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Effect of Methionine Supplementation on Performance and Carcass Characteristics of Awassi Ram Lambs Fed Finishing Diets

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ABSTRACT : The objective of this study was to evaluate the effects of ruminally-protected methionine supplementation (0, 7, or 14 g/head/d) on nutrient intake, digestibility, growth performance, carcass, and meat characteristics of Awassi ram lambs fed finishing diets. Twenty four Awassi ram lambs (16.8±1.17 kg body weight) were randomly assigned to 3 treatment diets (8 lambs/treatment) and housed in individual pens. Lambs were given an adaptation period of 7 days before the intensive feeding period that lasted for 86 days. On day 74 of the trial, a digestibility experiment was performed. At the end of the trial (d 86), all lambs were slaughtered to evaluate carcass characteristics and meat quality. Increasing the level of methionine supplementation did not improve ($p>0.05$) performance nor feed conversion ratio. Nutrient intake and digestibilities were not influenced ($p>0.05$) by methionine supplementation. There were no differences in final weight, hot and cold carcass weights, dressing percentages or any of the measured non-carcass components. Tissues and fat depth measurements together with all meat quality attributes measured on longissimus muscle of the loin cut were not affected by methionine supplementation. The only meat quality parameters affected were redness (a*) and the hue angle being higher for the control group ($p<0.05$). These results suggest that methionine supplementation is not likely to produce any production benefits in nutrient digestibilities, performance or carcass characteristics of ram lambs fed a high performance diet. (**Key Words :** Ram Lambs, Methionine, Digestibility, Carcass Characteristics)

INTRODUCTION

All animals require amino acids, the building blocks of proteins, for optimal growth, reproduction, lactation and maintenance. Amino acids absorbed in the ruminant small intestine are derived from microbial and dietary proteins that are undegraded in the rumen. Methionine is often the first or second limiting amino acid in most diets and in microbial protein (Storm and Orskov, 1984; Buttery and D'Mello, 1994). Ruminally-protected methionine (RPM) bypasses the ruminal degradation, because of the coating process, and enters the small intestine where it can be directly absorbed. Thus, RPM could improve growth and retained N in ruminants.

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Meeting the amino acid requirements becomes more crucial during high productivity stages (high milk production or rapid growth for meat production) (Rulquin and Delaby, 1997; Izumi et al., 2000). Deficiency in methionine often limits ruminants' growth (Richardson and Hatfield, 1978) and milk production (Schwab et al., 1992). On the other hand, excess of supplemental methionine has an adverse effect on feed intake (Satter et al., 1975) which could occur due to amino acid imbalance.

The use of RPM and/or lysine to improve cattle and sheep performance has yielded controversial and inconsistent results (Oke et al., 1986; Titgemeyer et al., 1988; Han et al., 1996; Tripp et al., 1998). Potential reasons for this controversy are the type of ingredients used in the diets, dietary crude protein percentage and stage of animal production (lactating, pregnant, or finishing). Ruminally-protected methionine improves gain and feed conversion efficiency in growing cattle (Wright and Loerch, 1988) and milk and protein yield in dairy cows (Rulquin and Delaby, 1997; Wu et al., 1997). Others did not observe such improvements in growing (Tripp et al., 1998) or lactating (Pisulewski and Kowalski, 1999) cattle.

Awassi sheep flocks are predominant in the Middle East. They are raised for supplying humans with high quality edible products such as milk and meat. As the human population increases, the demands also increase for these products. Therefore, it is necessary to investigate methods to improve productivity of sheep in order to supply the increasing demand. To our knowledge, little work is available on the use of RPM in sheep. Therefore, the objective of this study was to evaluate the effect of methionine supplementation on growth performance, nutrient digestibility, N balance and carcass characteristics of Awassi ram lambs fed high performance diets commonly used for finishing fat-tailed Awassi sheep.

MATERIALS AND METHODS

Experiment design, animals, and diets

This study was conducted at the Agricultural Center for Research and Production at Jordan University of Science and Technology. Twenty four newly weaned (average age = 70±0.99 d) Awassi ram lambs (average BW = 16.8±1.17 kg) were randomly assigned to one of three dietary treatments in a completely randomized design. All lambs were housed in individual pens (0.75×1.5 m) and subjected to the same practical management during the entire experiment. Treatments were: no RPM (CON; n = 8), 7 g of RPM (L-Met; n = 8), and 14 g of RPM (H-Met; n = 8). Ruminally-protected methionine used was DL-methionine with 45% ruminal degradability (DL-Methionine 55%, JEFD Nutrition Inc., Québec, Canada). For each animal, the feed was top dressed with RPM to ensure complete consumption of the assigned amount. An isonitrogenous-isocaloric diet was given to all animals, which was formulated to supply 17% crude protein (NRC, 1985). The basal diet consisted of barley grain (50%), soybean meal (14%), wheat hay (19%), wheat bran (13%), salt (1%), dicalcium phosphate (1.5%), calcium carbonate (1%), and mineral and vitamins (0.1%). The composition per kg of the minerals and vitamins mix contained dicalcium phosphate, 800 g; sodium chloride, 60 g; trace elements mixture, 20 g (Zn, Mn, Fe, Cu, Co, Se); magnesium oxide, 20 g; vit. A, 500,000 IU; vit. D_3, 85,000 IU, vit. E, 200 IU. The dry matter, organic matter, crude protein and methionine content (% of the CP) of the diet was 89.8, 88.3, and 17.4%, and 6.49%, respectively. The methionine content of the diet was calculated according to NRC (1985). Diets were mixed every two to three weeks and were sampled for laboratory analysis to ensure consistency in their chemical composition. Lambs were given an adaptation period of 7 days before starting the intensive feeding period that lasted for 86 days. Lambs in all treatments were weighed individually for two consecutive days before feeding the assigned diets to determine initial weight and were weighed every 7 days before morning feeding during the whole experimental period. Lambs were fed *ad libitum* twice per day at 0800 and 1600 using plastic buckets with free access to fresh water. Feed refusals were collected, weighed and sampled for future analyses.

Digestion and N balance experiment

On day 74 of the finishing period, three animals from each treatment group were randomly chosen and housed individually in metabolism crates (130 cm×46 cm), that allowed for fecal and urine separation, to evaluate nutrient digestibilities and N balance. Animals were given a 7-day adaptation period in the metabolism crates followed by a 4-day collection period. Diets were offered to lambs for *ad libitum* consumption at 0800. During the 4-day collection period, feed intake and refusals were recorded daily. Daily fecal output was collected, weighed, mixed, sampled (10%), and frozen at -20°C for subsequent analyses. Using plastic containers containing 50 ml of 6 N HCl to prevent ammonia loss, urine was collected, weighed, mixed, sampled (5%) and frozen at -20°C to determine urinary N excretion. All fecal and urinary samples were composited for each lamb at the end of the collection period. Samples of feed, refusals and feces were dried at 55°C in a forced-air oven to reach a constant weight, air equilibrated, then ground to pass a 1 mm screen (Brabender OHG Duisdurg, Kulturstrase 51-55, type 880845, Nr 958084, Germany) and were kept for further analysis. Feed, refusals, and fecal samples were analyzed for dry matter (DM) (100°C for 24 h), organic matter (OM) (500°C for 8 h) and crude protein (CP) (Kjeldahl Procedure) to evaluate nutrient intakes and digestibilities of DM, OM, and CP (AOAC, 1984). Urine samples were analyzed for N (Kjeldahl Procedure) to evaluate N balance.

Slaughtering procedures

At the end of the experiment (d 86), all animals were slaughtered to evaluate carcass characteristics. Animals were fasted for about 18 h, weighed and then immediately slaughtered following standard procedures described by Abdullah et al. (1998). Carcasses were weighed after slaughter to evaluate hot carcass weight and then chilled at 4°C for 24 h to evaluate cold carcass weight. Non-edible carcass components (trachea, lungs, heart, liver, testes, spleen, kidneys and kidney fat) were removed and weighed directly after slaughter. On the next day, chilled carcasses were cut in half and further divided into 4 major parts (shoulders, racks, loins and legs) in addition to tail fat and their weights were recorded. Measurements of fat depth and dimensions on the transverse section of *M.longissimus thoracis* between ribs 12 and 13 were also conducted as

Table 1. Least squares means for nutrient intake and performance of Awassi ram lambs supplemented by different levels of rumen-protected methionine

Item	Treatment[1]			SE
	CON	L-met	H-met	
Nutrients intake (g/d)				
Dry matter	1,122	1,040	1,029	48.4
Organic matter	1,001	934	923	44.1
Crude protein	156	145	135	8.6
Initial body weight (kg)	16.7	16.8	16.8	1.17
Final body weight (kg)	38.3	37.3	37.2	1.63
Total gain (kg)	21.6	20.4	20.4	0.85
ADG (g)[2]	251	238	237	9.1
FCR[3]	4.49	4.39	4.35	0.2

[1] No RPM (CON; n = 8), 7 g RPM (L-met; n = 8), and 14 g RPM (H-met; n = 8).
[2] ADG = Average daily gain ((final weight-initial weight)/86 days).
[3] FCR = Feed conversion ratio (kg dry matter intake/kg ADG).

Table 2. Nutrient digestibilities and N balance of Awassi ram lambs supplemented by different levels of ruminally-protected methionine

Item	Treatment[1]			SE
	CON	L-met	H-met	
Digestibility (%)				
Dry matter	81.0	80.4	79.0	4.5
Organic matter	82.8	81.9	81.3	4.0
Crude protein	80.6	79.6	76.5	4.1
N (g/d)				
Intake	31.6	28.3	27.1	3.19
Fecal	5.9	5.8	6.1	0.90
Urinary	20.1	15.0	12.9	4.09
Retained	5.6	7.5	8.2	3.56
Retention (%)	18.3	27.9	25.3	12.66

[1] No RPM (CON; n = 8), 7 g RPM (L-met; n = 8), and 14 g RPM (H-met; n = 8).

described by Abdullah et al. (1998). Area of *M. Longissimus,* measured as the area of the loin cut surface which was traced on paper, was determined using a plastic grid for quick measurement of loin eye (pork and lamb) as described by Abdullah and Musallam (2006) Right loin cuts were dissected to determine their muscle, bone and fat components. Longissimus muscles were excised from the right side of loin cuts, cleaned of the subcutaneous fat, vacuum-packaged and frozen at -20°C for meat quality measurements.

Meat quality measurements

The measured meat quality parameters were pH, color, cooking loss, shear force values and water holding capacity (WHC). Frozen longissimus muscles were thawed in a cooler at 4°C overnight while still in plastic bags. Meat quality measurements were performed using the procedures described by Abdullah and Musallam (2006). Each muscle was cut into slices of different thickness, and assigned for a certain meat quality measurement. Muscle slices were weighed, placed in plastic bags and cooked in a water bath at 75°C for 90 minutes. Cooking loss was measured as a percent of the pre-cooked weight. Shear force values of cooked meat were measured using a Warner-Bratzler shear device to determine the maximum force required to cut through each core in perpendicular direction of muscle fibers. Color was measured on a 10-15 mm thick slice. Muscle pH was measured in an homogenate of 2 g of muscle in 10 ml of neutralized 5-mM iodoacetate reagent. The WHC was measured using the method described by Grau and Hamm (1953) and modified by Sañudo et al. (1986).

Statistical methods

All data were analyzed using MIXED procedure of SAS (version 8.1, 2000, SAS Inst. Inc., Cary, NC). The model used treatment as the only fixed effect. Initial body weight was used as a covariant for analysis. Least square means were separated using appropriate pair-wise t-tests if the fixed effects were significant ($p<0.05$).

RESULTS AND DISCUSSION

Live weight gain, feed conversion ratio, and nutrient digestibility

All lambs completed the study without any health problems being noted. Dry matter intake was similar ($p>0.05$) among treatment diets during the 86-d growth trial of the experiment and averaged 1,122, 1,040, and 1,029± 48.4 g/d for the CON, L-Met, and H-Met treatment diets, respectively (Table 1). Intakes of OM and CP followed the same pattern. At the beginning of the study, initial body weight was similar among all treatment groups and averaged 16.7, 16.8, and 16.8±1.17 kg, which increased to 38.3, 37.3, and 37.2±1.63 kg by the end of the experiment for the CON, L-Met, and H-Met treatment groups, respectively (Table 1). Total gain, average daily gain (ADG), and feed conversion ratio were similar ($p>0.05$) among treatment diets (Table 1). Digestibility of DM, OM, and CP did not differ ($p>0.05$) among treatment diets (Table 2). Also, no significant ($p>0.05$) differences were observed in N intake, N losses in the feces and urine, retained N and retention % among all three treatment diets.

In the current study, supplying Awassi ram lambs with RPM had no significant effects on nutrient intakes and digestibilities, N retention %, ADG or feed efficiency (Tables 1 and 2). Similarly, Wiese et al. (2003) found that RPM did not affect growth rate, feed conversion efficiency, carcass characteristics or wool growth in Merino lambs. Furthermore, Hussein and Berger (1995) demonstrated that RPM did not improve ADG in growing steers. In contrast, other studies have reported improvement in growth rate and feed efficiency (Oke et al., 1986; Wright and Loerch, 1988)

Table 3. Least square means of carcass and non-carcass components of Awassi ram lambs supplemented with different levels of ruminally-protected methionine

Item	Treatment[1]			SE
	CON	L-met	H-met	
Fasting live wt (kg)	36.8	36.2	35.7	1.58
Hot carcass wt (kg)	19.2	18.8	18.3	1.02
Cold carcass wt (kg)	18.7	18.5	17.9	1.00
Dressing percentages	50.7	50.8	50.1	0.91
Non-carcass components				
Heart wt (g)	160.5	150.0	148.8	8.70
Liver wt (g)	584.5	601.8	559.8	26.43
Spleen wt (g)	69.5	68.5	61.0	5.00
Kidney wt (g)	101.5	102.5	95.3	4.55
Kidney fat wt (g)	155.25	149.25	193.75	38.40
Testes wt (g)	164.3	190.8	153.0	21.96
Lungs and trachea (g)	494.5	457.0	489.8	25.11

[1] No RPM (CON; n = 8), 7 g RPM (L-met; n = 8), and 14 g RPM (H-met; n = 8).

Table 4. Least square means of carcass cuts weights and loin tissues percentages of Awassi ram lambs supplemented with different levels of ruminally-protected methionine

Item	Treatment[1]			SE
	CON	L-met	H-met	
Carcass cuts weights				
Fat tail (kg)	1.55	1.89	1.45	0.19
Legs (kg)	6.09	5.98	5.88	0.31
Shoulders (kg)	6.88	6.60	6.44	0.32
Racks (kg)	1.64	1.61	1.59	0.09
Loins (kg)	1.86	1.96	1.91	0.13
Loin cut tissues percentages				
Intramuscular fat (%)	17.8	17.2	18.9	1.9
Subcutaneous fat (%)	3.9	4.3	4.5	0.4
Total fat (%)	21.7	21.5	23.4	2.0
Total lean (%)	48.0	49.5	50.0	2.4
Total bone (%)	16.1	15.5	16.8	1.6
Loin meat to bone ratio	3.2	3.6	3.1	0.3
Loin meat to fat ratio	2.5	2.9	2.4	0.6

[1] No RPM (CON; n = 8), 7 g RPM (L-met; n = 8), and 14 g RPM (H-met; n = 8).

and DM intake (Tripp et al., 1998) when growing cattle were supplemented with RPM. The inconsistency in the results when animals were supplemented with RPM could be attributed partially to dietary composition and the growth stage of animal production.

Microbial proteins reaching the duodenum and dietary proteins escaping ruminal degradation provide the amino acids required by ruminants and determine the order of the limiting amino acids (Merchen and Titgemeyer, 1992). Thus, dietary composition could influence the ruminant's response to RPM. Additionally, the level of dietary CP would influence the response of growing ruminants to RPM. Fenderson and Bergen (1975) found that for growing steers, methionine was identified as the first-limiting amino acid in barley-based diets; but lysine was the first-limiting amino acid in corn-based diets (Titgemeyer et al., 1988). Furthermore, replacing high-degradable protein sources (soybean meal) with slower-degradable sources (blood meal; Loerch and Berger, 1981; fish meal; Hussein and Jordan, 1991) did not improve performance in growing lambs fed corn-based diets. Barley was the only grain source in our diets and was used instead of corn to prevent digestion problems previously reported (Loerch and Berger, 1981; Hussein and Jordan, 1991). Additionally, because barley is degraded in the rumen (>80%; NRC, 1985) more than corn (65%; NRC, 1985), we expected that RPM would improve the lambs' performance as a result of a smaller amount of dietary proteins that escaped ruminal degradation.

Previous studies in Jordan (Harb, 1994; Haddad et al., 2001) have shown that the optimum dietary crude protein level for finishing Awassi lambs is 16-17%. The lack of observed positive responses to supplemental methionine (via RPM) could be attributed mainly to: i) the high levels of dietary CP (>17%) and the content of the methionine (6.49% of the CP) in the basal diet that may have completely met the lambs' protein requirements (NRC, 1985) and ii) dietary composition (barley as the main grain source). When dietary CP was marginal (13%) to the recommended requirements (NRC, 1985), RPM and lysine improved N retention in growing lambs (35 kg) fed corn-based diet (69% of DM; Oke et al., 1986).

Carcass characteristics

Methionine supplementation did not improve (p>0.05) live weight, hot and cold carcass weights, dressing percentages, non-carcass component measurements and carcass cuts (Tables 3 and 4). Dissected loin cuts were comparable (p>0.05) in their tissue percentages, meat to bone and meat to fat ratios (Table 4). Tissue depth and fat depth measured on various cuts did not differ (p>0.05) among treatments as shown in Table 5. Eye muscle width, depth, and area were also comparable (p>0.05) among treatments. The lack of improvement in carcass characteristics, carcass cuts, loin cut tissues percentages and carcass tissue dimension measurements may be explained by the results reported earlier for ADG, nutrient intakes and digestibilities. However, in the present study, the carcasses produced were considered to be of similar meat quality and characteristics based on previous research conducted on Awassi sheep (Abdullah and Awawdeh, 2004; Qudsieh, 2006). Dressing percentages obtained in this study (50.7, 50.8, and 50.1 kg for the CON, L-Met, and H-Met treatment groups, respectively) were similar to the findings of Abdullah and Awawdeh (2004) and Qudsieh (2006) for Awassi ram lambs slaughtered at weights comparable to the present study. According to their findings, carcass traits and dressing percentages were very acceptable at the designated slaughter weights. Additionally, fat depth measurements

Table 5. Least square means for carcass tissue dimensions of Awassi ram lambs supplemented with different levels of rumen-protected methionine

Item	Treatment[1]			SE
	CON	L-met	H-met	
Leg fat depth (L3) (mm)	10.44	14.19	11.81	1.58
Tissue depth (GR) (mm)	15.19	14.63	14.81	1.15
Rib fat depth (J) (mm)	6.88	7.50	7.63	0.95
Fat depth (C) (mm)	4.31	4.69	3.63	0.61
Shoulder fat depth (S2) (mm)	4.69	4.75	4.25	0.60
Eye muscle width (A) (mm)	65.44	64.56	62.00	1.15
Eye muscle depth (B) (mm)	28.25	28.13	27.06	0.75
Eye muscle area (cm^2)	15.9	15.4	13.3	2.49

[1] No RPM (CON; n = 8), 7 g RPM (L-met; n = 8), and 14 g RPM (H-met; n = 8).

Table 6. Least square means for a range of loin lean meat quality characteristics of Awassi ram lambs supplemented with different levels of ruminally-protected methionine

Item	Treatment[1]			SE
	CON	L-met	H-met	
pH[2]	6.10	6.01	6.09	0.04
Cooking loss (%)	39.6	41.2	40.0	0.7
Water holding capacity (%)	21.8	23.0	22.5	1.2
Shear force (kg/cm^2)	3.1	3.6	3.0	0.2
Color coordinates				
L* (brightness)	36.1	38.7	38.4	0.8
a* (redness)	4.98^a	3.93^b	3.29^b	0.4
b* (yellowness)	11.7	14.1	14.1	2.0
Croma	12.6	14.5	14.3	1.6
Hue angle	63.4^a	73.0^b	75.1^b	2.7

[1] No RPM (CON; n = 8), 7 g RPM (L-met; n = 8), and 14 g RPM (H-met; n = 8).
[2] pH measured after thawing.
[a, b] Within a row, means without a common superscript letter differ ($p<0.05$).

were comparable with our findings and were within the acceptable range for marketing Awassi lambs. However, Wiese et al. (2003) reported that fat depth (C) was affected by methionine supplementation in Merino and Poll Dorset× Merino lambs. This could be due to the difference in age and breed of the lambs used in their study, dietary ingredients, dietary crude protein content, stage of animal's production and the basal level of weight gain.

Meat quality

Least square means of longissimus muscle quality are presented in Table 6. Meat quality parameters measured were similar ($p>0.05$) among treatments except for redness (a*) and hue angle ($p<0.05$). In the current study, carcass pH values measured after 24 h was between 5.7-5.9. Values for ultimate pH are not reported in this study, however, values for pH measured after thawing were slightly higher than 6; it is normal for pH to increase due to freezing and thawing. These pH values were within the acceptable range at which meat is considered to be tender. Tenderness is affected by ultimate pH (Harrell et al., 1978) which consequently affects the pH after thawing. A pH value of 5.9 was reported to yield tough meat while tenderness increased as pH decreased below 5.7 or increased above 5.9 in ram lambs (Devine et al., 1993).

No differences ($p>0.05$) were observed among treatment diets in terms of cooking loss and WHC. The degree of shrinkage on cooking is directly correlated with loss of juiciness to the palate. Juiciness in cooked meat has two organoleptic components. The first is the impression of wetness during the first few chews and is produced by the rapid release of meat fluid; the second is of sustained juiciness largely due to the stimulatory effect of fat on salivation (Weir, 1960). The percentage of water lost was 39.6, 41.2, and 40.0% for the CON, L-Met, and H-Met treatment groups, respectively. The WHC values obtained in this study were 21.8, 23.0, and 22.5% for the CON, L-Met, and H-Met groups, respectively. These results are in agreement with the findings of Qudsieh (2006) for male lambs slaughtered at different live weights. Shear force tended to be higher (p = 0.08) for the L-Met treatment group when compared to the CON and H-Met treatment groups, with no differences ($p>0.05$) between the CON and the H-Met treatment groups. However, tenderness values obtained are considered to be within the acceptable range. Field (1971) stated in his review that shear force values in the range of 3.6 kg/cm^2 or less are considered to fall within the acceptable tenderness range for goat and sheep meat.

No differences ($p>0.05$) were found in brightness (L*), yellowness (b*) and croma among all treatment groups. However, redness (a*) was greater ($p<0.05$) in the CON group than the L-Met and H-Met groups. The difference in redness could be due to methionine content of the diet. However, no previous research has been established to report such a relationship. Hue angle, which determines and defines the exact color, was lower ($p<0.05$) in the CON than the L-Met and H-Met groups (Table 6), indicating that color of meat from treated animals was more definite and precisely determined.

CONCLUSION

Results of this study imply that supplementing the diet of growing Awassi lambs with rumen-protected methionine at 0, 7 or 14 g/d per head did not affect nutrient intake, nutrient digestibilities, N balance, growth performance, carcass characteristics and meat quality. The lack of difference among treatments may be attributed to diet composition or protein content of the basal diet. Therefore, more studies are needed to evaluate the effect of methionine supplementation to low protein diets or to diets of various composition.

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