Egyptian J. Nutrition and Feeds (2005) 8 (1) : 41 - 51

EFFECT OF RUMEN-PROTECTED METHIONINE AND / OR LYSINE SUPPLEMENTATION TO THE RATION ON NUTRIENTS DIGESTIBILITY AND ON SOME RUMEN PARAMETERS OF MALE BALADY GOATS

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(Received 21/11/2004, accepted 6/3/2005)

SUMMARY

Four mature Balady male goats were used in 4 x 4 Latin square designed experiment. The feeding treatments were (1) control diet, (2) control diet + 7 g Smartamine™ M (rumen protected methionine), (3) control diet + 21 g rumen protected lysine, (4) control diet + 7 g Smartamine + 21 g rumen protected lysine. The control diet was consisted of concentrate feed mixture: rice straw (70% : 30%, on dry matter basis). Smartamine™ M and protected lysine (ration 4) supplementation increased (P<0.05) the dry matter intake (DMI), digestibility of nutrients and ruminal content of total volatile fatty acids (TVFA's), total nitrogen and true protein as compared to the control. Smartamine™ M supplementation alone (ration 2) increased (P<0.05) the DMI, digestibility of nutrients and ruminal content of TVFA's, total nitrogen and true protein as compared to the control. Protected lysine supplementation (ration 3) increased (P<0.05) the DMI and digestibility of nutrients, except ether extract and nitrogen-free extract. Rumen protected lysine supplementation also increased the ruminal content of TVFA's, total nitrogen and true protein as compared to the control. Blood serum total protein content was increased (P<0.05) in treated groups, while the concentration of glucose and total lipids were increased (P<0.05) with ration 4, and slightly higher (P>0.05) with ration 2 and ration 3 compared with control.

The highest DMI, nutrients digestibility, TVFA's, total nitrogen and true protein in ruminal fluid, and blood serum protein, glucose and total lipids were obtained with Smartamine™ M + protected lysine supplementation which was followed by Smartamine than protected lysine supplementation. In conclusion, Smartamine™ M+ protected lysine supplementation to rations of goats had beneficial effects on nutrients digestibility and dietary nitrogen utilization. Moreover, it could improve rumen fermentation and blood serum levels of total protein, glucose and lipids.

Keywords: *goats, rumen-protected amino acids, nutrient digestibility, rumen, blood serum.*

INTRODUCTION

Protein is one of the major limiting nutrients in the diets of ruminants. Feeding a diet containing more protein is not satisfactory solution because the breakdown of dietary protein in the rumen is one of the most inefficient processes in ruminant nutrition. In dairy rations, only 25 to 35% of the feed protein reaches the small intestine for absorption. In an attempt to overcome this inefficiency, dietary protein sources that are considered to be good sources of

"by pass" or rumen undegradable protein (UDP) have been used (Rode and Kung, 1996). Blauwiekel *et al.* (1997) found that, lysine supplementation increased the flow and percentage of lysine in duodenal digesta and increased the concentration of lysine in blood plasma in Holstein Friesian cows and then increased the percentage of milk protein. Also, Overton *et al.* (1998) noted that the rumen protected methionine tended to increase both the crude protein and casein N content of milk. Therefore, the aim of present study was test the effect of rumen-protected methionine and/or lysine on nutrients digestibility, some rumen and blood serum parameters of Balady male goats.

MATERIALS AND METHODS

This study was conducted at the Experimental of Milk Replacer Research Center, Faculty of Agriculture, Ain Shams University and Dairy Science Department, National Research Center, Dokki, Cairo, Egypt, during August – November 2004.

1- Animals and rations:

Four mature Balady male goats aged 3 years old and weighed 25-32 kg were used in 4 x 4 Latin square designed experiment lasted 4 months (one animal each treatment per period). Dietary treatments were (1) control, (2) control + 7 g Smartamine™ M (Protected Methionine, RHONE- POULENC, France), (3) control + 21 g protected lysine (lysine, ADWIA Co., Egypt), which was treated with formaldehyde (40% v/v) according to the method as proposed by Fergueson (1975), and (4) control + 7 g Smartamine™ M+ 21 g protected lysine. Supplemented doses of protected amino acids were applied according Sevi *et al.* (1998). The control ration was consisted of concentrate feed mixture (CFM): rice straw (RS); 70:30% on dry matter basis. Chemical composition of feed ingredients is shown in Table (1).

2- Management:

Amounts of daily feeds were assessed to cover the maintenance requirements (ARC, 1983). The CFM was offered once daily at 8.00 am, while roughage was offered at 9.00 am. Water was freely available to experimental animals. The daily supplemental protected amino acids were mixed with CFM just before feeding to ensure that each animal had consumed its own supplement. The digestibility trial consisted of a 23 days preliminary period followed by a period of 7 days for total collection of feces and urine.

Method used for lysine amino acid protection was as follows: lysine was sprayed with formaldehyde (40% v/v) calculated to provide 1 g formaldehyde / 100g crude protein (Fergueson, 1975). The treated lysine was stored for 7 days in plastic bags at room temperature before being used.

3- Analysis of feed samples, and feces:

Samples of CFM, RS, protected amino acids and feces were analyzed for dry matter (DM), crude ash, crude protein (CP), crude fiber (CF), and ether extract (EE) was determined according to A.O.A.C. (1995). Nitrogen free extract (NFE) was calculated by difference.

4- Sampling of feces:

During the collection period, feces were collected once daily at 7.00 a.m. Fresh feces was collected quantitatively from each animal and weighed. Samples of 10% of total daily feces were taken and sprayed with two solutions of 10% formaldehyde and 10% sulfuric acid, and then dried at 70°C for 24 hours. Dried feces samples were kept individually in plastic bags for chemical analysis. Residues of feeds if any, were also recorded.

5- Sampling and analysis of ruminal fluid:

Ruminal fluid was sampled by a stomach tube from each animal at the end of the collection period. The samples were taken before feeding (0 time) and 3 and 6 hours after feeding. The ruminal fluid samples were filtered through two layers of cheesecloth and immediately used to determine the pH. Strained ruminal fluid samples were stored in glass bottles (25 ml) with few drops of toluene and paraffin oil just to cover the surface and stored at -18°C until determination of total nitrogen, ammonia nitrogen, non-protein nitrogen and urea according to A.O.A.C. (1995), and for total volatile fatty acids according to Warner (1964).

6- Sampling and analysis of blood serum:

Blood samples were collected (four hours post CFM feeding) from the jugular vein of each animal at the last day of the collection period. Collected blood samples were centrifuged at 4000 r.p.m. for 20 min. and stored in glass vials at -18°C till analysis. The concentration of serum parameters determined as follows: total protein (Armstrong and Carr, 1964), serum albumin (Doumas *et al.* 1971), urea (Patton and Crouch, 1977), glucose (Siest *et al.*, 1981), creatinine (Husdan, 1968), and total lipids (Postma and Stroes, 1968). Activities of transaminases (ALT and AST) determined by the method of Reitman and Frankel (1957).

7- Statistical analysis:

The data were analyzed according to Statistical Analysis System (SAS, 1998). Duncan multiple range test (1955) was carried out for separation among means.

1- Data of DMI, nutrients digestibility, and blood parameters were analyzed according to Latin square design where the model was:

$$Y_{ijk} = \mu + T_i + P_j + A_k + E_{ijk}$$

As, Y: expressed the every observation of the K^{th} animal in the J^{th} period given I^{th} treatment, T: expressed the treatment effect, P: expressed the periods effect, A: expressed the animals effect and E: expressed the experimental error.

2- Data of ruminal parameters were: analyzed according split plot design where the model was;

$$Y_{ijk} = U + T_i + A_j + E_{1ij} + S_k + (T \times S)_{ik} + E_{2ijk}$$

As, Y: expressed the every observation of the K^{th} time in the J^{th} animal given I^{th} treatment, T: expressed the treatment effect, A: expressed the animals effects, E_1: expressed the experimental error, S: expressed the sampling times effect, (T x S): expressed the interaction between the treatments and sampling times effect and E_2: expressed the interaction error.

RESULTS AND DISCUSSION

1- Dry matter intake (DMI):

The highest DMI value was obtained by protected methionine + protected lysine supplemented (4) group ($P<0.05$), followed by methionine supplemented (2) group and than lysine supplemented (3) group (Table 2). The lowest DMI value was obtained by control (1) group.

These results are in accordance with those of Overton *et al.* (1998), Nichols *et al.* (1998), XU. *et al.* (1998) and Varvikko *et al.* (1999). However, Iwanska *et al.* (1999), Bharadwaj *et al.* (2000), Krober *et al.* (2000a), Bach *et al.* (2000) and Younge *et al.* (2001) reported that there was not improvement in DMI when protected amino acids was given to animals.

2- Nutrients digestibility

Data presented in Table (2) clearly showed that animals fed rations supplemented with protected amino acids (groups 2-4) had higher ($P<0.05$) DM, OM, CP, CF, EE and NFE digestibility

Table (1): Chemical composition of concentrates feed mixture (CFM), rice straw (RS), Samartamine[tm] M (Met) and protected lysine (Lys) (% Dry matter basis).

Items	Feed ingredients			
	CFM*	RS	Met[1]	Lys[1]
Dry matter	91.29	92.85	95.93	94.60
Organic matter	89.89	84.55	96.55	97.69
Crude ash	10.11	15.45	3.45	2.31
Crude protein	14.15	3.5	68.23	63.61
Ether extract	4.05	2.10	8.60	4.10
Crude fiber	15.33	33.9	0.00	3.30
Nitrogen-free-extract	56.36	45.05	19.72	26.68

*** The CFM consisted of 25% undecorticated cotton seed meal, 35% wheat bran, 30% corn, 3% rice bran 3% molasses, 2% limestone, 1% urea and 1% salt (NaCl).**
[1]Total nitrogen obtained was multiplied by each of Met and Lys factor

Table (2): Effect of treatments on dry matter intake (DMI) and apparent nutrient digestibility of goats.

Parameter	Treatments				±SE
	C	Met	Lys	Met + Lys	
Dry matter intake (DMI) (g/h/day)	640.5^{C}	744^{B}	835.5^{A}	835.5^{A}	10.98
DMI(g/kg/wt $^{0.75}$ /day)	51.28	59.56	56.58	66.89	-
DMI from concentrate (g/h/day)	443	481.25	484.20	547.0	-
DMI from roughage (g/h/day)	197.5	262.75	222.50	288.5	-
DMI from concentrate as % of DMI	69.16	64.68	68.51	65.46	-
Apparent digestibility					
DM %	63.45^{B}	69.17^{A}	64.50^{B}	70.97^{A}	0.956
OM %	68.55^{C}	74.49^{A}	71.86^{B}	74.99^{A}	0.545
CP %	64.70^{D}	73.65^{B}	70.60^{C}	76.15^{A}	0.352
CF %	56.35^{B}	61.75^{A}	61.42^{AB}	62.40^{A}	0.731
EE %	69.25^{B}	73.72^{A}	71.90^{AB}	74.10^{A}	1.138
NFE %	73.70^{B}	79.56^{A}	76.20^{AB}	79.80^{A}	0.952

Each value is the mean of 4 values (4 animals).
A,B,C and D means with different superscripts in the same raw are significantly different at (P<0.05).
C= control diet Met = C + protected methionine Lys = C+ protected lysine
Met+Lys= C+ protected methionine + protected lysine

values than those of the control (1) group.

The highest digestibility value was obtained with methionine + lysine supplemented (4) group, followed by methonine (2) and then lysine (3) supplemened groups. The improvement in apparent digestibility coefficient with protected amino acid supplementation may be refer to improve digestibility in the abomasum. In addition, Blauwiekel *et al* (1997) noticed that protected lysine supplementation increased the flow and percentage of lysine in duodenal digesta of Holstein friesian cows. Berthiaume *et al* (2000) also found that bacterial nitrogen flow and bacterial efficiency were higher for non lactating Holstein friesian heifers fed rumen protected methionine supplemented ration based on timothy silage but they could not find clear explanation for this phenomenon. These results are in line with those obtained by Bacar (1995) who reported that apparent digestibility of crude protein was significantly improved and Dinn *et al.* (1998) reported that apparent digestibility of fiber (ADF) had higher ($P<0.05$) with added protected amino acids. However, Varvikko *et al.* (1999) also Klemesrud *et al.* (2000) found that apparent digestibility of organic matter and crude protein were not affected by protected amino acid supplementation.

3- Rumen parameters:

The effect of protected amino acids on some rumen parameters in goats during the digestibility trial are shown in Table (3). The average pH values were not affected by the different experimental treatments. These results are in accordance with those reported by Han *et al* (1996), Dinn *et al* (1998) and Robinson *et al* (2000). However, Bharadwaj *et al* (1999) and Demeterova *et al* (2002) reported that there was slight decrease in rumen pH when protected amino acids was given to animals. The overall mean of total volatile fatty acids (TVFA) for groups treated with methionine and lysine (group 4) or methionine (group 2) were higher ($P<0.05$) than that of lysine supplemented (3) and control (1) groups. The differences among treatments were statistically significant. The increase TVFA with all protected amino acids treatments may be due to the increase of apparent digestibility of organic matter (Table 2). These results are in accordance with those reported by Bharadwaj *et al* (1999) and Demeterova *et al* (2002). However, Han *et al* (1996); Dinn *et al* (1998); Kobayashi *et al* (1999) and Robinson *et al* (2000), found that TVFA content were not affected by protected amino acids. The overall mean of total nitrogen concentration in ruminal fluid was higher ($P<0.05$) in treated (2-4) groups than the control (1). Methionine and lysine supplementation (group 4) increased total nitrogen content of ruminal fluid ($P<0.05$) compared with methionine (group 2) and lysine (group 3) treatments. The overall means of NPN content in ruminal fluid were not affected by the different experimental treatments. The mean of NPN as percent of TN in ruminal fluid were decreased with treatments ($P<0.05$) compared with control. The not significantly different values of ruminal NPN concentration among treatments may be due to slightly lower concentration of ruminal ammonia nitrogen with protected amino acids supplementation. These results are in accordance with the lower degradability of protected amino acids in the rumen. The values of true protein nitrogen and true protein nitrogen as percent of TN were increased ($P<0.05$) with protected amino acid supplementation as compared to the control. These results reflect the high values of rumen total nitrogen concentration with protected amino acid supplementation as compared to the

control group. The overall means of ammonia nitrogen, and ammonia nitrogen as percent of NPN were not affected by the different experimental treatments but, ammonia nitrogen as percent of TN was increased ($P<0.05$) as the control compared with other treatments. These results seems to be a good indicator of undegraded the protected amino acids (methionine and lysine), which used in this study in rumen, therefore it was not effected on ruminal ammonia –N concentration. These results are in accordance with those reported by Kobayashi *et al.* (1999). However, Bharadwaj *et al.* (1999) found that NH_3- N was decreased by using protected amino acids.

Concerning the effects of time of sampling (Table 4), it was found that the ruminal pH was higher ($P<0.05$) in pre-feeding samples while the lowest pH value was obtained 3 hours post feeding then it began to increase. This trend was similar to the findings of El-Ashry *et al* (1988). In contrary, ruminal TFVA were increased ($P<0.05$) with the time after feeding from zero to 3 hours post feeding. These results are in an agreement with the conclusion of Roddy and Roddy (1985) who stated that, the pH values were inversely related to TVFA concentration in rumen. The total nitrogen and true protein nitrogen reached the highest ($P<0.05$) values at 6 hours after feeding, while the highest ($P<0.05$) values of ammonia and non-protein nitrogen were obtained at 3 hours post feeding.

4- Blood serum parameters

The data in Table 5. indicate that protected methionine and lysine supplemented (4.) group had not significantly higher serum total protein content ($P>0.05$), but glucose and total lipid differed significantly ($P<0.05$) as was compare to the control. Methionine (2) and lysine (3) supplemented groups had significantly higher serum total protein ($P<0.05$) but, glucose and total lipid content of blood serum was not significantly higher ($P>0.05$) than control. The increase of serum total protein with protected amino acid supplementation may be due to increase the level of methionine and lysine in the blood as proposed in earlier studies (Blum *et al.*,1999 and Vanhatalo *et al.*, 1999). The increase of glucose level agreed as those obtained by Kröber *et al.* (2000a). It is may be due to the increase in TVFA, whereas, the increase in blood glucose level correlates with an increase in propionic acid level in the rumen (being the main precursor of gluconeogenesis (Demetevova, 2002). The higher serum total lipid content was showed in the groups fed with protected amino acid supplemented diet and it may caused the methionine and lysine facilitated hepatic secretion of lipoproteins rich in triacylglcerol (Mc Carthy *et al.*, 1968 and Durand *et al* 1992).

Concerning serum content of albumin, globulin, A/G ratio, urea, creatinine also activities of ALT and AST those parameters did not affected by the different experimental treatments. The activities of ALT and AST showed normal activity of the hepatic tissues and those were in the physiological range. These results are in accordance with the findings of Xu *et al.* (1998). Creatinine content also did not show significant differences among the treatments, which indicated to the normal activity of the kidney as proposed by Kröber *et al* (2000a). Blood serum urea concentration are in accordance with the results of Pacheco-Rios *et al* (1999) and Varvikko *et al* (1999). However, Piepenbrink *et al* (1996) found that blood plasma concentration of urea increased when ruminally protected methionine and lysine were fed.

Table (3): Effect of treatments on some rumen parameters of goats.

Parameter	Treatments				±SE
	C	Met	Lys	Met+ Lys	
pH	6.45	6.25	6.31	6.30	0.052
TVFA (meq/l)	65.2^{C}	87.0^{A}	74.1^{B}	89.0^{A}	1.24
TN (mg/l)	988.3^{C}	1102.4^{B}	1114.6^{B}	1153.7^{A}	11.5
NPN (mg/l)	560.2	544.5	549.7	544.7	9.89
NPN as % of TN	57.63^{A}	59.81^{B}	50.69^{B}	48.59^{B}	1.16
True. Protein N (mg/l)	428.0^{B}	557.9^{A}	564.9^{A}	608.9^{A}	17.2
True. Protein N as % of TN	42.30^{B}	49.08^{A}	49.16^{A}	51.30^{A}	1.17
Ammonia. N (mg/l)	262.4	256.2	259.5	258.3	2.93
Ammonia. N as % of TN	26.99^{A}	23.75^{B}	23.94^{B}	23.05^{B}	0.41
Ammonia. N as % of NPN	46.58	47.08	47.25	47.16	1.304

Each value is the mean of 4 values (4 animals).
A,B,C and D means with different superscripts in the same raw are significantly different at (P<0.05).
C= control diet Met = C + protected methionine Lys = C+ protected lysine
Met+Lys= C+ protected methionine + protected lysine

Table (4): Effect of sampling time – hours after feeding – on overall mean of some rumen parameters of goats.

Parameter	Time (hour)			±SE
	0	3	6	
pH	6.59^{A}	6.00^{C}	6.40^{B}	0.045
TVFA (meq/l)	62.8^{C}	92.1^{A}	81.6^{B}	1.0
TN (mg/l)	860.3^{A}	1091.8^{B}	1317.1^{C}	9.9
NPN (mg/l)	494.5^{C}	632.6^{A}	522.2^{B}	8.5
NPN as % of TN	57.54^{A}	58.35^{A}	39.90^{B}	1.01
True. Protein N (mg/l)	365.8^{A}	459.1^{B}	794.8^{C}	14.9
True. Protein N as % of TN	42.35^{B}	41.56^{B}	59.96^{A}	1.01
Ammonia. N (mg/l)	241.0^{B}	288.0^{A}	248.0^{B}	2.5
Ammonia. N as % of TN	27.89^{A}	26.50^{B}	18.90^{C}	0.36
Ammonia. N as % of NPN	48.50	45.12	47.43	1.12

Each value is the mean of 4 values (4 animals).
A,B,C and D means with different superscripts in the same raw are significantly different at (P<0.05).

Table (5): Effect of treatments on some blood serum parameters of goats.

Parameter	Treatments				±SE
	C	Met	Lys	Met+ Lys	
Total protein (g/l)	60.2^{B}	67.5^{A}	67.2^{A}	70.0^{A}	1.16
Albumin (g/l)	30.5	34.2	33.7	35.0	1.30
Globulin (g/l)	29.7	33.3	33.5	35.0	2.13
A/G ratio	1.04	1.04	1.03	1.00	0.110
Urea (mg/l)	417.7	408.7	407.0	419.2	14.26
Creatinine (mg/l)	6.1	5.7	5.2	6.3	0.52
ALT (units/l)	32.75	32.75	33.50	31.50	1.574
AST (units/l)	16.25	15.00	16.25	15.50	0.901
Glucose (mg/l)	608.7^{B}	655.0^{AB}	663.5^{AB}	680.7^{A}	17.52
Total lipid (mg/l)	2580^{B}	2657^{AB}	2667^{AB}	2695^{A}	27.38

Each value is the mean of 4 values (4 animals).
A,B,C and D means with different superscripts in the same raw are significantly different at (P<0.05).
C= control diet, Met = C + protected methionine, Lys = C+ protected lysine, Met+Lys= C+ protected methionine + protected lysine

CONCLUSION

Although all supplemented diets enhanced the performance of the experimental animals as compared to the controls, protected methionine plus lysine and methionine alone were more effective to improve the nutritive value and apparent digestibility of diets than protected lysine alone.

ACKNOWLEDGMENT

The authors would like to acknowledge Multi Vita Co. for Animal Nutrition, Egypt for supplying Smartamine ™ M from Aventis Animal Nutrition, France for this study.

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تأثير إضافة الميثيونين والليسين المحميان من الهدم فى الكرش إلى العليقة على معاملات الهضم وبعض مقاييس الكرش فى ذكور الماعز البلدى

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استخدمت فى هذه هذه الدراسة ٤ ذكور ماعز بلدى وتم تقسيمها على ٤ معاملات على النحو التالى:
١- المعاملة المقارنة: وتحتوى على ٧٠% علف مركز + ٣٠% قش أرز
٢- المعاملة بالميثيونين المحمى من الهدم فى الكرش: عليقة المقارنة مضاف إليها ٧ جرام من الميثونين المحمى.
٣- المعاملة بالليسين المحمى من الهدم فى الكرش: عليقة المقارنة مضاف إليها ٢١ جرام من الليسين المحمى.
٤- المعاملة بالميثيونين والليسين المحميان من الهدم معاً: عليقة المقارنة مضاف إليها ٧ جرام ميثيونين محمى + ٢١ جرام ليسين محمى.
ولقد استمرت التجربة ٤ شهور (شهر لكل مرحلة) بنظام المربع اللاتينى ٤ × ٤ ، وقسمت كل مرحلة إلى :
أ – ٢٣ يوم مرحلة تمهيدية.
ب- ٧ أيام مرحلة التجميع لعينات الروث والبول ، كما تم تجميع عينات سائل الكرش قبل التغذية وبعد ٣ و ٦ ساعات من التغذية، وأيضاً عينات الدم بعد ٤ ساعات من التغذية فى آخر يوم من أيام التجميع.

النتائج المتحصل عليها:
- أدت إضافة الميثيونين والليسين المحميان من الهدم معاً لعليقة الماعز إلى زيادة معنوية (على مستوى ٥%) فى المادة الجافة المأكولة وكذلك زيادة فى كل من النسب الهضمية لمكونات الغذاء ومجموع الأحماض الدهنية الطيارة بالكرش وأيضاً النيتروجين الكلى والبروتين الحقيقى بالكرش عن المعاملات الأخرى ومجموعة المقارنة، كما أدت إلى زيادة معنوية (على مستوى ٥%) فى محتوى سيرم الدم من البروتين الكلى والجلوكوز والليبيدات الكلية عن مجموعة المقارنة، وحققت أفضل النتائج بالمقارنة بالمعاملات الأخرى.
- أدت إضافة الميثيونين المحمى من الهدم وحدة فقط للعليقة إلى زيادة معنوية (على مستوى ٥%) فى المادة الجافة المأكولة والنسب الهضمية لمكونات الغذاء والأحماض الدهنية الطيارة الكلية فى سائل الكرش والنيتروجين الكلى والبروتين الحقيقى بالكرش وأيضاً زيادة فى محتوى سيرم الدم من البروتين الكلى والجلوكوز والليبيدات الكلية عن مجموعة المقارنة.
- أدت إضافة الليسين المحمى من الهدم وحدة فقط للعليقة إلى زيادة معنوية على (مستوى ٥%) فى المادة الجافة المأكولة ومعاملات الهضم لمكونات الغذاء ماعدا معامل هضم كل من المادة الجافة ومستخلص الأثير والمستخلص الخالى من الأزوت لم يتأثروا بالمعاملة وأيضاً زيادة فى الأحماض الدهنية الطيارة الكلية والنيتروجين الكلى والبروتين الحقيقى بالكرش وزيادة فى محتوى سيرم الدم من البروتين الكلى عن مجموعة المقارنة.
- تم الحصول على أعلى قيم للمادة الجافة المأكولة وللنسب الهضمية للمكونات المختلفة للعليقة ونسبة الأحماض الدهنية الطيارة الكلية فى سائل الكرش والنيتروجين الكلى والبروتين الحقيقى بالكرش وأيضاً محتوى سيرم الدم من البروتين الكلى والجلوكوز والدهون الكلية فى المجموعة المضاف إلى عليقتها الميثونين والليسين معاً تليها مجموعة الميثيونين فقط ثم تليها مجموعة الليسين فقط وأخيراً عليقة المقارنة.

من هذه النتائج يمكن القول بأن استخدام الأحماض الأمينية المحمية من الهدم فى الكرش يمكن أن تحسن من كفاءة الحيوان الغذائية مما ينعكس ذلك على زيادة أداء الحيوان فى صورة إنتاج دون التأثير على صحة الحيوان.