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The Influence of Dietary Betaine Supplementation of Ossimi Rams on: (B) Carcass Characteristics

Abd-Allah, M.[1*] and M. W. H. Daghash[2]

[1]Department of Animal Production, Faculty of Agric.Al-Azhar Univ, Assiut Branch, 71524 Assiut, Egypt.
[2]Department of Animal Production, Faculty of Agric. Assiut Univ, Assiut, Egypt.

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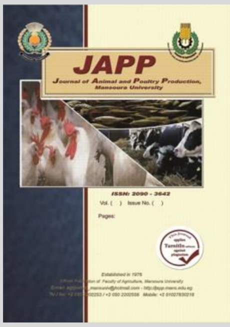

ABSTRACT

Eighteen Ossimi rams of about 40.63 kg body weight were used to evaluate the impacts of betaine supplementation on carcass characteristics of Ossimi rams. Animals were assigned randomly to three treatment groups (CO, BET[1] and BET[2]), the control group was fed a BET free diet while BET[1] and BET[2] groups received 2.0 and 4.0g BET/h/d for 120 days experimental period. three rams from each group were slaughtered at the end of the experiment. The results revealed that, BET[2] group increased ($P\leq0.05$) fasting and empty weight compared with BET[1] and control groups. Hot carcass and carcass weight without tail tended to be heavier in BET treated rams than control. Betaine supplementation led to improve the dressing percentage compared with control. Carcass measurements influenced significantly due to feeding on betaine. A significant increase in weights of liver and sex organs of BET[2] than BET[1] and control diets. Fed betaine caused a significant ($P\leq0.05$) lower in carcass fats than control. Testicular morphology increased ($P\leq0.05$) in treated animals. BET[2] were higher ($P\leq0.05$) leg weight and length than control. Weights of shoulder, fore shank and breast were heavier ($P\leq0.05$) in BET[2] than BET[1] and control groups. Betaine supplementation increased ($P\leq0.05$) weights of 9,10 and 11 ribs cut and muscle weight and lower ($P\leq0.05$) fat and bone weight compared with control. All individual skeletal muscle measurements were higher in rams fed on BET than control. No significant differences among treatments on chemical composition of muscles. In conclusion, betaine supplementation may improve carcass characteristics of treated rams.

Keywords: Betaine, carcass characteristics, testicular morphology, chemical composition of carcass muscles, Ossimi rams

INTRODUCTION

Betaine supplementation to diets for livestock has increased during the last decade (Fernández-Fígares *et al.,* 2008). Betaine, the trimethyl derivative of the amino acid glycine, is a naturally occurring compound, which is widely distributed in many plants and animal tissues. It is present in large quantities in aquatic invertebrates and sugar beets, but also in wheat, wheat products and lucerne meal (Chendrimada *et al.,* 2002). Common sources of betaine are sugar beets and their by-products such as molasses and molasses soluble (Eklund *et al.,* 2005). As a feed additive, betaine is also available in purified form and most commonly added to animal diets in the form of condensed anhydrous betaine, betaine monohydrate and betaine hydrochloride (Eklund *et al.,* 2005). Betaine is stable and non-toxic (Yu *et al.,* 2004).

Due to its chemical structure, betaine has a number of different functions both at the gastrointestinal, metabolic level, growth, lactation, protein synthesis, and fat metabolism in animals (Eklund *et al.,* 2005). Betaine is involved in the synthesis of methylated compounds choline such as carnitine and reducing the requirement for other methyl donors such as creatine (Zhan *et al.,* 2006 and Eklund *et al.,* 2005). Consequently, betaine is used as a carcass modifier to increase the lean percent and decrease the fat percentage. Moreover, McDevitt *et al.,* (2000) showed higher levels of the methionine and cysteine by the additive betaine which is necessary for protein synthesis. Several studies have found that betaine could enhance carcass weight. For instance, Hassan *et al.* (2011) found that the hot carcass weights of rabbits were significantly (*P≤0.05*) increased with the increasing levels of betaine. In contrast, in steers Löest *et al.,* (2002) found that betaine did not affect the hot carcass weights.

Feeding betaine to lambs during the growing phase reduces subcutaneous fat thickness (Fernandez *et al.,* 1998). In contrast, in finishing steers, supplementing betaine increases subcutaneous fat thickness (Bock *et al.,* 2004). Furthermore, betaine is vital for fetal development (Lever and Slow, 2010). The objective of the present study was to assess the effects of feeding betaine on carcass characteristics of Ossimi rams.

MATERIALS AND METHODS

The experiment was conducted at the Animal Experimental Farm, Animal Production Department, Faculty of Agriculture, Al-Azhar University Assiut Branch, Assiut, Egypt. The main objective of this study was to evaluate the impact of dietary betaine supplementation on carcass characteristics and intestine morphology of Ossimi male sheep under Upper Egypt conditions.

1. Animals and management

A total of eighteen Ossimi rams of about 40.63 kg body weight were used in this trial. The animals were assigned randomly to three treatment groups (CO, BET[1] and BET[2]). The control group (CO) was fed a BET free diet, while BET[1] and BET[2] treatment groups received 2.0

[*] Corresponding author.
E-mail address: muhtaram@azhar.edu.eg
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and 4.0 g BET/h/d. The body weights of rams were recorded biweekly until the end of the experiment. The animals were fed roughage and concentrated diet *ad libitum* during the experimental period. The concentrate diet has consisted of 45% yellow corn, 22% wheat bran, 15% decorticated cotton seeds, 14% soybean meal, 1% vitamin-minerals (Premix®), 1% limestone and 1% sodium chloride. The daily betaine dose was administered orally in gelatin capsules to BET[1] and BET[2] Ossimi rams group. Diets were offered twice daily at 09:00 am and 16:00 pm. Wheat straw was provided *ad libitum* for all experimental animals.

2. Slaughter and carcass characteristics

The experimental period lasted for 120 days. At the end of the experimental period, three animals from the experimental groups were slaughtered. The animals were left fasting for 12 hours prior to slaughter and the fasted body weight (FBW) was recorded. Average slaughter weights of the chosen rams were 49.00, 53.33 and 59.83 kg for control, BET[1] and BET[2] treated groups, respectively. The feet were separated and the animals were skinned with much care. The weight of the head, feet and pelt was recorded. The body cavity opened and the following organs were detached and weighed (liver, spleen, heart, lungs and trachea, digestive tract, kidneys, intestine, tail, fatting, gall bladder, reproductive system, heart fat, kidney and pelvic fat, gut and bowel fat).

The weight of empty body was calculated as the difference between the weight of the fasted body and gut contents. Dressing percentages and percentages of hot carcass to fasted body weight were calculated. The carcass was split carefully into two sides and weighed. The left side was divided into retail cuts and the weight of the tail, leg, sirloin, best neck, mid neck; fillet, neck, shoulder, brisket, flank and best rib were recorded. Samples of Eye muscle *Longissimus dorsi (LD), Semimembranosus (SM), Semitendinosus (ST), Biceps femoris, (BF) muscle and Supraspinatus, (SP*) muscle were taken for weight, length and circumference.

3. Physiological stomach components weight

The physiological weight of stomach components (reticule-rumen and omaso-abomasum) and the intestinal segments (Small intestine, cecum and colon-rectum) and gastro-intestinal tract weight (stomach and intestinal segment) were measured by the difference between the weight of each part when filled with its contents and its weight after emptying the contents.

4. Statistical analysis:

Data were tested using the GLM procedure published by SAS® (SAS Institute, Cary, NC, USA) (2007). For carcass characteristics (slaughter), one-way classification was used as the following model: $Y_{ij} = \mu + Ti + E_{ij}$, Where; Y_{ij}= the observation, μ= the general mean, T_i = the effect due to BET treatment and E_{ij}= the errors related to individual observation.

RESULTS AND DISCUSSION

1. Effect of Dietary betaine on carcass characteristics.

1 . Fasting (kg) and dressing (%) of slaughtered rams.

The results presented in Table 1 show that the BET2 group increased (P≤0.05) fasting and empty body weight compared with BET1and control groups. However, hot carcass and carcass weight without tail tended to be heavier in BET treated rams than controls. The present results are similar to those of Hassan et al., (2011) who found that the hot carcass weights of rabbits were significantly (P≤0.05) increased with the increasing levels of betaine. In contrast, with steers Löest et al. (2002) found that betaine did not affect the hot carcass weights. The increase in hot carcass may be related to the increase in fasting weight (Table 1). Highly significant (P≤0.01) effect for fasting weight on hot carcass was reported with lambs reported by Cameron and Drury (1985). Similar findings were reported also by Dahmen et al., (1985) and Attalah (1988).

In the present study, it seems likely that betaine supplementation to rams led to improve the dressing percentage compared with control groups (Table 1). These results are in agreement with those of Matthews *et al.,* (1998) who reported that dietary betaine (1.25 g/kg of diet) elevated (*P≤0.05*) the dressing percentage. With pigs, similar results were observed (Zheng *et al.,* 2001 and Wang and Huang, 2011) and rabbits (Hassan *et al.,* 2011). In addition, in steers, acute (7 days) dietary betaine supplementation did not alter hot carcass weight or marbling score (Bock *et al.,* 2004), while longer term dietary betaine supplementation in feedlot steers improved hot carcass weight (Löest *et al.,* 2002). On the other hand, other studies showed that betaine did not affect the dressing percentage. For example, Fernández *et al.* (2000) found that dietary betaine (2 g/kg of diet) did not affect the dressing percentage of lambs.

Table 1. Effect of dietary betaine supplementation on fasting (kg) and dressing (%) in carcass of growing Ossimi rams.

Items	Treatments			±SE	Sig
	CO	BET[1]	BET[2]		
Fasting body weight, kg	49.00 ^{b}	53.33 ^{ab}	59.83 ^{a}	2.18	*
Empty body weight, kg	47.17 ^{b}	52.00 ^{ab}	58.33 ^{a}	2.27	*
Hot carcass weight, kg	21.05	25.57	25.98	2.07	ns
Carcass weight without tail, kg	19.17	22.32	23.28	1.72	ns
Dressing,% (A) $^{\alpha}$	42.96	47.74	43.41	2.84	ns
Dressing without tail, %	38.14	41.68	39.92	2.28	ns
Dressing,% (B) $^{\beta}$	49.60	54.85	51.32	2.91	ns

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 = Rams fed on diet without betaine. BET[1] = Rams fed on 2 g /h/d. BET[2]= Rams fed on 4 g /h/d. $^{\alpha}$Dressing,% (A) =[(hot carcass weight/slaughter weight)*100]; $^{\beta}$Dressing,% (B)= [(hot carcass weight/slaughter weight – GIT content)*100]

2 . Carcass measurements (cm) and gastro-intestinal tract weight (kg) of slaughtered rams.

Table (2) presented the effect of dietary BET supplementation on carcass measurements (right and left) and gastro-intestinal tract weight of slaughtered rams. The data revealed that, carcass measurements were influenced significantly due to feeding experimental rams on diet containing BET in the diet of experimental rams. Supplementation of dietary BET[2] were significantly (*P≤0.05*) increased carcass external length and carcass circumference before cavity compared with BET[1] and control ones. On the other hand, carcass depth at 7th rib and carcass circumference after cavity tended to increase (*P>0.05*) by feeding rams on treated diets. Length of CRS and CLS elevated (*P≤0.05*), while the weight of CLS increased (*P≤0.05*) and circumference of CRS was higher

($P\leq0.05$) in BET¹ and BET² groups compared with a control group. The weight of CRS and circumference of CLS did not differ among treatments.

Table 2. Effect of dietary betaine supplementation on carcass measurements (cm) and gastro-intestinal tract weight (kg) of growing Ossimi rams carcass.

Items	Treatments			± SE	Sig
	CO	BET1	BET2		
Carcass measurements, cm					
Carcass external length	84.00 ^{b}	86.67^{b}	96.33^{a}	2.20	*
Carcass depth at 7th rib, cm	27.00	28.33	30.00	1.22	ns
Carcass circumference before cavity	86.00 ^{b}	86.67 ^{b}	94.67^{a}	2.15	*
Carcass circumference after cavity	76.00	80.00	81.00	2.75	ns
Carcass right side measurements (CRS)					
CRS weight, kg	8.67	10.62	10.71	0.88	ns
CRS length, cm	80.00^{b}	87.63^{a}	94.67^{a}	2.86	*
CRS circumference, cm	59.67 ^{b}	72.00 ^{a}	75.67 ^{a}	3.79	*
Carcass left side measurements (CLS)					
CLS weight, kg	9.85^{b}	10.82^{a}	11.54^{a}	0.62	*
CLS length, cm	77.00^{b}	86.33^{a}	93.67^{a}	3.37	*
CLS circumference, cm	58.00	61.50	65.00	3.40	ns
Gastro-intestinal tract weight, kg (GIT)					
GIT full, kg	9.27^{b}	9.72^{ab}	12.67^{a}	0.92	*
GIT empty, kg	2.77	2.73	3.43	0.22	ns
Rumen full weight, kg	6.69	7.02	9.31	0.79	ns
Rumen empty weight, kg	1.33	1.14	1.43	0.12	ns
Intestine full weight, kg	2.58	2.70	3.36	0.26	ns
Intestine empty weight, kg	1.47	1.59	1.99	0.17	ns
Physiological weight					
For GIT , kg	6.20^{b}	6.99^{ab}	9.24^{a}	0.77	*
For rumen, kg	5.36	5.88	7.88	0.69	ns
Intestinal segment, kg	1.11	1.11	1.37	0.20	ns
Gall bladder (g)	33.33^{a}	2 3.33^{b}	23.33^{b}	2.82	*

**Each value represents an average of 3 samples. ^{a,b}, means at the row with different superscript are significantly (P≤0.05) different. SEM = Standard error mean. CO = Rams fed on diet without betaine BET¹ = Rams fed on 2 g BET/h/d.
BET² = Rams fed on 4 g BET/h/d.**

These results are more close to those of DiGiacomo *et al.* (2014) who reported in feedlot steers that carcass weight at slaughter tended towards being increased by dietary betaine. Siljander-Rasi *et al.*, (2003) found that dietary betaine (250, 500 or 1000 mg/kg of diet) significantly ($P\leq0.01$) increased the carcass weight but did not influence slaughter loss proportions.

The increase in carcass weight of BET fed rams might be due to the reduction of some edible offal's weight of carcass components than control rams (Table 3). Such improvements in carcass components might be due to the increase of both daily gain and body weight of BET-treated rams (Abd-Allah and Daghash, 2019). Results of Table (2). Show that BET supplementation did not have a significant effect on gastrointestinal tract (GIT) weight and physiological weights of rams except full GIT which significantly ($P\leq0.05$) increased in BET² group compared with BET¹ and control groups. In this field, full rumen was higher ($P\leq0.05$) in BET² than BET¹ and control ones, while weight of gall bladder was lower ($P\leq0.05$) in rams treated with betaine supplementation which compared with control group. These results are in agreement with those reported by Daghash, (2015) who indicated that the physiological volume of rumen was higher, while the weight of gall bladder was lower significantly ($P\leq0.05$) in rams treated with prebiotic supplementation compared with control group.

3 . Edible and non-edible parts of slaughtered rams.

The effects of BET treatments on edible and non-edible parts of slaughtered rams are summarized in Table 3. Dietary BET² in rams' diet caused a significant increase in weights of liver and sex organs than in BET¹ and control diet, while the overall means of heart, kidney, spleen, and heart fat did not differ significantly due to feeding on BET in the diet. In the present study, BET supplementation did not have a significant effect on feet and pelt weight, except head and lungs plus trachea which significantly ($P\leq0.05$) increased in BET treated rams.

Table 3. Effect of dietary betaine supplementation on edible and non-edible offal's of growing Ossimi rams carcass.

Items	Treatments			± SE	Sig
	CO	BET¹	BET²		
Edible offal's weight					
Liver (g)	520.0^{b}	560.0^{b}	656.7^{a}	24.50	*
Heart(g)	180.0	180.0	196.7	10.37	ns
Kidney weight, (g)	100.0	100.0	110.0	4.71	ns
Spleen (g)	56.67	66.67	66.50	4.71	ns
Tail fat (kg)	3.25^{a}	2.88^{b}	2.69^{b}	0.51	*
Sex organs (g)	336.7^{b}	446.7^{ab}	530.0^{a}	29.11	*
heart fat (g)	60.00	55.00	50.00	10.16	ns
kidney fat (g)	186.7^{a}	141.7^{b}	120.0^{b}	07.42	*
Bowel fat (g)	1.68^{a}	1.27^{b}	1.18^{b}	0.127	*
Non edible offal's weight					
Head weight, kg	2.93 ^{b}	3.40 ^{ab}	4.27 ^{a}	0.364	*
Feet weight, kg	1.44	1.33	1.27	0.069	ns
Pelt (Skin) weight, kg	4.95	5.76	5.74	0.532	ns
Lung and trachea weight, g	626.7^{b}	710.0^{a}	703.3^{a}	23.83	*

**Each value represents an average of 3 samples. ^{a,b}, means at the row with different superscript are significantly (P≤0.05) different.
SEM = Standard error mean. CO = Rams fed on diet without betaine.
BET¹ = Rams fed on 2 g BET/h/d.
BET² = Rams fed on 4 g BET/h/d.**

The present results are similar to those of Fernández-Fígares *et al.* (2002) who showed that dietary betaine (1.25, 2.5, or 5 g/kg of diet) offered to feed tended to reduce viscera weight and small intestine weight. However, the weights of the large intestine, stomach, gall bladder, spleen, liver, kidney, and heart were not affected by dietary betaine with pigs. In another study on rabbits, Hassan *et al.* (2011) found that the kidney weight was significantly ($P\leq0.05$) increased with the increasing betaine levels. However, the weights of the heart, liver, and lungs were not affected by dietary betaine. The heavier of such parts of edible carcass in the present study (Table 3) may be related to dietary BET which increased concentration intake, where it was referred to in another part of this study (Abd-Allah and Daghash, 2019). High concentrate intake increases the energy supply for protein synthesis/growth and May increases serum glucose concentration and consequently, increase insulin concentration (Hadly, 1984). Insulin increased both number and size of cells (Gardner and Kaye, 1991). Murray and Slezacek (1980) illustrated that lambs fed a high plan of nutrition had greater weights of liver, kidney, pelts than similarly fed a low plane of nutrition. In addition, thyroid hormones, which increase due to fed BET (Abd-Allah and Daghash, 2019) accelerated cellular reactions in most organs and tissues of the body, including the liver where these proteins are formed (Smith *et al*., 1983).

It is interesting to observe from the present study the reduction of carcass fats (tail fat, Kidney and bowel fat) in animals fed on BET diets (Table 3). Many studies on the effect of betaine have been conducted on carcass fat weight. In sheep, Fernández *et al.* (1998) showed that dietary betaine decreased the subcutaneous fat of lamb carcass by 11%, suggesting that betaine inhibits the accumulation of extra muscular fat. Cadogan *et al,* (1993) showed 14.8% decrease in backfat thickness in finishing pigs fed 1250 mg/kg dietary betaine. Furthermore, Wang *et al.*, (2000) found that betaine (1g/kg of diet) reduced ($P \leq 0.01$) the dissected fat by 18.27% compared with the control group. In addition, Ma *et al.* (2000) working on pigs, found that betaine reduced fat ratio and mean backfat by 16.62% ($P \leq 0.01$) and 16.19% ($P \leq 0.05$), respectively, compared with control group.

4 . Testicular morphology of rams.

The effects of dietary supplementation of BET on gross morphology of right and left rams testicles are shown in Table 4. Weight of right side testicle (191.3 *vs*. 159.9 and 119.1 g, $P \leq 0.05$), circumference (18.79 *vs.* 16.39 and 12.67 cm, $P \leq 0.05$) and volume (190.8 *vs*. 167.5 and 130.8 cm^3, $P \leq 0.05$) increased in BET^2 as compared to BET^1 and CO ones. On the other side, weight of the left side of testicle (194.2 and 159.5 *vs* 115.7 g, $P \leq 0.05$), circumference (18.79 *vs* 16.39 and 12.67 cm, $P \leq 0.05$) and volume (188.3 and 156.3 *vs* 115.0 cm^3, $P \leq 0.05$) increased in BET^1 and BET^2 as compared to CO ones. The length of the right and the left side of the testicle were not affected due to feeding on betaine.

Table 4. Effect of dietary betaine supplementation on testicular morphology of growing Ossimi rams.

Items	Treatments			± SE	Sig
	CO	BET^1	BET^2		
Testis right side measurements (cm) (TRS)					
TRS weight, g	119.1^b	159.9^{ab}	191.3^a	12.98	*
TRS length, cm	12.17	14.16	16.29	1.42	ns
TRS circumference, cm	12.67^b	16.39^{ab}	18.79^a	1.48	*
TRS volume, cm3	130.8^b	167.5^{ab}	190.8^a	15.86	*
Testis left side measurements (cm) (TlS)					
TLS weight, g	115.7^b	159.5^a	194.2^a	11.82	*
TLS length, cm	12.12	15.41	17.32	1.52	ns
TLS circumference, cm	12.67^b	16.39^{ab}	18.79^a	1.48	*
TLS volume, cm3	115.0^b	156.3^a	188.3^a	11.89	*

Each value represents an average of 6 samples. ^{a,b}, means at the row with different superscript are significantly ($P \leq 0.05$) different. SEM = Standard error mean . CO = Rams fed on diet without betaine BET^1 = Rams fed on 2 g BET/h/d. BET^2 = Rams fed on 4 g BET/h/d.

The effects of dietary supplementation of BET on gross morphology of right and left rams' testicles are shown in Table 4. Weight of right side testicle (191.3 *vs*. 159.9 and 119.1 g, $P \leq 0.05$), circumference (18.79 *vs.* 16.39 and 12.67 cm, $P \leq 0.05$) and volume (190.8 *vs*. 167.5 and 130.8 cm^3, $P \leq 0.05$) increased in BET^2 as compared to BET^1 and CO ones. On the other side, weight of the left side of testicle (194.2 and 159.5 *vs*. 115.7 g, $P \leq 0.05$), circumference (18.79 *vs*. 16.39 and 12.67 cm, $P \leq 0.05$) and volume (188.3 and 156.3 *vs.* 115.0 cm^3, $P \leq 0.05$) increased in BET^1 and BET^2 as compared to CO one. The length of the right and the left side of the testicle were not affected due to feeding on betaine.

The morphometric study of the testis is crucial to evaluate the qualitative distinctions in testicular machinery and its functions. The utilization of males with superior testicular development and consequently with high fecundation capability is significant to ensure the good reproductive competence of the flock. There is no available data on the effects of dietary BET on testicular morphology of rams. But there is an indirect effect only through the role of betaine as an antioxidant effect. He *et al,* (2015) illustrated that, plant-derived antioxidants such as betaine were widely used as feed additives to enhance body function. Furthermore, research showed that there was a positive association between the testicular weight, testicular diameter and circumference (Oyeyemi *et al.*, 2012). Thus, due to the improved weight of testicles, the thickness of testicles also improves along with its circumference. Hence, BET supplementation improved the gross morphological parameters of testicles.

2. Effect of dietary betaine on the composition of the wholesale side:

Results in Table (5) show that rams supplemented with BET^2 rams had higher ($P \leq 0.05$) weight and length of leg by about 16% and 35.86 %, respectively than control ones. In the same context, weights of the shoulder, fore shank (1-6 ribs) and breast (7-12 ribs) were heavier ($P \leq 0.05$) in BET^2 group than BET^1 and control groups. In the present study, it seems likely that betaine supplementation of rams led to increase significantly ($P \leq 0.05$) weights of 9, 10 and 11 ribs cut and muscle compared with rams of control group. Furthermore, feeding rams with betaine at levels of 2 g and 4 g/ kg diet reduced ($P \leq 0.05$) weights of fat and bone compared with group treatment. The data from the present experiment indicate some interesting carcass and meat quality responses to dietary betaine. In the same context, Dong *et al.* (2019) reported that the meat quality in growing lambs improved as a result of betaine supplementation. Yu *et al,* (2004) illustrated that the 1,000 mg/kg betaine treated group significantly reduced carcass fat proportion and fat depth by 27.21% ($P \leq 0.05$) and 14.86% ($P \leq 0.05$), respectively with growing pigs compared to the control group.

Table 5. Effect of dietary betaine supplementation on composition of wholesale side of growing Ossimi rams carcass.

Items	Treatments			± SE	Sig
	CO	BET^1	BET^2		
Wholesale cut weights, kg					
Leg weight, kg	3.55^b	3.70^{ab}	4.12^a	0.49	ns
Leg length, cm	28.50^b	33.00^{ab}	38.67^a	1.55	*
Leg circumference, cm	34.33	35.67	36.00	1.62	ns
Shoulder weight, (kg)	2.29^b	2.58^b	3.69^a	0.35	ns
Fore shank (1-6 ribs) weight, kg	1.36^b	1.37^b	1.90^a	0.08	*
Breast (7-12 ribs) weight, kg	1.37^b	1.44^b	1.72^a	0.07	*
9,10 and 11^{th} ribs cut					
9,10 and 11 ribs cut weight, (g)	466.7^b	600.0^a	633.3^a	24.44	*
Muscle weight (g)	226.7^b	303.3^a	296.7^a	16.47	*
Fat weight (g)	243.1^a	176.7^b	196.7^b	18.87	*
Bone weight(g)	100.0^a	66.67^b	76.67^b	7.01	*

Each value represents an average of 3 samples. ^{a,b}, means at the row with different superscript are significantly ($P \leq 0.05$) different.
SEM = Standard error mean. CO = Rams fed on diet without betaine
BET^1 = Rams fed on 2 g BET/h/d..
BET^2 = Rams fed on 4 g BET/h/d. BET/h/d.

The increase in the wholesale side may be related to the increase of fasting weight (Table 1). Similar findings were also reported by Dahmen *et al.,* (1985) with Suffolk versus Lincolin rams and Attalah (1988) with crossbred lambs. In addition, the increase in carcass components of BET-fed rams might be due to the increase in both daily gain and body weight of BET-treated rams as reported by Abd-Allah and Daghash, (2019). Gravert and Rosenhaha, (1965) showed that as the daily gain increased the percentage of muscle tissues increased. Betaine is often considered a carcass modifier due to methyl group donor property, which causes a higher availability of methionine and cysteine for protein deposition, thus contributing to improving the carcass lean percentage (Yang *et al.,* 2016). Rao *et al*., (2011) and Zhan *et al*., (2006) reported that dietary betaine supplementation enhanced the breast muscle yield of male broiler chickens.

3. Effect of dietary betaine supplementation on individual carcass muscles weight:

Betaine effect on individual muscle weights is shown in Table (6). All Individual skeletal muscle measurements (weight, length and circumference) were higher in rams fed on BET than control rams. Weight of Longissimus *Doris* (LD) and *Supraspinatus* (SP) muscles were higher ($P\leq0.5$) in rams fed on BET^2 than rams fed on BET^1 and control diets. While, there are a significant increase ($P\leq0.5$) in the weight of *Semimembranosus* (SM), *Semitendinosus* (ST) and *Biceps Femoris* muscle (BF) for BET^1 and BET^2 treated rams compared to the control one. Dietary BET^2 in rams' diet caused a significant increase ($P\leq0.05$) in the length of (ST), (BF) and (SP) muscles compared with rams fed on BET^1 and control ones. Circumference of all individual muscles did not differ significantly due to fed on betaine.

Table 6. Effect of dietary betaine supplementation on individual muscles weight of growing rams carcass components

Items	CTR	BET^1	BET^2	± SE	Sig
Carcass muscles					
Eye muscle (Longissimus dorsi),(LD) muscle					
LD weight, (g)	653.3^b	666.7^b	726.7^a	22.95	*
LD length, cm	62.33	56.00	60.67	1.96	ns
LD circumference, cm	12.33	12.00	12.67	0.92	ns
Semimembranosus,(SM) muscle					
SM weight, (g).	263.3^c	383.3^b	470.0^a	12.64	*
SM length, cm	13.33	15.33	18.33	1.56	ns
SM circumference, cm	19.67	20.00	22.00	1.27	ns
Semitendinosus, (ST) muscle					
ST weight, (g).	113.3^c	146.7^b	213.3^a	10.37	*
ST length, cm	14.33^b	15.67^b	17.67^a	0.47	*
ST circumference, cm	10.83	13.33	11.33	0.93	ns
Biceps femoris, (BF) muscle					
BF weight, (g).	253.3^b	336.7^a	360.0^a	9.69	*
BF length, cm	21.00^b	22.67^{ab}	25.00^a	1.85	*
BF circumference, cm	14.33	14.67	14.67	1.29	ns
Supraspinatus,(SP) muscle					
SP weight, (g).	176.7^b	183.3^b	236.7^a	10.00	*
SP length, cm	18.00^b	20.33^{ab}	21.33^a	0.37	*
SP circumference, cm	11.67	12.33	12.33	0.94	ns

Each value represents an average of 3 samples. ^{a,b}, means at the row with different superscript are significantly ($P\leq0.05$) different. SEM = Standard error mean . CO = Rams fed on diet without betaine BET^1 = Rams fed on 2 g BET/h/d.. BET^2 = Rams fed on 4 g BET/h/d.

Dong *et al.,* (2019) *i*llustrated that with increasing BET doses in the diets, the eye muscle area of the lambs linearly increased ($P\leq0.05$). Yu *et al.,* (2004) illustrated that the 1,000 mg/kg betaine treated group significantly elevated carcass lean proportion by 7.49% ($P\leq0.05$) and longissimus muscle area by 19.12% ($P\leq0.05$), respectively compared to the control group. Gravert and Rosenhaha, (1965) with beef cattle, showed that as the daily gain increased the percentage of muscle tissue increased. It was hypothesized that a decrease in intestinal pathogen challenge provided by betaine supplementation would result in improvements in nutrient utilization and allocation leading to benefits in lean muscle gain and dressing percentage (Ferket, 2004).

The different responses between tested muscles for muscle weight may be due to the fiber type of muscle. Yang and McElligott (1989) noted from histochemical observations that the anabolic effect may be specific to certain fiber types. Muscles are composed of various ratio of type I (slow- contracting, oxidative) and type II (fast-contracting, mixed glucolytic/oxidative) fibers. In addition, the increase of muscle weight was due to hypertrophic model of BET induced muscle growth in addition to the increase in protein content (Newbold *et al.,* 1997). There is no available data on the effects of dietary BET on the composition of skeletal muscles (LD, SM, ST, BF and SP), but there are indirect effect only through the effect of thyroid hormones on composition of muscles, whereas dietary supplementations of BET increased (*P≤0.05*) triiodothyronine (T_3) concentration in rams as reported by Abd-Allah and Daghash (2019). Thyroid hormones are associated with protein synthesis and degradation. Cullen and Oace (1976) stated that "thyroid hormones have a biphasic effect on protein synthesis, at normal physiological levels as it increase the rate of protein synthesis but higher levels lead to the breakdown of protein". Diamant *et al.,* (1972) showed that the thyroid hormone increased enzyme activities associated with both fatty acid synthesis and degradation.

4. Effect of dietary betaine supplementation on chemical composition of individual muscles weight (g) in growing rams:

There is no data upon the chemical composition of individual muscles of ruminants fed BET supplementation, especially sheep. Table 7 shows the results of the chemical analysis of longissimus Dorsi (LD), leg and shoulder muscles. The data revealed that there were no significant differences among treatments on the chemical composition of tested muscles. But the protein percentage tended to be higher, while the fat percentage tended to be lower in rams fed on BET than control ones. Reduced fat content in BET treated rams might be a reflection of the low level of fat percentage as shown in Table 3. The increase in the protein content in experimental muscles might be related to the increase of thyroid hormones and feed intake of BET - treated rams (Abd-Allah and Daghash, 2019). Hubbard *et al.,* (1986) reported that thyroid hormone led to increase the rate of protein synthesis.

Daghash, (2015) showed that treated rams with prebiotic supplementation tended to be higher in protein percentage while the fat percentage was lower in LD muscle than control rams. In addition, Abd-Allah and Abdel-Raheem, (2012) found in growing Japanese quails that the meat chemical composition of birds fed a diet supplemented with prebiotic had numerically higher crude protein and lower average fat percentages compared to control ones. In the other side, Yu *et al.* (2004) reported that the 1,000 mg/kg betaine treated group significantly elevated the content of ether extract in *longissimus dorsi* by 34.21% ($P \leq 0.01$) compared to the control group.

Table 7. Effect of dietary betaine supplementation on chemical analysis of individual muscles in carcass of growing rams.

Items	CO	BET[1]	BET[2]	± SE	Sig
		Longissimus Dorsi muscle			
Moisture	68.78	68.87	68.73	0.38	ns
Protein	18.22	18.93	19.20	0.33	ns
EE	8.00	7.34	7.48	0.23	ns
Ash	1.35	1.31	1.39	0.06	ns
		Leg muscles			
Moisture	71.20	70.21	70.37	0.38	ns
Protein	19.81	20.17	19.99	0.33	ns
EE	6.49	6.42	6.39	0.23	ns
Ash	1.37	1.46	1.48	0.06	ns
		Shoulder muscles			
Moisture	69.10	69.44	69.49	0.38	ns
Protein	19.14	19.22	19.85	0.33	ns
EE	6.93	6.39	6.78	0.23	ns
Ash	1.39	1.31	1.42	0.06	ns

CO = Rams fed on diet without betaine .
BET[1] = Rams fed on 2 g BET/h/d. BET[2] = Rams fed on 4 g BET/h/d.

CONCLUSION

Sheep feeders become more conscious of dressing percentage when grade and yield marketing is practiced because payment is based on carcass weight, rather than live body weight. Consequently, any practice that increases the dressing percentage and increases carcass weight would benefit producers. In the same context, previous results revealed that dietary betaine may improve carcass characteristics and can promote testicular development which reflects a positive effect on the reproductive performance of growing rams.

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تأثير إضافة البيتائين للحملان الأوسيمى على: (ب) خصائص الذبيحة

محترم عبدالله محمد ابراهيم[١] و محمد وائل حسن دغش[٢]

[١] قسم الانتاج الحيواني - كلية الزراعة - جامعة الأزهر فرع أسيوط

[٢] قسم الانتاج الحيواني - كلية الزراعة - جامعة أسيوط

أجريت هذه الدراسة بمزرعة قسم الانتاج الحيواني التابعة لكلية الزراعة جامعة الازهر فرع اسيوط بهدف تقييم تأثير إضافة البيتائين كمكمل غذائي على خصائص الذبيحة ومورفولوجيا الامعاء للحملان الأوسيمى، حيث تم استخدام عدد ثمانية عشر من الحملان الأوسيمي بمتوسط وزن جسم ٤٠,٦٣ كجم في هذه التجربة. قسمت الحملان عشوائيا الى ثلاث مجاميع الاولى مجموعة الكنترول غذيت على عليقة خالية من البيتائين (CO)، بينما المجموعة الثانية BET1 والثالثة BET^2 أعطيت بيتائين بمعدل ٢جم/راس/يوم، و٤ جم بيتائين/راس/يوم على التوالي حيث استمرت التجربة لمدة ١٢٠ يوم من بداية يوليو وحتى نهاية نوفمبر لعام ٢٠١٩ م. في نهاية التجربة تم ذبح ٣ كباش من كل مجموعة. أظهرت النتائج أن هناك زيادة معنوية ($P\leq0.05$) في وزن الجسم الصائم والفارغ فى المجموعة الثالثة BET^2 مقارنة مع المجموعة الثانية BET^1 ومجموعة الكنترول. لوحظ أن هناك زيادة فى وزن الذبيحة ووزن الذبيحة بدون الذيل في المجموعات المعاملة بالبيتائين مقارنة بمجموعة الكنترول، أيضا لوحظ أن المعاملة بالبيتائين تحسن من نسبة التصافى كما تأثرت مقاييس الذبيحة معنويا بسبب التغذية على البيتائين. حدثت زيادة معنوية ($P\leq0.05$) في أوزان الكبد والاعضاء التناسلية ودهن الذبيحة فى كباش المجموعة التي اعطيت ٤ جم بيتائين/راس/يوم BET^2 مقارنة مع المجموعة الثانية BET^1ومجموعة الكنترول. حيث تسببت المعاملة بالبيتائين فى خفض نسبة دهون الذبيحة (دهن الذيل، الكليتين و دهن الامعاء) مقارنة بمجموعة الكنترول. كانت هناك زيادة معنوية ($P\leq0.05$) فى وزن وطول ومحيط وحجم الخصية فى المجموعات المعاملة عن مجموعة الكنترول. وزن وطول الفخذ كان أعلى معنويا ($P\leq0.05$) فى المجموعات المعاملة مقارنة بالكنترول بينما أوزان الكتف والأضلاع من ١-٦ (Foreshank) والضلع من ٧-١٢(Breast) كانت أعلى فى المجموعة الثالثة عن كلا من المجموعة الثانية ومجموعة الكنترول. كانت هناك زيادة معنوية ($P\leq0.05$) فى أوزان العضلات والضلوع ٩،١٠ و١١ فى المجموعات المعاملة بالبيتائين مقارنة بمجموعة الكنترول علاوة على إنخفاض أوزان الدهون والعظام فى تلك الضلوع. جميع القياسات التى سجلت على العضلات المهمة للذبيحة (الوزن،الطول والمحيط) كانت أعلى فى الحملان المعاملة بالبيتائين مقارنة مع مجموعة الكنترول، بينما لم توجد أى إختلافات معنوية فى التركيب الكيماوى لتلك العضلات بالرغم من وجود إرتفاع طفيف فى نسبة البروتين وإنخفاض نسبة الدهون فى المجموعات المعاملة بالبيتائين. في الختام يمكن استخلاص أن، مكملات البيتائين قد تحسن من خصائص الذبيحة وتعزز من تطور الخصية مما يعكس تأثيرًا إيجابيًا على الأداء الإنتاجي والتناسلي للكباش المعاملة بالبيتائين.