been carried out in the recent years in order to identify the limiting amino acids in milk production, in cows and ewes (Bequette *et al.* 1998), as well as in goats (Flores *et al.* 2009). Some of the most frequently reported limiting amino acids for milk production in lactating goats are lysine and methionine (Flores *et al.* 2009). Protected amino acids are introduced to the market to improve the nutrient availability and utilization and consequently the general performance of ruminant livestock.

The immense amounts of research have been done on the dairy cows with the primary goal to study the effect of supplementing rumen protected methionine on milk production and its composition (Poljičak Milas & Marenjak 2007). Meanwhile, information in literature on dairy goats fed with rumen-protected amino acids is scarce (Flores *et al.* 2009). Although, the literature data are rather promising regarding the protected amino acid supplements and their influence on milk production and its milk composition in dairy cows, it could be suspected the same effect on the dairy goat's performance (Overton *et al.* 1996, Wang *et al.* 2003).

The objective of this study was to evaluate the effect of supplementing rumen-protected methionine (RPM) on milk yield and composition of Shami goats as well as on growth performance of their suckling kids.

Material and methods

Animals and diets

Twenty-four fresh lactating Shami goats were used in this study with initial body weight averaged between 47 to 75 ± 7.07 kg and aged 2 to 4 ± 0.56 years. Does were randomly assigned into three dietary treatment groups of 8 each in a completely randomized design. Diets were a control diet with no supplements, or supplemented with either 2.5, or 5.0 g/head/d of RPM (calcium salt of methionine hydroxy analogue, min. 84 %; Novus, Saint Charles, MI, USA). The protected methionine was top dressed over the daily dietary allowances offered. Diet offered was a concentrate ration presented individually and once daily at 7.00. It was provided as *ad lib* and amounts consumed was measured and recorded daily. The percent ingredient composition and chemical composition of the basal diet are shown in Table 1. In addition to that, alfalfa hay was also offered to animals in the experiment at a rate of 1.0 kg/head/d on group basis. Clean drinking water was provided all the time.

Rations were mixed twice weekly, sampled upon mixing and kept frozen for further chemical analysis. No special diet was offered to kids during the study and milk of their dams was the only feeding source. The experiment started just after kidding and lasted up to 60 d post kidding.

Goats in the experiment were weighed once at the start of the experiment and again at the end of experiment. Kids born in all groups were weighed at kidding for birth weight and weaning time at 60 d of age. Kids were left with their dams in the same yard for the whole duration of the experiment with full access to suckling. Animals with their kids were maintained at ambient temperature and natural day length in covered-seal yards with an open side.

Table 1
Ingredients and chemical analysis of the concentrate diet offered to Shami goats[1]

	%	
Ingredients		
Barley	70.00	
Soybean meal	15.00	
Wheat bran	13.00	
Limestone	0.5	
Dicalcium phosphate	1.00	
Salt	0.4	
Vitamins and mineral premix[2]	0.1	
Chemical composition		
Dry matter	90.86	
Crude protein	17.51	
Ether extract	2.4	
Ash	6.54	
Neutral detergent fibre	26.84	
Acid detergent fibre	8.68	
Metabolizable energy	11.4 MJ	Calculated according to NRC (1985)

[1]All results are expressed based on dry matter basis. [2]Vita-M Premix (DADvet, Na'ur, Jordan) each 1 g contains: 1500 I.U. vitamin A; 150 I.U. vitamin D3; 2 mg vitamin E 50 %; 300 µg vitamin B1; 300 µg vitamin B2; 300 µg vitamin B6; 300 µg vitamin K3 50 %; 218 µg manganese oxide; 435 µg ferrous sulfate; 15.5 µg cupper oxide; 138.5 µg zinc oxide; 2.2 µg potassium iodide; 0.9 µg sodium selinate; 0.43 µg cobalt carbonate; $CaCO_3$ reach 1 g.

Milk sampling

Milk production was measured biweekly on individual basis by hand milking and adjusted for daily millk production. A double oxytocin injection procedure was used to estimate milk production over a 4 h period and corrected for 24 h (Goulas *et al.* 2003). The first injection was of 1.5 ml oxytocin (Dila-part, Cenavisa, Reus, Spain) given intramusculary at 8.00 in the day of sampling accompanied by complete emptying of the udder. Another injection was given at 12.00 when goats were milked for the second time and milk production was recorded as production over the 4 h interval. Kids were separated from their dams during this period. Milk samples were preserved with 2-3 ml potasium permangenat and stored in the freezer untill analysis.

Energy corrected milk was determined following the equation of Flores *et al.* (2009) as follows:

$$ECM = (0.327 \times milk\ yield) + (12.86 \times fat\ yield) + (7.65 \times protein\ yield) \quad (1)$$

Feed to milk ratio was determined as daily dry matter intake: daily milk production, kg/kg.

Milk samples were analysed for fat (Gerber), crude protein (Kjeldahl), and total solids contents using the standard procedures of AOAC (2006). Protein values were determined by multiplying the nitrogen results by 6.38. Casein was determined according to AOAC (2006). Feed samples, taken upon mixing, were ground through a 1-mm screen by IKA mill MF 10 (IKA GmbH, Staufen, Germany) and analysed for dry matter (DM), crude protein, ether extract and ash (AOAC 2006). In addition, neutral detergent fibre and acid detergent fibre were analysed according to Georing & van Soest (1970) using Ankom fibre analyser (Ankom220, Ankom Technology, Macedon, NY, USA). For milk fatty acid analysis, fat was separated following the Roese-Gottlib method (AOAC 2006), transesterified into fatty acid methyl esters by methylation at room temperature with KOH (2M) in Methanol, and analysed by gas chromatography (Třináctу *et al.* 2006) using a Shimadzu 2010 (Shimadzu Corp., Kyoto, Japan) equipped with flame ionization detector. The GC conditions were column oven temperature was 70 °C for 1 min, increased to 165 °C at 20 °C/min and kept at 165 °C for 8 min, then increased to 180 °C 1 °C/min and then increased to 220 °C at 3 °C/min and kept at this temperature for 10 min. The carrier gas was helium. Injector and detector temperatures were 250 °C and helium flow rate was 1.1 ml/min.

Statistical analysis

The effect of supplementing rumen protected methionine to the diet on studied variables were analysed using general linear model (GLM) procedure of SAS v. 9.0 (SAS Institute Inc., Cary, NC, USA) in a completely randomized design. The analysis model includes treatment (0, 2.5 or 5.0 g/head/d of RPM), sex, kidding type of kids (single or twin), and their two-ways interactions as independent variables. Dry matter intake, milk yield, and its composition were analysed in a repeated measures design. Initial body weight of dams was taken as covariates for final body weight while birth weight was used as covariates for weaning weight and average daily gain for kids. Least square means were separated for significances (P<0.05) using Fisher protected LSD test.

Results and discussion

Milk yield and composition

The present study indicated that daily milk production of early lactating goats was not affected when RPM was supplemented to their diets (Table 2). Contrary to that, Madsen *et al.* (2005) showed that supplementing RPM had a positive effect on milk yield in early lactation goats when methionine and lysine were given in combination concluding that mammary supply of both amino acids were limiting for milk production. Likewise, Poljičak Milas & Marenjak (2007) reported that the supplementation of protected methionine (Mepron) to lactating goats resulted in higher milk production that which is directly related to well established lactation and nutritional quality following methionine supplementation. No changes were observed in milk yield of dairy cows when supplemented with RPM (Kudrna *et al.* 2009).

Lacking response in milk yield following RPM supplementation in the present case might probably indicate that methionine was not limiting for these goats. However, some results indicated that methionine was a limiting amino acid for high milk production in dairy cows fed corn and soybean meal during early lactation (Lara *et al.* 2006, Ali *et al.* 2009). Differences in response among experiments in milk yield might be attributed to the degree to which Met was limited in the diets fed, an excess of amino acids, an imbalance in amino acids, increased intake of compounds used to protect the amino acids from ruminal degradation, or other factors (Lara *et al.* 2006).

Milk fat content and yield (g/d) were not different among treatments. Lacking effect on milk fat percentage following RPM supplementation was reported earlier with dairy goats (Poljičak Milas & Marenjak 2007) and with dairy cows (Lara *et al.* 2006, Třináctý *et al.* 2006, Yang *et al.* 2010, Soltan *et al.* 2012). However, both (fat content and yield) were negatively affected by supplementation of RPM to early lactating dairy goats (Madsen *et al.* 2005).

Table 2
Milk yield and composition of Shami goats supplemented with different levels of rumen protected methionine in their diets

	Methionine g/head/d				
	0	2.5	5	SEM	*P*-value
Milk yield, kg/day	2.72	3.16	2.68	0.28	0.55
Milk fat					
Content, %	5.77	6.51	6.40	0.45	0.49
Yield, g/day	153.1	207.5	173.6	20.3	0.20
Milk protein					
Content, %	2.79	2.87	2.67	0.09	0.43
Yield, g/day	75.47	90.86	71.71	7.47	0.23
Total solids, %	14.21	14.93	14.81	0.49	0.55
Casein, %	2.32	2.38	2.29	0.07	0.66
Energy corrected milk, kg/d[1]	3.43	4.39	3.66	0.39	0.24

[1]ECM = (0.327×milk yield) + (12.86×fat yield) + (7.65×protein yield), (Flores *et al.* 2009)

On the other hand, percentage of milk fat was increased quadratically as RPM doses increased in dairy goats (Flores *et al.* 2009) and in ewes (Goulas *et al.* 2003) justified by that methionine plays a central role in lipoprotein synthesis in the liver as the key intermediate in methyl group donor for choline and phosphatidylcholine synthesis, both are constituents of the lipoprotein, to transport lipids and supply of fatty acids to the udder cells.

In the same line, milk protein percentage and yield as well as percentages of total solids were not different among treatments. No differences in milk protein content and/or yield of lactating goats was also reported by Poljičak Milas & Marenjak (2007) due to higher RDP level in duodenum of treated goats. In addition, parity and live weight of animals could have had an impact on the results. No effect of RPM supplementation on milk protein content was also reported in dairy cows due to low bioavailability of methionine from RPM for protein synthesis (Yang *et al.* 2010). Contrary to that, the inclusion of RPM in the diet of lactating ewes resulted in an increase of daily protein yield with no effect on milk protein content as a function of elevated milk yield (Goulas *et al.* 2003). Those reported increased milk protein content attributed that to a major synthesis of casein and a reduction in urea nitrogen (Lara *et al.* 2006).

No differences were observed in milk casein content following supplementation with RPM to lactating Shami goats. No effect was also reported in dairy cows (Overton *et al.* 1996), and lactating ewes due to elevated milk yield (Goulas *et al.* 2003). Meanwhile, Girard *et al.* (2005) reported that the primary response to supplemented RPM to dairy cows was increased secretion of casein which may be due to numerically lower milk production.

Energy corrected milk (ECM) was not different among treatments regardless of the RPM level. EMC is a correction of milk production for its content of fat and protein yields. Therefore, as treatments showed no changes in yield of either fat or protein, thus would result in no effect in ECM. Supplementing RPM to the diet of dairy goats increased ECM (Flores *et al.* 2009). Moreover, Ardalan *et al.* (2010) and Soltan *et al.* (2012) suggest that the increased ECM suggests that RPM can positively impact milk energy output when early-lactation curve peaks and drops. No effect of RPM supplementation was reported on ECM of dairy cows (Girard *et al.* 2005). Contrary to that, supplementing RPM to the diet of dairy cows increased ECM (Soltan *et al.* 2012).

Feed measurements

No changes were reported in feed intake (kg DM/hd/d) or feed to milk ratio (kg feed per kg milk) by RPM supplementation (Table 3). Similar results were observed by Madsen *et al.* (2005) where neither in early nor in late lactation had the supplementation of RPM and lysine any effect on feed intake in the restrictedly fed goats. Likewise, supplementing RPM in the diets of dairy cows had no effect on dry matter intake or nutrient intake (Lara *et al.* 2006, Kudrna *et al.* 2009). Lacking response in dry matter intake following supplementation of RPM could probably be due to the slight sulfur smell of the rumen protected methionine sources (Soltan *et al.* 2012). On the other hand, increased dry matter intake of lactating ewes with RPM supplementation was possibly due to the increased milk yield, the increased absorption of the most limiting nutrient of the diet, or the improved protein balance and available amino acid profile (Goulas *et al.* 2003).

No differences in feed efficiency were observed in dairy cows supplemented RPM (Noftsger & St-Pierre 2003), while Soltan *et al.* (2012) indicated that RPM improved milk-to-feed ratio by 1.3 % across the experimental period when compared to the control group.

Table 3
Feed intake and body weight of Shami goats supplemented with different levels of rumen protected methionine in their diets

	Methionine g/head/d				
	0	2.5	5	SEM	*P*-value
Feed intake, kg DM/d	2.57	2.60	2.51	0.05	0.52
Concentrate	1.46	1.49	1.40	0.05	0.52
Alfalfa Hay, DM[1]	1.11	1.11	1.11		
Feed : Milk[2]	1.15	0.92	1.04	0.13	0.46
Initial body weight, kg	60.17	63.17	64.20		
Final body weight[3], kg	53.22	56.37	59.70	1.83	0.1
Body weight change[3], kg	9.2	6.04	2.71	1.83	0.1

[1]Alfalfa hay was fed at a rate of 1.0 kg for all animals. [2]Feed : Milk: daily dry matter intake: daily milk production, kg/kg. [3]Final body weight and body change weight were adjusted to initial body weight using covariate analysis.

Body weight

Final body weights among treatments were not affected by RPM supplementation. Likewise, body weight change was also not different among treatment (Table 3). No change in body weights were reported for dairy goats (Flores *et al.* 2009) or dairy cows (Lara *et al.* 2006, Soltan *et al.* 2012) when their diets were supplemented by RPM. Meanwhile, Overton *et al.* (1998) indicated that dairy cows supplemented with RPMet tended to have greater BW than the controls cows probably due to the increased dry matter intake observed in the experiment.

Kids' results

Birth weights were used as covariate during analysis, yet, no differences were observed in weaning weights among treatments regardless to the sex of born kids (Table 4). Likewise, total gain obtained by these kids, as well as their average daily gain was also not affected regardless to the sex of born kids. Milk conversion ratio (milk to gain ratio) was not different among treatments. However, that for kids born to the 5.0 g/head/d RPM group tended to have better ratio compared to others. Milk conversion ratio reflects the efficiency of converting suckled milk into body weight during the 60 d suckling period. No effect of RPM supplementation was shown on growing performance of Shami kids' (Abdelrahman 2009), or growing Awassi lambs due to dietary composition of the fed diet and the growth stage of lambs in the experiment (Obeidat *et al.* 2008). However, Abdelrahman & Hunaiti (2008) found that growth performance of growing lambs was improved by RPM supplementation possibly due to the improvement in feed nutrients digestion and utilization.

Table 4
Weaning weight and weight gain of kids born to Shami goats supplemented with different levels of rumen protected methionine

	Methionine g/head/d				
	0	2.5	5	SEM	*P*-value
Birth weight, kg	4.18	3.24	3.33		
Weaning weight, kg	16.89	18.96	21.40	1.61	0.21
Male	17.38	20.45	23.56	1.73	0.84
Female	16.39	17.47	19.25	2.66	0.84
Total weight gain, kg	13.01	15.09	17.54	1.61	0.21
Male	13.51	16.58	19.69	1.73	0.84
Female	12.52	13.60	15.38	2.66	0.84
Average daily gain, kg/day	0.22	0.25	0.29	0.03	0.20
Male	0.23	0.28	0.33	0.03	0.84
Female	0.21	0.23	0.26	0.04	0.84
Milk conversion ratio, kg/kg	14.14	12.66	8.45	1.34	0.06
Male	13.28	11.71	8.62	1.76	0.89
Female	14.99	13.61	8.29	2.27	0.89

Milk conversion ratio: milk consumed (suckled) during 60 d : body weight gain, kg/kg

Milk fatty acid composition

No changes were found neither in the concentration of short chain fatty acids (C4-C10), nor in that of medium chain fatty acids (C12-C14) or long chain fatty acids (C16-C20) by RPM supplementation (Table 5). However, arachidic acid (C20:0) tended to be higher in the milk of the control group compared to other groups of RPM supplementation.

The goat milk fat is composed of several hundred fatty acids, and mainly a rich source of short chain fatty acids which are synthesized de novo in the mammary gland (Strzałkowska *et al.* 2009). Published literature concerning the effect of RPM on milk fatty acids of dairy goats is very scarce. Lacking the response in milk fatty acids composition following RPM is in line with Kudrna *et al.* (2009) who indicated that the supplementation of ruminally protected methionine to dairy cows produced insignificant changes in the fatty acid profile of milk fat.

Opposite to that, Sevi *et al.* (1998) found that supplementation of rumen protected methionine or lysine to diets of lactating ewes resulted in a reduction in the proportion of 4:0-12:0 fatty acids and an increase in the proportion of 16:0-18:3 (primarily palmitic and stearic). They concluded that this was mainly due to the role of Lysine and Methionine in milk secretion. Rulquin *et al.* (2006) found that supplementation of dairy cows with RPM increased the C18 content and reduced that of C18:2 in milk lipids. Likewise, the inclusion of RPM in the diet of the lactating ewes reduced the ratio of short chain fatty acids, C16 fatty acid, and increased the ratio of the long chain fatty acids (Goulas *et al.* 2003). Reducing the content of saturated fatty acids and increasing that of long chain insaturated fatty acids have been associated with increase healthfulness of milk. In terms of human health, these changes may represent an improvement in the fatty acid profile of milk because medium-chain fatty acids and saturated fatty acids have been reported to constitute the hypercholesterolemic portion of milk fat (Třinácty *et al.* 2006).

In conclusion, results of this study imply that supplementing the diet of early lactating Shami goats with rumen-protected methionine at 0, 2.5 or 5.0 g/head/d failed to improve their milk production, composition, or growth performance of their suckling kids. Also feed intake and body weights of dams parameters were not changed. The lack of difference among treatments may be attributed to the limited number of animals that were used in this experiment or the dose levels of rumen protected methionine. Response to RPM is dependant on milking potential of supplemented animals and their level of nutrition. Therefore, further studies are needed to determine optimum doses of ruminally protected methionine on lactating goats with a higher number of animals and different feeding and management conditions than those used in this experiment.

Table 5
Milk fatty acid composition (as percent milk lipid) of Shami goat supplemented with rumen protected methionine in their diets

	Methionine g/head/d				
	0	2.5	5	SEM	*P*-value
C 4	1.91	2.42	2.19	0.15	0.1
C 6	2.33	2.71	2.75	0.16	0.2
C 8	2.76	2.97	3.33	0.21	0.26
C 10	9.77	9.41	11.22	0.78	0.34
C 12	4.25	3.74	4.57	0.40	0.42
C 14	10.04	8.55	8.47	1.58	0.75
C 16	28.96	29.29	28.75	0.52	0.50
C 16:1	0.50	0.52	0.611	0.06	0.65
C 18	11.28	10.52	11.63	0.72	0.60
C 18:1	24.90	26.69	23.71	2.02	0.64
C 18: 2	2.77	2.42	2.43	0.21	0.45
C 18:3	0.32	0.34	0.32	0.03	0.84
C 20	0.17	0.15	0.15	0.007	0.06

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