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The influence of dietary betaine supplementation to Ossimi rams on: (A) Growth performance, digestibility coefficients, some blood parameters and activity of thyroid gland

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ABSTRACT

The purpose of this study was to evaluate the effect of dietary betaine supplementation on growth characteristics and some blood constituents of Ossimi rams. A total of 18 Ossimi rams were randomly divided into three equal groups, considering their body weight. Animals of the first group (Co) served as control, while animals of the second (BET1) and third (BET2) groups offered 2 and 4 g of betaine/head/day, respectively. At the last day of the experiment, blood samples were taken to estimate some blood metabolites. Three digestibility experiments were carried out to determine nutrients digestibility and nutritive values of the rations. Body weight was recorded while average daily gain, feed conversion and feed economic efficiency were calculated. The results show that betaine supplementation to rams either with 2 or 4 g/head/day increased ($P \leq 0.05$) plasma total protein, plasma globulin, plasma glucose and triiodothyronine hormone (T_3), while it significantly ($P \leq 0.05$) decreased A/G ratio and plasma total cholesterol. Concentrations of plasma albumin and plasma urea N did not differ significantly due to betaine supplementation. Digestibility coefficients of DM, OM, CP, EE and CF were significantly ($P \leq 0.05$) increased for BET2 group than for BET1 and Co groups. However, NFE digestibility was not influenced by betaine. The TDN value was increased ($P \leq 0.05$) for BET2 diet compared with other treated diets. While, the nutritive values as DCP did not significantly differ among treatments. Animals in BET1 and BET2 consumed more ($P \leq 0.05$) metabolizable energy (ME, Mcal/kg) compared with the control group. Live body weight did not differ ($P > 0.05$) among groups while average daily gain and total weight gain were improved ($P \leq 0.05$) in treated groups. Feeding Ossimi rams on BET1 increased significantly ($P \leq 0.05$) daily dry mater intake (DMI), and total digestible nutrient intake (TDNI) when compared with BET2 and Co groups, while treated groups consumed ($P \leq 0.05$) metabolizable energy (ME) more than the control group. Daily digestible crude protein intake (DCPI) did not significantly differ among treatments. In conclusion, dietary betaine supplementation to Ossimi rams could modify some metabolic processes, and enhance feed consumption and energy mobilization which could be reflected on improving the productive performance.

Keywords: Digestibility coefficients, nutritive values, growth performance, blood parameters, Ossimi sheep.

INTRODUCTION

Betaine is a dimethyl glycine derivative of amino acids and is widely found in a variety of plants in nature (Liu *et al.*, 2019). Betaine is a natural compound either produced endogenously by choline oxidation (Zeisel, 2013) or found naturally in feed ingredients, such as sugar beet solubles, which have the most abundant betaine content (Eklund *et al.*, 2005). Betaine has two main functions on animal's body. It serves as an organic osmolyte, helping to reduce dehydration, stabilize protein structure, and preserve enzyme function when a cell is under osmotic stress. However, betaine is not present in large quantities in animals feedstuffs (Wang *et al.*, 2004). Thus, betaine is a multi-nutritional agent that may help animals to resist poor management. Betaine influences many key functions in the body, such as growth, liver health, and lactation (Ratriyanto *et al.*, 2009). Lakhani *et al.* (2020) on growing Karan Fries heifers found that betaine supplementation resulted in significant increase of dry matter intake, feed conversion efficiency and body weight gain.

In ruminants, betaine alters rumen fermentation (Mitchell *et al.,* 1979) and improves nutrient digestibility (Wang *et al.*, 2010). Feeding betaine to lambs during the growing phase did not change the weight gain or BW at slaughter (Fernandez *et al.*, 1998). In contrast, in finishing steers, supplementing betaine increased average daily gain (Bock *et al.*, 2004). Furthermore, betaine is vital for fetal development (Lever and Slow, 2010), and is related to the offspring's weight and immunity (Van *et al.*, 2016). The objective of this study was to elucidate digestibility coefficients, nutritive values, growth performance and some blood constituents of Ossimi rams fed diets supplemented with betaine.

MATERIALS AND METHODS

Experimental animals, management and treatments:

Eighteen Ossimi rams (40.63 kg average body weight) were used in this study. The experiment was carried out at the Animal Experimental Farm, Animal Production Department, Faculty of Agriculture, Al-Azhar University, Assiut, Egypt. The objective of this study was to evaluate the impact of dietary betaine supplementation on productive performance, digestibility coefficients and selected blood parameters as well as the activity of thyroid gland of Ossimi male sheep under Upper Egypt condition.

Animals were allocated according to their body weight into three equal groups (6 rams each). The first group was used as control while second and third groups were given 2 g/head/day (BET1) or 4 g/head (BET2) betaine, respectively. The rams were group housed indoors in stables constructed of 5 m high cement and brick walls, wood roof and corrugated concrete floors. The animals were fed green fodder and concentrate mixture during the experiment (120 days). The ingredients percent and chemical composition of experimental diets are presented in Table 1. Diets were offered twice daily at 09:00 am and 16:00 pm. Wheat straw was provided *ad libitum* for all experimental animals.

Table 1. Ingredients and chemical analysis (%) of the experimental diets.

Items	Ingredient, %	Chemical analysis (%DM basis)	
		DM	90.32
Yellow corn	44	OM	88.84
Soybean meal	16	CP	17.72
Wheat Bran	15	EE	2.48
Whole cottonseed	18	CF	4.38
Molasses	4	NFE	64.26
Calcium carbonate (Limestone)	1	Ash	11.16
Vitamin-mineral (Premix®)	1	ME	2.65
Sodium chloride (Salt)	1	Ca	0.50
Total	100	P	0.82

®One kilogram of premix contained: vit. A 12000 000 IU, vit. E 1000 mg, vit K_3 2000 mg, vit. B_1 1000 mg, vit. B2 4000 mg, vit. B12 10 mg, pantothenic acid 3.33 g, biotin 33 mg, folic acid 0.83 g, choline chloride 200 g, Mn 5 g, Fe 12.5 g, Cu 0.5 g, I 133.3 mg, Se 16.6 mg and Mg 66.7 g.

Throughout the experimental period, animals were weighed monthly and group feed consumption was daily recorded. Live weight gain and feed conversion (kg feed / kg gain) were calculated. Economic efficiency for all the experimental diets were estimated. Economic efficiency is defined as the net revenue per unit feed cost calculated from input/output analysis as described by Hassan *et al.* (1996). Three digestibility trials were carried out to determine nutrients digestibility (CP, EE, CF, NFE, Ash, DM and OM) and nutritive values (TDN and DCP) of the experimental diets. Nine animals (three from each treatment) were randomly chosen for each digestibility trial. Animals were individually housed in metabolic cages supported by feces collection facility. The experimental diets were offered daily *ad libitum* for 22 d (primary period 15 d and collection period 7 d). Drinking water was provided all the time. All animals were weighed at the beginning and at the end of the collection period. Feces daily voided for seven consecutive days, collected and stored at – 20^{o}C in polyethylene bags. Feces were dried and mixed together, weighed, finely grained and stored in plastic bags until analyzed. Samples of diets and feces were analyzed for protein, fat, fiber, and NFE according to A.O.A.C. (2005). The NFE was calculated. Digestibility values of nutrients of the experimental trials were estimated on DM basis. Dry matter was determined by drying duplicate ground samples overnight at 105^{o}C. Dry matter intake (DMI, kg/day), TDN and DCP were calculated, while metabolizable energy of feeds was estimated according to NRC (1988).

At the last day of the trial (120 days), blood samples (10 ml of each) were collected from all experimental animals in heparinized tubes, via the jugular vein at 8:00- 09:00 h before access to feeding and drinking. Plasma was obtained by centrifugation of the blood samples for 20 min. at 3000 rpm, and stored at -20 ^{o} C until analysis. Plasma concentrations of total protein, albumin, urea N, glucose and total cholesterol were determined calorimetrically using commercial kits (Diamond, Egypt). Plasma total globulin was obtained by difference (total protein minus albumin) and albumin/globulin ratio was calculated. Plasma concentration of triiodothyronine hormone (T3) was determined using enzyme-linked immunosorbent assay kits supplied by Biotecx, USA. Economic efficiency for all the experimental diets were estimated. Economic efficiency is defined as the net revenue per unit feed cost calculated from input output analysis as described by Hassan *et al.*, (1996).

Statistical analysis

Analysis of variance procedure (SAS, 2004) was employed to evaluate the effects of betaine supplementation on growth performance, digestibility coefficients, nutritive values, economic efficiency and some plasma constituents of Ossimi rams. Linear contrasts were used to compare least square means for all variables previously indicated: $Y_{jk} = U + T_i + e_{jk}$ Where Y_{jk} = observations, U = overall means, T_i = The fixed effect of (i=1, 2, 3), where T_1 control, T_2 effect of BET1 and T3 effect of BET2. e_{jk} = The random error. Differences among means were tested by using Duncan's new multiple range test (MRT).

RESULTS AND DISCUSSION

Tested blood constituents

Serum biochemical indices used to focus on animal health and to evaluate protein quality and amino acid requirements of animals as reported by Harper *et al*. (1979). The results illustrated in Table 3 show that betaine supplementation to rams with either 2 or 4 g/head/day significantly (*P≤0.05*) increased plasma total protein, plasma globulin, plasma glucose and triiodothyronine hormone (T_3), while it decreased significantly (*P≤0.05*) A/G ratio, and plasma total cholesterol. Concentrations of plasma albumin and plasma urea N did not differ significantly due to betaine supplementation.

The increase in plasma total protein and globulin due to betaine are in agreement with previous results reported by Wang *et al.* (2019) and Hassan *et al.* (2012). The increase of plasma total protein concentration caused by betaine supplementation is possibly due to the role of betaine in rumen fermentation as evidenced by the greater microbial protein synthesis (Wang *et al., 2010 and* Wiedmeier *et al.*, 1992). Another explanation for the increase of plasma total protein could be associated with its ability as a methyl group donor which is fairly consistent in protein metabolism (Kidd *et al.,* 1997). In addition, the plasma total protein and globulin concentrations of calves significantly increased with maternal betaine supplementation, which indicates that it might improve the immunity of newborn calves because of maternal methyl donors supplementation (Van *et al.*, 2016 *and* Liu *et al.,* 2013). Furthermore, plasma total protein level is a general indication of immune status (White *et al.*, 2002).

Betaine supplementation increased (*P≤0.05*) serum glucose in BET1 and BET2 groups by about 23.88 % and 22.59 %, respectively compared with the control group (Table 2.) Such increase may be due to the elevation of T3 hormone as shown in the present study (Table 2). Accordingly, thyroid hormones administration increase gluconeogenesis and/ or plasma glucose concentrations in lambs (Cole *et al.*, 1994). In addition, Greenspan (1994) found that hyperthyroidism is accompanied by slight hyperglycemia due to increase rate of hepatic gluconeogenesis, glucogenolysis and absorption of glucose from the intestinal tract. The results dis agree with those reported by Wang *et al.* (2019) and Huang *et al.* (2006).

Table 2: Effect of betaine supplementation on selected plasma metabolites of Ossimi rams.

Items	Experimental diets			± SEM
	CO	BET1	BET2	
Blood metabolites				
Total protein (g/dl)	6.30^{b}	7.77^{a}	7.43^{a}	0.71
Albumin (g/dl)	2.90	2.97	2.50	0.28
Globulin (g/dl)	3.40^{b}	4.80^{a}	4.93^{a}	0.55
A/G ratio	0.86^{a}	0.62^{b}	0.56^{b}	0.11
Urea N (mg/dl)	43.73	41.57	40.90	3.08
T cholesterol(mg/dl)	77.0^{a}	62.66^{b}	67.00^{b}	3.82
Glucose (mg/dl)	51.00^{b}	67.00^{a}	65.88^{a}	4.14
Activity of thyroid hormone				
T3 (ng/mL)	2.13^{b}	2.44^{ab}	2.79^{a}	0.12

Each value represents an average of 6 samples. ^{a,b}, means at the row with different superscript are significantly (*P≤0.05*) different. SEM = Standard error mean. CO= Control; BET1 = Rams fed 2 g /kg CFM, BET2 = Rams fed 4 g /kg CFM.

In contrast, there was no effect of dietary betaine on plasma glucose concentrations of Merino sheep as reported by DiGiacomo *et al.* (2016).

The decrease in plasma cholesterol concentration due to betaine supplementation may be attributed to the marked inhibition of betaine for lipogenesis (DiGiacomo *et al*., 2016). Moreover, it causes a decrease in the plasma non-esterified fatty acid concentrations (Wang *et al.*, 2010), which may prevent excess uptake by the liver and reduce incidence of fatty liver and lower plasma ketone concentration. In addition, Betaine can enhance the synthesis of methylated compounds such as phospholipids and therefore can directly influence lipid metabolism (Huang *et al*., 2008). According to Wray-Cahen *et al.* (2004) and Huang *et al*. (2008), dietary betaine supplementation influences lipid metabolism via reducing adipose accretion rather than influencing oxidation. Huang *et al*. (2008) demonstrated that dietary betaine supplementation reduces the activity of key enzymes (such as fatty acid synthase) that regulate fatty acid accretion in porcine subcutaneous adipose tissue.

The results presented in Table 2 show that betaine supplementation elevated T3 level in BET1 and BET2 (*P≤0.05*) groups by 12.7 % and 23.66%, respectively compared with a control group. Thyroid hormones (T3 and T4) are the main substances secreted by the thyroid. The T3 is mainly transformed from T4. Although lower quantities of T3 are produced compared to T4, its activity is stronger than T4 (Zhang *et al.*, 2014). Circulating T3 can be considered as an indicator of the metabolic and nutritional status of the animals (Riis and Madsen, 1985). The overall effects of T3 are increasing the basal metabolic rate, to make more glucose available to cells, stimulate protein synthesis and increase lipid metabolism (Capen and Martin, 1989).

Higher T3 in the present study (Table 2) increased metabolic rate which improved body weight gain and elevated plasma total protein and plasma glucose in treated animals (Table 2 & 4). Sarwar *et al.* (2010) found that lambs fed diets with probiotic had higher T3 level than those fed diets without additives. In contrast, dietary betaine supplementation did not influence plasma T3 level as reported by Zhang *et al.* (2014). In general, results of selected blood metabolites concentrations were within the normal reported by Merck Sharp and Dohme Corp (2011).

3.2. Digestibility coefficients and nutritive values

The effect of betaine on nutrient digestibility coefficients and nutritive values are presented in Table 2. Digestibility coefficients of DM, OM, CP, EE and CF were significantly ($P\leq0.05$) increased for BET2 group than for BET1 and Co groups, while NFE percent was not influenced due to betaine supplementation. In addition, the TDN value was increased ($P\leq0.05$) for BET2 diet compared with other treated diets. While, the nutritive values as DCP did not significantly differ among treatments. Animals in BET1 and BET2 consumed more ($P\leq0.05$) metabolizable energy (ME, Mcal/kg) compared with the control group.

The present results are similar to those of Wang *et al.* (2010) who found that digestibility of DM, OM, CP and EE by dairy cows were elevated due to adding betaine in the diet. The improved digestibility coefficients and nutritive values of dietary components are consistent with increase of rumen VFA concentration (W*ang et al.*,2010), improved microbial fermentation of the neutral detergent fiber (NDF) fraction (Wiedmeier *et al.*,1992), enhanced growth of ruminal microbial populations that would increase ammonia N utilization, especially by the fiber-degrading populations, decreased ruminal pH and ammonia N, improved ruminal fibrolytic bacterial activity as total digestibilities of NDF and acid detergent fiber (ADF), (Wang *et al.*, 2010). The increased VFA concentrations indicate a greater microbial fermentation rate.

Growth performance

Live body weight gain and Feed intake:

Total gain and average daily gain were improved ($P\leq0.05$) as a function of betaine level fed to BET2 rams compared with BET1 and Co groups (Table 4), while final body weight did not differ significantly among treatments. These results are in agreement with those of Lakhani *et al.* (2020) who indicated that betaine supplementation improved body weight gain of growing heifers. In addition, a number of studies reported increased average daily gain (ADG) of steers (Bock *et al.* 2004) and goats supplemented with betaine. Dunshea, *et al.* (2019) and Rao, *et al.* (2011) reported that betaine is a functional active substance from a variety of plants, which can act as methyl group donor and organic osmolyte, and has the ability to improve growth performance of animals.

In contrast, Gralak *et al. (1998)* reported that supplementation with 25 g betaine/kg basal diet had no effect on ADG and relative growth rate of 6-month-old calves. In lambs, dietary betaine supplemented at 2 g/kg feed had no effect on weight gain, final live weight (Fernandez *et al.*,1998) or average daily gain (Löest *et al.* 2002). Improved animal growth rate could partially attributed to the increased nutrient digestibility in the digestive tract with betaine supplementation (W*ang et al.*, 2010). Another idea has been advanced to explain the mechanism by which betaine supplementation improves body performance is that betaine improves intestinal function by enhancing the digestive enzymes, ameliorating intestinal morphology, and enriching intestinal microbes (Wang *et al.*, 2018).

They added that high salt decreased the length of villi and increased the thickness of crypts. When betaine supplemented , the histomorphology of gut microstructure was greatly improved. The ratio of villus height to crypt depth also showed similar results. Feeding Ossimi rams on BET1 significantly ($P\leq0.05$) increased daily dry mater (DMI), and total digestible nutrients intake (TDNI) when compared with BET2 and Co groups, while rams feed supplement of betaine consumed more ($P\leq0.05$) metabolizable energy (ME) compared with the control trial (Table 4).

Table 3. Digestion coefficients (%) and nutritive values (%) of the experimental diets (LSM ± SE)

Items	Experimental diets			± SEM
	CO	BET1	BET2	
Digestibility coefficients %				
DM	68.72[b]	73.91[b]	77.13[a]	1.75
OM	68.40[b]	70.84[ab]	73.64[a]	1.79
CP	78.82[b]	80.45[ab]	82.33[a]	0.53
EE	50.18[b]	54.03[ab]	58.45[a]	0.97
CF	29.52[c]	34.96[b]	41.21[a]	1.45
NFE	68.88	71.29	74.05	1.73
Nutritive values %				
TDN	62.32[b]	64.61[ab]	67.24[a]	0.55
DCP	10.88	11.42	11.35	0.33
ME,Mcal/kg	2.24[c]	2.33[b]	2.42[a]	0.09

[a,b,c] means in the same raw with different superscripts differ significantly at *(P≤0.05).*

SEM = Standard error mean. CO= Control; BET1 = Rams fed 2 g /kg CFM, BET2 = Rams fed 4 g /kg CFM. ME, Mcal/ Kg DM = (TDN x 3.6)/100 (Ranjhan, 1980) and (Church and Pond, 1982)

Table 4. Effect of betaine supplementation on growth performance and feed intake of Ossimi rams.

Item	Experimental diets			± SEM
	CO	BET1	BET2	
Growth performance				
Initial BW (kg)	40.75	41.38	39.75	3.36
Final BW (kg)	55.50	57.50	56.38	3.63
Total gain (kg)	14.75[b]	16.13[ab]	16.63[a]	0.47
Average daily gain (g)	122.9[b]	134.4[ab]	138.5[a]	3.95
Feed intake				
TDMI/h	122.6[b]	151.6[a]	127.4[b]	2.38
TDMI/h/d	1.02	1.26	1.06	0.10
TDNI/h/d	0.60[b]	0.80[a]	0.68[ab]	0.08
DCPI/h/d	0.11	0.14	0.12	0.01
ME,Mcal/h/d	2.14[c]	2.86[a]	2.44[b]	0.09

BET1 = Rams fed 2 g /kg CFM. BET2 = Rams fed 4 g /kg CFM. BW = Body weight. TDMI= total dry mater intake, TDNI= total digestible nutrient intake, DCPI= digestible crude protein intake, ME= m*etabolizable* energy. [a,b,c] means in the same raw with different superscripts differ significantly at *(P≤0.05).* ME, Mcal/ Kg DM = (TDN x 3.6)/100 *(Ranjhan, 1980) and (Church and Pond, 1982).*

Daily digestible crude protein intake (DCPI) did not significantly differ among treatments. Lakhani *et al*. (2020) reported an increase in feed consumption, while other studies found no effect for betaine supplementation on dry matter (DM) intake by ruminants (Wang *et al.*, 2010 and Löest *et al.* 2002). These inconsistent effects of betaine on DM intake may be due to differences in the form and in the rumen of the betaine fed animals, the dose of betaine supplemented, basal methionine supply and amino acid status of the animals, as well as the crude protein (CP) content in basal diet (Shenkoru, 2001 and Fernández-Fígares *et al.* 2002). Such variability could be due to age, breed, body condition of the animals, feed ingredients, amount and type of energy supplied, physical form of feed, saliva amount and composition, and also VFA production and hence ruminal pH. There is also a possibility of difference due to climate conditions.

Feed conversion and economical efficiency

Data presented in Table (5) shows the effect of treatments on feed conversion and economic efficiency of treated groups. Feed conversion of DM, TDN and DCP were insignificantly (*P>0.05*) improved due to feeding the experimental diets. The present results are similar to those of Shakeri *et al.* (2018) who reported that betaine supplementation induced a significant (*P<0.02*) decrease of feed conversion. In the present study, it seems likely that betaine supplementation to rams led to increase weight gain as a result of increased nutrient digestibility in the digestive tract (Wang *et al.*, 2010) *and* improve intestinal function by enhancing the digestive enzymes, ameliorating intestinal morphology, and enriching intestinal microbes (Wang *et al.*, 2018). This phenomena led to decrease feed conversion of DM, TDN and DCP in the treated groups compared to the control.

Table 5. Effect of betaine supplementation on feed conversion and economical efficiency of Ossimi rams

Items	**Experimental diets**			**± SEM**
	CO	**BET1**	**BET2**	
Feed conversion, kg/kg gain				
DM	6.96	6.85	6.41	0.70
TDN	4.93	4.06	4.09	0.51
DCP	0.86	0.75	0.74	0.09
Economical efficiency				
Feed cost, LE/h/d	0.40	0.41	0.40	0.03
Feed cost, LE/kg gain	2.72	2.53	2.40	0.15
Economic efficiency*	20.33	22.11	23.03	1.33
RFE %	100	108.8	113.3	

Where, price of 1 ton CFM = 3600 and wheat straw = 400 LE. Price of 1 kg live body weight = 55 LE as the dominant market price of finishing ram lambs at Assiut market in this period, respectively. *Economic efficiency = price of one kg LBW (LE/kg gain) / feed cost (LE/kg gain).

RFE = Assuming that the relative economic efficiency (RFE) of the control diet equal 100.

Feeding betaine did not affect total feed cost (LE/h/d), while total feed cost (LE/kg gain) induced insignificant decrease (*P>0.05*) in BET1 and BET2 by 6.99 % and 11.77 % , respectively compared with the control diets due to feed of treated animals (Table 5). In this field, economic efficiency was increased (*P>0.05*) by 8.76 % and 13.28 %, while relative economic efficiency (RFE) was 108.8 % and 113.3 % better in BET1 and BET2 groups, respectively than that of the control one.

CONCLUSION

In conclusion, dietary betaine supplementation to Ossimi rams could modify some metabolic processes, and enhance feed consumption and energy mobilization which may be reflected in an improvement in the productive performance. From economic point of view, using betaine supplement is recommended. However, adding betaine to the diet of rams needs more studies.

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تأثير إضافة البيتائين للحملان الأوسيمى على: (أ) أداء النمو ، ومعاملات الهضم، وبعض مقاييس الدم ونشاط الغدة الدرقية

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أجريت الدراسة بمزرعة الإنتاج الحيواني التابعة لكلية الزراعة جامعة الأزهر بأسيوط، حيث استخدم عدد ثماني عشر (١٨) كبش أوسيمى قسمت الى ثلاث مجموعات متساوية حسب وزن الجسم كالآتي: المجموعة الاولى المجموعة الضابطة (كنترول) بينما أعطيت المجموعة الثانية BET1 والمجموعة الثالثة BET2 البيتائين بمعدل ٢ جم و٤ جرام/للرأس/ يوم على التوالي. وفى نهاية التجربة تم جمع عينات الدم من الخراف لتقدير مقاييس الدم، كما أجريت تجارب الهضم في نهاية التجربة لحساب معاملات الهضم وكفاءة تحويل الغذاء والقيمة الغذائية والكفاءة الاقتصادية للمعاملات. كما تم تسجيل أوزان الجسم وحساب معدلات الزيادة اليومية.

أظهرت نتائج التجربة أن المعاملة بالبيتائين بمعدل ٢ أو ٤ جم/للراس/ يوميا ادى الى زيادة معنوية (*P≤0.05*) في مستوى بروتينات البلازما والجلوبيولين والجلوكوز وهرمونات ثلاثي يودو الثيرونين (T3) بينما إنخفض مستوى الكوليسترول ونسبة الجلوبيولين/الألبومين معنويا (*P≤0.05*)، بينما لم يشاهد أي إختلاف معنوي في مستويات الألبيومين واليوريا بسبب المعاملة بالبيتائين. كانت هناك زيادة معنوية (*P≤0.05*) لمعاملات الهضم لكلا من DM, OM, CP, EE, CF لمجموعة BET2 مقارنة بمجموعات BET1 والمجموعة الضابطة. في حين أن المستخلص الخالي من النيتروجين NFE لم يتأثر بسبب المعاملة بالبيتائين. كانت هناك زيادة معنوية (*P≤0.05*) فى مجموع المواد الغذائية القابلة للهضم TDN للمجموعة الثالثة BET2 والتي اعطيت ٤ جم/للراس/يوم مقارنة بمجموعات BET1 و الكنترول، بينما لم يلاحظ اى اختلافات معنوية بين المعاملات فى القيمة الغذائية للبروتين المهضوم DCP. لوحظ ان الحيوانات في المجموعة BET1 و BET2 تستهلك طاقة ممثلة (ME Mcal/kg) أكثر (*P≤0.05*) مقارنة بمجموعة الكنترول. لم يختلف وزن الجسم الحي (*P>0.05*) بين المجموعات بينما لوحظ ان هناك تحسن فى معدلات النمو اليومي والكلي (*P≤0.05*) في الكباش المعاملة.

تغذية الكباش الأوسيمي على البيتائين بمعدل ٢جم/للراس/يوم فى مجموعة BET1 زادت (*P≤0.05*) من استهلاك المواد الجافة (DMI) بشكل كبير، وإجمالي استهلاك المواد الغذائية القابلة للهضم (TDNI) بالمقارنة مع مجموعات BET2 و مجموعة الكنترول CO ، بينما تستهلك الكباش المعاملة التي عوملت بالبيتائين طاقة ممثلة (ME) أكثر (*P≤0.05*) بالمقارنة مع مجموعة الكنترول. لم يلاحظ ان هناك اختلافات معنوية فى البروتين الخام المهضوم يوميا (DCPI) بين المعاملات. من هذه النتائج يمكن استنتاج ان تغذية الكباش الاوسيمى بالبيتائين كمكمل غذائي يمكن ان يحسن من عمليات التمثيل الغذائي ويعزز من استهلاك الاعلاف والطاقة الممثلة مما ينعكس على الاداء الإنتاجي للحيوانات المعاملة.