Egyptian J. Anim. Prod. 35, Suppl. Issue, Dec. (1998):561-574.

EFFECT OF CLENBUTEROL ON: I- GROWTH PERFORMANCE AND SOME CARCASS CHARACTERISTICS IN LAMBS

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SUMMARY

Eight wether Japanese Corriadale lambs with average weight of 36 kg were assigned at random to receive either 0 (control) or 80 µg clenbuterol /kg body weight/day to investigate the effects of long term (eight weeks) administration of clenbuterol on growth rate, feed efficiency and carcass characteristics. All lambs were fed high concentrate diet *ad libitum* for eight weeks.

Average daily gain was significantly higher by 65% during the first two weeks but was not significantly affected thereafter. Feed/ gain ratios were reduced significantly by 48.3% and 32.3% at two and four weeks of treatment, respectively and tended to be close to the control level thereafter. Clenbuterol administration increased significantly cold carcasses weight by 20.5 %, dressing percentage by 12.4%, leg thickness by 24%, lean percentage by 12.0, muscle/fat ratio by 43.4 % and muscle/bone ratio by 24%, respectively. The treatment reduced fat percentage by 21.3% and bone percentage by 9.9%.

Keywords: Lambs, clenbuterol, daily gain, efficiency, carcass

INTRODUCTION

Growth rate and feed efficiency have been recognized as important parameters of efficiency in meat animals. Carcass composition has become more important in recent times as consumers demand for leaner meat has increased, in response to concern about health and fitness in general.

The effects of β-agonist (clenbuterol or cimaterol) on growth performance and carcass characteristics are variable and depend on the type and dose of b-agonist, length of administration, age, species, breed, sex and diet.The present study was designed to investigate the effects of clenbuterol administration for long-term (8 weeks) on growth performance, feed efficiency and carcass characteristics in lambs.

MATERIAL AND METHODS

Animals and experimental design: This experiment was carried out at the Animal Experimental Farm, Animal Science Deartment, Faculty of Agriculture, Kyoto University, Japan. Eight wether Japanese Corriadale lambs with an average weight (BW) of 36 kg (6 months old) were randomly assigned to two treatment groups, control and clenbuterol groups. Lambs were individually housed in metabolic crates. All lambs were fed *ad libitum* a high concentrate diet (Table 1) containing 120 g crude protein / kg diet for 8 weeks. Every morning feed residue was weighed and subtracted from the amount offered to calculate the actual feed intake. Clenbuterol group was given orally 80 µg clenbuterol [benzyl alcohol, 4-Amino-α-(t-butylamino) methyl-3,5- dichloro] /kg BW / day in gelatin capsules with glucose.

Table 1. Constituents of feed mixture

Ingredient	%
Timothy hay	22.0
Corn	37.0
Barley grain	15.7
Wheat bran	15.0
Soybean meal	9.0
$CaCo_3$	0.8
NaCL	0.5

Growth performance: Animals were weighed at the beginning of the experiment and biweekly thereafter. Weights were recorded in the morning before feeding. Feed consumption was measured through the experimental period and live weight gain and feed conversion were calculated.

Slaughter technique: At the end of the experimental period (8 weeks) all animals were slaughtered. Animals were left fasting for 12 hours prior to slaughtrer and fasted body weight (FBW) was estimated. The weight of empty body (EBW) was calculated as the difference between the weight of the fasted body and gut contents. Immediately after the animal being dressed, the carcass was weighted, hot carcass weight (HCW) and stored in the chilling room at 2°C

Carcass measurements: After 24 hours of cooling, the carcass was re-weighted "chilled carcass weight" (CCW) and halved into right and left sides. The two halves were weighted. Carcass measurements are shown in (Table 2)

Table 2. Carcass measurements

Measurements and definition
1- Dorsal length of carcass (DLC): taken from the 1st thoracic vertebra to the end sacrum.
2- Leg thickness (LT): depth of meat from inner to outer side of carcass at the upper angle of the triangle with the pubic as a base.
3- Depth of chest (DC): horizontal distance from top of the spinal column just behind shoulder blade to the ventral line of the carcass.

The right side was separated into commercial joints (neck, shoulder, brisket, bestend, breast, loin, flank and leg) according to the methods of Brown and Williams (1979). Each joint was dissected into lean tissue, fat, including nervous tissue and blood vessels, and bone including associated connective tissue, as described by Sulieman *et al.* (1986).

Statistical analysis: The data were analyzed using Student's t- test of Statistical Analysis System (SAS, 1988).

RESULTS

Growth performance: Live weight and daily feed intake were not significantly affected by clenbuterol treatment throughout the experiment (Table 3). Total weight gain or average daily gain was significantly higher after 2 weeks of treatment (357 vs. 216 g/d, $P < 0.05$) and remained high at 4, 6 and 8 weeks but the differences were not statistically significant.. Feed/gain ratio was significantly reduced by 48.3% ($P < 0.01$) and 32.3% ($P < 0.05$) by clenbuterol administration during the first and second two weeks of treatment, respectively and tended to close to control level thereafter.

Table 3. Effect of clenbuterol treatment on live weight, gain , feed intake and efficiency of gain in lambs (mean ± SE)

Trait	Weeks of clenbuterol administration			
	0 - 2	2 - 4	4 - 6	6 - 8
Live weight[1], kg				
Control group	36.00±2.16	39.05±1.81	41.60±1.78	43.50±2.07
Clenbuterol group	35.55±2.35	40.55±2.36	44.92±2.46	46.65±2.27
Total gain, kg				
Control group	3.05± 0.76	2.55±0.39	1.90±0.37	1.95±0.42
Clenbuterol group	5.00 ±0.57*	3.50±0.25	2.60±0.26	2.13±0.30
Average daily gain, g				
Control group	216±27	182±25	136±26	139±30
Clenbuterol group	357±41*	250±18	186±18	152±21
Feed intake, kg/d				
Control group	1.70±0.11	1.58±0.08	1.38±0.09	1.26±0.08
Clenbuterol group	1.47±0.10	1.54±0.02	1.51±0.06	1.34±0.09
Feed:gain ratio, kg/kg				
Control group	8.16±1.16	9.22±1.29	11.21±1.87	9.77±1.19
Clenbuterol group	4.22±0.33*	6.24±0.45*	8.35±0.82	9.20±1.01

[1] Initial weights of each period ; live weight of 8 weeks for control group was 45.45 ± 2.28 kg and for clenbuterol group was 48.78 ± 2.41 kg

* P <0.05

Offal components: Clenbuterol administration did not have significant effect on fasted body weight, empty body weight, head, skin, feet, stomach, lungs plus trachea and intestine weights, but fasted body weight and empty body weight were numerically higher in the clenbuterol lambs than in control lambs (Table 4).

When weights of non edible parts were related to fasted body weight, no significant differences were obtained between clenbuterol and control lambs for head, skin, feet and intestine. But, stomach percentage was significantly lower (2.51 vs 2.86, P <0.05) in clenbuterol lambs group than in control one (Table 4).

The effects of clenbuterol treatment on weights and percentages of liver, heart, kidney, kidney and pelvic fat and gut fat are presented in Table (5). Although, the weights of liver, heart, kidney, kidney and pelvic fat and gut fat were lower in lambs fed clenbuterol than control lambs, still, the difference was not statistically significant. Liver and heart as percentage of live body weight differed significantly (P<0.05) between the two treatment. The clenbuterol-fed lambs had significantly lower liver and heart percentage than control lambs (1.40 and 0.37 vs 1.67 and 0.43, respectively).

Table 4. Effect of clenbuterol treatment on fasted body weight ((FBW), empty body weight and non edible parts in lambs (mean ± SE)

Trait	Control	Clenbuterol
Fasted body weight, kg	43.28±3.00	45.80±2.04
Empty body weight, kg	37.26±2.24	40.72±1.47
Head weight, kg	2.58±0.25	2.68±0.10
Skin weight, kg	7.68±0.58	7.35±0.15
Feet weight, kg	1.14±0.01	1.06±0.10
Stomach weight, kg	1.21±0.06	1:16±0.06
Lungs and trachea, kg	0.51±0.04	0.48±0.02
Intestine weight, kg	0.95±0.09	0.89±0.06
Non edible parts as% of FBW		
Head %	5.99±0.50	5.89±0.46
Skin %	17.87±1.32	16.16±0.87
Feet %	7.67±0.58	7.33±0.15
Stomach %	2.86±0.18	2.51±0.05*
Lungs and trachea %	1.21±0.19	1.06±0.04
Intestine %	2.18±0.07	1.95±0.13

* P <0.05

Table 5. Effect of clenbuterol treatment on edible parts weight and percentage in lambs (means ± SE)

Trait	Control	Clenbuterol
Liver weight, g	717.00±37.30	644.50±51.83
Heart weight, g	183.75±7.87	170.00±10.14
Kidney weight, g	111:25±6.46	106.25±8.42
Kidney and pelvic fat, g	554.00±91.00	517.00±97.00
Gut fat weight, kg	1.21±0.31	1.09±0.18
Edible parts as% of FBW:		
Liver %	1.67±0.05	1.40±0.07*
Heart %	0.43±0.02	0.37±0.01*
Kidney %	0.26±0.02	0.23±0.01
Kidney and pelvic fat %	1.32±0.27	1.15±0.24
Gut fat %	2.82±0.68	2.42±0.44

* P <0.05

Carcass characteristics: Carcasses of lambs fed clenbuterol were significantly heavier by 19.2% ($P<0.05$) than those of control lambs(Table 6). Also, clenbuterol administration significantly improved ($P<0.01$) dressing percentage by 12.4% (53.8 vs 47.8). However, clenbuterol treatment had no significant effect on shrinkage percentage

Dorsal length of carcass and depth of chest did not differ significantly between treated and control lambs. Leg thickness was significantly higher by 24%.in lambs fed clenbuterol than in control ones (Table 6).

Carcass components : Right carcass side weights of treated lambs were heavier ($P<0.05$) than control lambs (Table 7) and those were confirmed by significant ($P<0.05$) increase in muscle weight in treated lambs compared with control lambs (7.4 vs 5.5 kg). Clenbuterol treatment reduced fat weight by 5.1%, although this effect was not statistically significant.

Table 6. Effect of clenbuterol treatment on carcass characteristics in lambs (mean ± SE)

Trait	Control	Clenbuterol	% Change
Hot carcass weight, kg	20.64±1.32	24.61±1.09*	+19.23
Cold carcass weight, kg	19.70±1.16	23.75±1.10*	+20.50
Dressing percentage	47.84±1.52	53.75±.33**	+12.35
shrinkage percentage	4.45±1.01	3.54±0.51	-20.45
Carcass measurements (cm)			
Dorsal length of carcass	46.00±0.58	47.08±4.46	+2.35
Leg thickness	6.92±0.25	8.58±.0.59*	+23.99
Depth of chest	26.47±1.00	26.18±2.04	-1.10

* $P<0.05$; ** $P<0.01$

Treatment with clenbuterol influenced all carcass components percentages. Lambs fed clenbuterol had higher lean percentage (63.6 vs 56.8%,$P<0.05$) and lower both fat percentage (19.2 vs 24.4%, $P<0.01$) and bone percentage (16.3 vs 18.1%, $P<0.05$) than control lambs (Table 7). Furthermore, clenbuterol treatment increased muscle /fat ratio ($P<0.01$) by 43.4 % and muscle/bone ratio ($P<0.05$) by 24.0 % relative to control lambs.

Table 7. Effect of clenbuterol treatment on right carcass side weight (rcw), carcass components weight and percentage[1] in lambs (mean ± SE)

Trait	Control	Clenbuterol	% Change
Right carcass side, kg	9.64±0.55	11.66±0.58*	+12.55
Muscle weight, kg	5.51±0.42	7.44±0.62*	+35.03
Bone weight, kg	1.74±0.06	1.89±0.05	+8.62
Fat weight, kg	2.35±0.17	2.23±0.10	-5.11
Muscle %	56.80±1.05	63.60±2.5*	+11.97
Bone %	18.10±0.5	16.30±0.5*	-9.94
fat %	24.4±0.90	19.20±1.20**	-21.31
muscle : Fat ratio	2.35±0.10	3.37±0.37**	+43.40
Muscle: bone ratio	3.17±0.15	3.93±0.25*	+23.97

[1] relative to right carcass side weight

* P <0.05, ; ** P<0.01

DISCUSSION

Growth performance:

Several researchers have shown that ß-agonists; clenbuterol or cimaterol improved growth rate and feed: gain ratio. The effects of β-agonist on animal performance varied considerably among different experiments. In the present study, clenbuterol administration significantly increased average daily gain by 65% during the first 2 weeks of treatment (P <0.05) and had no significant effect thereafter. These results are in agreement with those reported by Pringle *et al.* (1993) who found that average daily gain was higher by 48% (P <0.05) after 2 weeks of β-agonist, $L_{644,969}$, administration and then returned to control levels after 4 and 6 weeks in lambs weighing 35 kg. Other studies have shown an early increase in average daily gain (Beermann *et al.*, 1986; Moloney *et al.*, 1990), long -term effects on daily gain (Kim *et al.*, 1987; Koohmaraie *et al.*, 1991 ; Rikhardsson *et al.*, 1991) and no β-agonists significant effect on average daily gain (Bohorov *et al.*, 1987; Claeys *et al.*, 1989; O'Connor *et al.*, 1991; Sinclair *et al.*, 1991). The varied response in average daily gain may be due to the type and dose of β-agonist, animal age or length of treatment.

During the first 2 and 4 weeks of treatment, feed efficiency was significantly improved by 48 and 32%, respectively by the administration of clenbuterol which was due to higher growth rate in treated lambs (Table 3). The above results suggest that lambs may be adapted to clenbuterol by 4 weeks and so the longer treatment of clenbuterol did not cause further improvement. Similar results were reported by Beermann *et al.* (1986) who concluded that β-agonist did not affect feed efficiency when ram lambs fed 10 ppm ofcimaterol for 7, 10 or 12 weeks, but improved feed efficiency if the animals were administered cimaterol only for 5 weeks. Also, Kim *et al.* (1989) reported that feed/ gain ratio was improved (P <0.05) by cimaterol administration during the first 6 weeks of the 13 weeks of experimental period and there was no effect thereafter.

Daily feed intake was not affected significantly by clenbuterol treatment overall the experimental period, although the clenbuterol treated group tended to consume 13.5 and 2.5% less than the control group at the first and second two weeks of the trial,respectively. The present results are in agreement with those reported in lambs (Duquette *et al.,* 1987; Aboul-Ela *et al., 1988;* Pringle *et al.*, 1993) and in steers (Ricks *et al.,* 1984).

Offal components: The effects of β-agonist on organ weights vary according to type of animals. While β-agonist treatment increased heart and liver weights in rats (Reeds *et al.,* 1986) and rabbits (Forsberg *et al.,* 1989) or only increased liver percentage (Pringle *et. al.* ,1994); it decreased weights of heart and liver in sheep (Hanrahan *et al.,* 1987; Kim *et al.,* 1989; Sinclair *et al.,* 1991) and cattle (Williams *et al.*, 1987; Allen *et al.,* 1987; Moloney *et al.,* 1990). In the present study, clenbuterol decreased weights of head, skin, stomach, intestine, liver, heart, kidney, kidney plus pelvic fat, gut fat, but the differences were not statistically significant. Stomach, liver and heart as percentge of live body weights were decreased significantly (P <0.05) by clenbuterol treatment (Table 4, 5). These observations are similar to those described by Williams *et al.* (1987) in young cattle treated withβ-agonist, clenbuterol, and in lambs treated with cimaterol (Sinclair *et al.,* 1991). They suggested that the reduction in liver (percentage of empty body weight) perhaps reflects the reduction in the content of glycogen. Similar results were reported by Kim *et al.* (1989) who found that weights of heart and liver were decreased significantly by cimaterol treatment in lambs. Another possibility for the decrease in liver weight is a decrease in the fractional protein synthesis rates, as reported by Muramatsu *et al.* (1991) in chicks.

Carcass characteristics: Significant increase in hot carcass (19.2%, P <0.05) and cold carcass (20.5%, P <0.05) weights of lambs fed clenbuterol were obtained in spite of the absence of statistically significant effects on fasted body weight. These results may be due to the decreased weights of non carcass components of lambs administrated with clenbuterol than control lambs (Table 4, 5). Also, significant improvement (12.4% ,P <0.01) in the dressing percentage was observed in treated lambs. This improvement was a result of both an increase in individual muscle weight (unpublished data) and a reduction in the weight of non carcass components in lambs fed clenbuterol compared to control lambs. Similar results were reported by Baker *et al.* (1984) ; Beermann *et al.* (1986); Kim *et al.* (1987 & 1989); O'Connor *et al.* (1991); Sinclair *et al.* (1991) and Pringle *et al.* (1993) in lambs, by Williams *et al.* (1986) and Berge *et al.* (1993) in calves as well as by Quirke *et al.* (1988) and Fiems *et al.* (1991) in cattle. The increase in the carcass weight resulting from clenbuterol treatment was associated with increase in leg thickness (24%, P <0.05, Table 6), and modest increase in dorsal length of carcass (2.4%).

Carcass composition: Dissection of carcass revealed that clenbuterol significantly increased lean weight by 35% whilst fat weight was decreased by 5% (not significant). The administration of clenbuterol substantially reduced fat percentage by 21.3 and bone percentage by 9.9 and increased lean percentage by 12.0% (Table 7). The increase of muscle weight or percentage is likly to be due to hypertrophic model for β-agonist induced muscle growth (Beermann *et al.* 1987; Koohmaraie *et al.*, 1991) and to the increase in protein content (unpublished data). The reduction of fat may be due to a direct effect of β-agonist on adipocyte by stimulating lipolysis and inhibiting lipogenesis in mammals (Fain and Garcia-Sainz, 1983; Stiles *et al.*, 1984). These results are in agreement with previous studies (Hanrahan *et al.*, 1987; Boueque *et al.*, 1987; Allen *et al.*, 1987; Sinclair *et al.*, 1991). Clenbuterol fed-lambs had higher muscle/fat ratio (43.4 % , P <0.01) and muscle/bone ratio (24.0 %, P <0.05) than control lambs. This may be attributed to the higher lean and the lower fat contents in lambs fed clenbuterol.

CONCLUSION

In the present study, clenbuterol improved growth rate and feed efficiency only during the first two and four weeks of treatment. The results of the present study suggest that lambs may be adapted to clenbuterol by 4 weeks and so longer treatment of clenbuterol did not cause further improvement. The most important variables that were improved are carcass weights, dressing percentage and leg thickness in lambs fed clenbuterol. The improvement in dressing percentage was a result of both an increase in individual muscle weight and a reduction in the weight of non carcass components.

It is clear that clenbuterol significantly reduced fat percentage and bone percentage and increased lean percentage. Clenbuterol fed-lambs had higher muscle/ fat ratio and muscle/bone ratio than control lambs. The results illustrate that β-agonist, clenbuterol is a repartitioning agent, markedly improved carcass quality by decreased fat deposition and increased lean accretion.

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تأثير مركب Clenbuterol على أداء النمو وبعض صفات الذبيحة فى الحملان

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أستخدم ٨ حملان مخصية من سلالة كوريديل اليابانية بمتوسط وزن ٣٦ كجم وقسمت عشوائياً الى مجموعتين وأعطيت المجموعة المعاملة ٨٠ ميكروجرام / كجم وزن حى / يوم من مركب Clenbuterol لمدة ٨ أسابيع والمجموعة الأخرى تركت بدون معاملة وغذيت جميع الحملان على عليقة مركزة حتى الشبع لدراسة تأثير المعاملة على معدل النمو والكفاءة الغذائية وصفات الذبيحة. وكان متوسط عائد النمو اليومى فى المجموعة المعاملة أكبر بمقدار ٦٥٪ بدرجة معنوية عالية بالمقارنة بالمجموعه الغير معاملةخلال أول أسبوعين ثم بعد ذلك كانت الزيادة غير معنويه. وإنخفضت نسبة الغذاء المأكول الى الزيادة فى الوزن معنوياً بنسبة ٤٨,٣ ٪ و ٢٣,٣ ٪ فى أول أسبوعين و ٤ أسابيع من المعاملة ثم بعد ذلك إقتربت هذه النسبة من مستوى الحملان الغير معامله. سبب تناول Clenbuterol زيادة معنوية فى وزن الذبائح المبردة (٢٠,٥ ٪) ونسبة التصافى (١٢,٤ ٪) وسمك الفخذ (٢٤,٠ ٪) ونسبة اللحم الأحمر (١٢,٠ ٪) وكذلك نسبة العضلات للدهن (٤٣,٤ ٪) ونسبة العضلات الى العظام (٢٤ ٪). بينما أدت المعاملة الى إنقاص نسبة الدهن (٢١,٣ ٪) ونسبة العظام (٩,٩ ٪).