Effects of Feeding Monensin in Combination with Zeranol Implants on Performance, Carcass Traits and Nutrient Digestibility of Growing Lambs

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ABSTRACT : Thirty-six Naeimi ram lambs were equally and randomly allotted to four treatment groups with three replications per treatment to determine the simple and additive effects of monensin and zeranol on growth performance, carcass characteristics and nutrient digestibility. The treatment groups were: basal diet-fed lambs (C), monensin-fed lambs (M) where the basal diet was supplemented with 33 mg monensin per kilogram DM, lambs implanted with 12 mg zeranol (Z), and monensin-fed lambs implanted with zeranol (MZ). Lambs fed monensin-containing diet consumed 10.5% less ($p<0.05$) DM/100 kg weight and were 8.3% more ($p<0.05$) efficient in converting feed than lambs fed control diet. Zeranol implanted lambs tended to grow 35.2% ($p<0.05$) faster, consumed 5.1% more ($p<0.05$) feed and were ($p<0.05$) 21.9% more efficient in their feed conversion than control lambs. Responses of lambs to monensin and zeranol implants were not additive. Except for Z treatment, there were no marked differences in all carcass characteristics among the various treatment groups. Z-lambs produced 12.7% heavier ($p<0.05$) carcasses compared with those from C treatment. Also fat parameters, namely, kidney and pelvic fat (KP), body wall thickness and fat thickness, indicated trends for higher finish in Z treatment lambs ($p<0.05$) than for those lambs from other treatments. Except for CF and ADF, no significant differences in nutrients digestibility were noticed between various treatments; feeding monensin resulted in 24.5% and 8.5% depressions ($p<0.05$) in CF and ADF digestibility, respectively in comparison to C treatment. Nitrogen retention as percentage of total N-intakes was averaging 7.5 and 20.2% higher ($p<0.05$) in lambs implanted with zeranol than those fed the M and C diets, respectively. ***(Asian-Aust. J. Anim. Sci. 2003. Vol 16, No. 9 : 1274-1279)***

Key Words : Monensin, Zeranol, Performance, Carcass, Digestibility in Lambs

INTRODUCTION

The feeding of lambs in Saudi Arabia has frequently resulted in great economic losses to the producers. The livestock industry is continually searching for methods of minimizing feed costs involved in lamb production. Therefore, a great deal of studies has been performed in the area of growth regulation and its effect on lamb performance. Zeranol is one of the anabolic implants that has gained wide acceptance by the producers (Goodrich et al., 1984; Song and Choi, 2001). The implantation with zeranol has been shown to improve growth rate, feed intake and feed efficiency of lambs (Larson et al., 1983; Hutcheson et al., 1992; Nold et al., 1992). Similarly, supplementation with the ionophore monensin has been shown to enhance feed efficiency of lambs (Bergstrom and Maki, 1976; Joyner et al., 1979). The primary action of the monensin appears to take place in the rumen. Goodrich et al. (1984) and Richardson (1990) reported that monensin is effective in altering the rumen fermentation to one of a higher molar proportion of propionate, and these alterations have been implicated as the primary factor responsible for the increased feed efficiency.

Fewer studies have reported effects of feeding monensin to implanted animals. Hoffman et al. (1977), Dinius et al. (1978) and Goodrich et al. (1984) found that the effect of a monensin-zeranol combination in cattle was additive and resulted in further increases in feed efficiency as compared to when either monensin or zeranol was used alone. The purpose of this study was to evaluate the effects of monensin supplementation and zeranol implants (separately and additively) on growth performance, carcass characteristics and nutrient digestibility of Naeimi ram lambs.

MATERIALS AND METHODS

A total of 36 Naeimi ram lambs, weighing an average of 36.1 kg, were used to evaluate the effects of monensin supplementation, zeranol implants and monensin plus zeranol implants on growth performance, carcass characteristics, digestibility and nitrogen balance. Lambs were stratified by weight and randomly allotted to four treatment groups with nine lambs per group. Lambs of each treatment group were equally divided into three replicates; each replicate was housed in a concrete-floored pen in an open-sided building. One-half of the lambs had been individually implanted with 12 mg zeranol 15 days before the initiation of the experiment, while the other 18 lambs had not been implanted. The experimental basal diet was prepared as a loose whole mixed diet consisting of 75%

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Table 1. Ingredients and chemical composition of basal diet

Item	DM basis (%)
Ingredients	
Alfalfa hay	25.7
Maize	38.6
Barley	23.8
Soybean meal	9.1
Mineral supplement[a]	2.6
Trace mineral and vitamin premix[b]	0.2
Chemical composition	
CP	15.25
CF	8.16
ADF	14.98
NDF	49.42
NFE	67.77
EE	2.44
Ash	6.04
Ca	0.81
P	0.45
ME, Mcal/kg[c]	2.74

[a] Supplement composition: 30% sodium bicarbonate; 30% ground limestone; 20% dicalcium phosphate; 20% sodium chloride.
[b] Contained per kg of mineral and vitamin premix: $CoSO_4$, 0.30 g; $CuSO_4$, 20.1 g; $FeSO_4$, 10.0 g; ZnO, 50.0 g; $MnSO_4$, 40.2 g; KI, 0.75 g; NaCl, 2.81 g; vitamin A, 500,000 IU; vitamin D, 500,000 IU and vitamin E, 10,000 IU.
[c] Calculated.

concentrate and 25% roughage; the ingredients (Table 1) were ground through a 4.76 mm screen and mixed thoroughly in a stainless steel vertical mixer. The treatment groups were: basal diet-fed lambs (C), monensin -fed lambs (M) where the basal diet was supplemented with 33 mg monensin per kilogram DM, zeranol implanted lambs (Z), and monensin-fed lambs implanted with zeranol (MZ).

Lambs were allowed 15 days to adapt to basal diet; during this adaptation period, lambs were dewormed and vitamin A-D-E injections were given. Upon initiation of the trial, an adequate amount of feed was weighed at the beginning of each week into a plastic container for each replicate. From these, a sufficient amount of feed was offered three times daily and adjusted as needed to minimize refusals; remaining refusals of each time were remixed into the fresh diet that was offered next time. Refusals were removed at the end of each week, weighed, sampled for DM determination and then discarded. Throughout the experiment, feed consumption data was recorded weekly and lamb weight after 18 h shrink without feed was recorded bi-weekly.

Lambs were slaughtered at the King Saud University's abattoir after 18 h shrink without feed. Live body and hot carcass weights were obtained from all lambs at the time of slaughter. After the carcasses were chilled for 48 h, the following measurements were obtained: 1) rib eye area taken by direct grid reading of the longissimus muscle at the 12th rib; 2) fat thickness over the center of the longissimus muscle; 3) body wall thickness 11 cm lateral to the dorsal process between the 12th and the 13th ribs; 4) kidney and pelvic (KP) fat. Thereafter, the 9-11th rib joint was separated from the right side of each carcass and physically separated into bone and soft tissues. The soft tissues were ground through a 4 mm plate, mixed and reground again. During the second grinding, 3 subsamples 10-12 g were taken from each carcass to form a 30-35 g sample that was placed in a plastic bag, frozen and stored at -20°C pending chemical analysis.

On day 60 of the experiment, a metabolism study was conducted with 12 rams to determine digestibility and nutritive value of each experimental diet. Rams were randomly selected and withdrawn from the feeding trial at the rate of one ram per each replicate, fed *ad libitum* and individually confined in false-bottom metabolic crates to facilitate separate collection of total feces and urine. A preliminary period of 3 days in order to accustom the lambs to new surrounding followed by 7 days collection period was conducted. Weights of feed offered and refused were recorded daily, sampled, ground to pass through a 1 mm screen and stored. Feces voided were collected before feeding in the morning, weighed and a 10% aliquot of total feces was dried at 65°C for 24 h. The dried samples were ground through a 1 mm screen and stored for later analyses. Total daily urine outputs of each ram was collected in a plastic bucket containing 100 ml 6 N HCl to prevent nitrogen losses, recorded and a 10% aliquot was sampled; at the end of collection period, samples of urine of each ram were mixed for nitrogen determination. On the final day of the digestibility trial, rumen fluid was collected via a stomach tube from each ram at 2 h after the morning feeding for measurement of volatile fatty acids (VFA) and ammonia-N concentrations.

Samples of basal diet, feces, urine and ground soft tissues were analyzed for moisture, ash, ether extract and crude protein according to AOAC (1990). NDF and ADF were determined according to Goering and Van Soest (1970). VFAs were measured by gas chromatography (model 404, Philip). Ammonia was determined by the distillation method using MgO (AOAC, 1990). Growth performance, carcass characteristics and digestibility data were statistically analyzed by ANOVA using GLM procedures (SAS, 1988). Duncan's multiple range test was used to test for significant differences among means.

RESULTS AND DISCUSSION

Overall performance data for the experiment are shown in Table 2. All but two of the lambs remained in good health throughout the feeding trial. One lamb, in the Z treatment, showed continuous distress and hyperirritability and was removed from the trial. Another lamb, in the M treatment, showed signs of urolithiasis in the 7th week and was also

Table 2. Effect of monensin, zeranol implant and monensin plus zeranol implant on performance of Naeimi lambs

Parameters	Treatment[1]				SEM
	C	M	Z	MZ	
No. of lambs	9	8	8	9	
Initial body weight, kg	36.3	35.8	35.7	36.4	0.82
Final body weight, kg	46.3^{b}	45.4^{b}	49.2^{a}	47.5^{b}	1.05
DM intake, kg/d	1.37^{b}	1.21^{c}	1.44^{a}	1.40^{ab}	0.02
DM intake, kg/ 100 kg body wt.	3.33^{b}	2.98^{c}	3.39^{a}	3.35^{ab}	0.02
Weight gain, g/d	142^{b}	137^{b}	192^{a}	158^{b}	8.20
kg DMI/ kg weight gain	9.6^{c}	8.8^{b}	7.5^{a}	8.9^{b}	0.51

[1]C=control diet; M=33 mg monensin/kg DM; Z=12 mg zeranol implant; MZ=M plus Z treatments.
[a, b, c] Means in the same row bearing different superscripts differ ($p<0.05$).

Table 3. Effect of monensin, zeranol implant and monensin plus zeranol implant on carcass characteristics of Naeimi lambs

Parameters	Treatment[1]				SEM
	C	M	Z	MZ	
Hot carcass weight, kg	22.96^{b}	22.61^{b}	25.88^{a}	23.59^{b}	0.61
Dressing, %	49.6	49.8	52.6	50.4	0.77
KP fat, kg	0.315^{b}	0.298^{b}	0.439^{a}	0.325^{b}	0.08
Body wall thickness, cm	2.1^{b}	1.8^{b}	2.8^{a}	2.2^{b}	0.18
Fat thickness, mm	1.5^{b}	1.2^{b}	2.3^{a}	1.5^{b}	0.07
Rib eye area, cm^{2}	19.3	19.9	21.0	19.8	0.56
Soft tissue: Bone[2]	3.81^{b}	3.60^{b}	4.52^{a}	3.94^{b}	0.22
Chemical composition[3]					
Moisture, %	55.44^{ab}	57.39^{a}	52.32^{b}	55.79^{ab}	1.41
Protein, %	14.61	14.42	14.33	14.80	0.46
Ether extract, %	29.04^{b}	27.21^{b}	32.50^{a}	28.49^{b}	2.14
Ash, %	0.91	0.98	0.85	0.92	0.02

[1] C=control diet; M=33 mg monensin/kg DM; Z=12 mg zeranol implant; MZ=M plus Z treatments. [2] Physically separated tissues from 9-11th rib joint.
[3] Chemical analysis of the physically separated soft tissues from 9-11th rib joint.
[a, b] Means in the same row bearing different superscripts differ ($p<0.05$).

removed from the experiment. Comparable lambs for replacement were not available. Dry matter intake did not differ ($p>0.05$) among lambs from Z and MZ treatments, but lambs from Z treatment consumed 5.1 and 19% more ($p<0.05$) daily DM than did those fed C and M treatment diets, respectively. On average, lambs implanted with zeranol had a 6% heavier ($p<0.05$) body weight than the lambs on the other treatments. Except for zeranol-implanted lambs, daily gain was not affected ($p>0.05$) by treatment; however, lambs implanted with zeranol grew 35.2% faster ($p<0.05$) than lambs fed C diet, and 40.1 and 21.5% faster ($p<0.05$) than M and MZ lambs, respectively. The DM requirement per kg live weight gain for Z treatment decreased significantly ($p<0.05$) in comparison with C treatment. The results of the present growth study agree with the earlier findings (Larson et al., 1983; Hutcheson et al., 1992; Nold et al., 1992) in that zeranol increased average daily gain and DM intake and improved feed efficiency in lambs. Zeranol has some estrogenic effects. The mechanism by which estrogenic substances increase growth seems to involve an indirect action on the pituitary that causes the release of somatotropin and a direct action on skeletal muscle receptors (Song and Choi, 2001). Except for the monensin-fed treatment, the daily DM intake of all the animals was above 3.3 kg per 100 kg live weight. Average daily DM intake per 100 kg live weight was 10.5% lower ($p<0.05$) in lambs fed monensin than those fed C diet. The M treatment improved feed efficiency ($p<0.05$) in comparison with the C treatment. The observed depression in daily DM consumption and improved feed efficiency of lambs as a result of monensin supplementation is well documented (Bergstrom and Maki, 1976; Joyner et al., 1979). However, improvements in feed efficiency have typically been explained by altering ruminal fermentation (Goodrich et al., 1984; Richardson, 1990) which, in effect, increases dietary energy utilization.

Although most reports have investigated the effects of zeranol implant or monensin when used singularly, fewer studies have reported the effects of feeding monensin to implanted lambs. The data of the present study showed that the percent improvements in feed efficiency for treatments over the control treatment were: 21.9 for zeranol, 8.3 for monensin, and 7.3 for monensin with zeranol. It is apparent from these results that feed efficiency responses to monensin and zeranol implantation are not additive. Similar results were reported by Utley et al. (1976) who reported no synergistic effect between monensin and zeranol implantation. On the other hand, Hoffman et al. (1977) and Dinius et al. (1978) suggested that the positive effect from monensin and zeranol implants on feed efficiency in cattle

was additive. The basis for the discrepancy in results is not clear.

Except for Z treatment, there were no marked differences in all carcass characteristics among the various treatment groups (Table 3). Implanting lambs with zeranol resulted in 12.7% improvement ($p<0.05$) in carcass weight compared with those carcasses from C treatment. This was primarily due to their heavier slaughter weights. In agreement, implanting with zeranol has been shown to increase carcass weight in lambs (Wilson et al., 1972; Hutcheson et al., 1992). Also, higher ($p<0.05$) KP fat, body wall thickness and fat thickness correspond with the greater carcass weight in Z treatment lambs as compared to lambs on the other treatments. The greater amount of fat thickness over the longissimus muscle at the 12th rib of implanted than of control lambs is supported by the data from Field et al. (1993). Carcass characteristics were numerically lower ($p>0.05$) for the lambs fed monensin than those values from C and MZ treatments. Goodrich et al. (1984) reviewed the influence of monensin on carcass characteristics and found that only rib eye area showed a positive response to monensin, while carcass weight, carcass dressing percentage and fat depth were negatively affected by monensin.

Various treatments did not alter the percentage of protein and ash in the soft tissue of the physically separated 9-11th rib joint, while the percentage of ether extract exhibited a significant ($p<0.05$) increase in the Z treatment in comparison with other treatments. Accordingly, the percentage of moisture in the soft tissue from Z treatment was lower ($p<0.05$) than those tissues from C, M and MZ treatments. The increase in fat percentage with zeranol implant was contrary to previous reports in sheep (Rompala et al., 1988; Maiorano et al., 1993), demonstrating an increase in protein deposition in implanted animals with zeranol. Ferrell et al. (1978) and Williams et al. (1987) found that feeding high levels of grain to implanted animals did not increase carcass protein but tended to increase carcass fat. Therefore, the increase in fat percentage in our study probably was attributed to the high-energy diet and its effect on increasing plasma insulin concentration, which is associated with lipogenesis (Williams et al., 1987).

The apparent digestibility coefficients and nutritive vales of various dietary treatments are given in Table 4. There were no marked differences ($p>0.05$) in nutrient digestibility coefficients and nutritive values among C and Z treatments. Except for CF and ADF, no significant ($p>0.05$) differences in nutrient digestibility were noticed as a result of monensin supplementation. Feeding monensin resulted in 24.5 and 8.5% depressions ($p<0.05$) in CF and ADF digestibilities, respectively, in comparison to C treatment. Similar results were reported by Schelling (1984) and Morris et al. (1990) who found no differences in DM, CP and NDF digestibilities with or without monensin. Several studies have indicated that monensin decreases microbial growth when the microbes are not adapted to monensin (Van Nevel and DeMeyer, 1977; Herod et al., 1979). However, microbial growth by adapted cultures were unaffected by monensin (Herod et al., 1979), a finding consistent with Dinius et al. (1978) and Poos et al. (1979) who found that monensin did not alter ADF digestibility in animals allowed a period of adaptation. In the present study, however, the observed reduction in CF and ADF digestibility with monensin is not readily explainable.

Nitrogen intake was numerically ($p>0.05$) lower for the M treatment than for those fed other dietary treatments.

Table 4. Effect of monensin, zeranol implant and monensin plus zeranol implant on nutrient digestion and nitrogen utilization by Naeimi lambs

Parameters	Treatment[1]				SEM
	C	M	Z	MZ	
Apparent digestibility, %					
DM	74.7	73.9	74.0	74.4	1.62
OM	77.0	75.8	76.4	76.3	1.67
CP	70.0	71.2	69.0	70.2	0.94
CF	26.9^{a}	20.3^{b}	24.1^{a}	21.4^{b}	1.03
ADF	34.0^{a}	31.1^{b}	33.2^{a}	32.4^{ab}	0.74
NDF	69.3	68.0	68.6	69.6	0.96
EE	86.1	85.4	85.4	85.3	1.85
NFE	84.4	83.5	84.2	84.0	1.21
Nutritive value					
TDN	74.8	73.9	74.4	74.3	0.85
DCP	10.6	10.9	10.6	10.7	0.45
Nitrogen balance					
N intake, g/d	24.8	22.4	25.4	25.7	1.51
N retained, g/d	8.6^{b}	8.7^{b}	10.6^{a}	10.6^{a}	0.22
N retained, % intake	34.7^{c}	38.8^{b}	41.7^{a}	41.2^{a}	0.72

[1] C=control diet; M=33 mg monensin/kg DM; Z=12 mg zeranol implant; MZ=M plus Z treatments.

^{a,b,c} Means in the same row bearing different superscripts differ ($p<0.05$).

Table 5. Effect of monensin, zeranol implant and monensin plus zeranol implant on ruminal fluid characteristics of Naeimi lambs

Parameters	Treatment[1]				SEM
	C	M	Z	MZ	
Ammonia-N, mg/dl	16.9[a]	13.6[b]	16.7[a]	13.7[b]	0.52
Total VFA, mmol	51.9	52.9	52.0	53.1	2.11
Acetate, %[2]	69.1[a]	65.2[b]	70.0[a]	66.0[b]	1.41
Propionate, %	18.8[b]	22.4[a]	18.2[b]	22.6[a]	0.81
Butyrate, %	9.5	9.7	9.2	9.1	0.23
Isobutyrate, %	0.5	0.5	0.4	0.4	0.08
Valerate, %	1.4	1.6	1.5	1.4	0.09
Isovalerate, %	0.7	0.6	0.7	0.5	0.05

[1] C=control diet; M=33 mg monensin/kg DM; Z=12 mg zeranol implant; MZ=M plus Z treatments.
[2] Percentage of total moles.
[a,b] Means in the same row bearing different superscripts differ ($p<0.05$).

Although the lambs in all treatment groups were in positive nitrogen balance, nitrogen retentions as percentage of intakes were averaging 7.5 and 20.2% higher ($p<0.05$) in animals implanted with zeranol than those fed the M and C diets, respectively. Song and Choi (2001) stated that zeranol implantation might increase nitrogen retention by altering circulating concentrations of endogenous somatotropin, thyroxin and insulin in treated animals. The calculated nitrogen retention as percentage of total N-intake was 11.8% higher ($p<0.05$) in monensin-fed than control-fed lambs. These results are in agreement with the data of Van Nevel and DeMeyer (1977) and Joyner et al. (1979) who found that monensin-fed animals utilized dietary nitrogen more efficiently for protein synthesis.

Metabolites of rumen fermentation at 2 h post-feeding are shown in table 5. Concentration of ammonia-N in the rumen fluid were lower ($p<0.05$) with monensin-fed treatments, namely, M and MZ treatments, than with non-monensin fed treatments. There was no difference ($p>0.05$) in total ruminal volatile fatty acid concentration between various treatments. Lowered ruminal ammonia concentration associated with no difference in total VFA concentrations between animals fed diets with or without monensin have been previously reported (Dinius et al., 1978; Surber and Bowman, 1998). Individual VFA as a percentage of the total concentration were different ($p<0.05$) between treatments. Lambs fed M or MZ diets had lower ($p<0.05$) percentage of acetic acid and higher ($p<0.05$) percentage of propionic acid than those fed no monensin. These results are similar to those previously reported (Utley et al., 1976; Dinius et al., 1978; Boss and Bowman, 1996; Surber and Bowman, 1998). Zeranol implants had no effect on ruminal fluid parameters.

The results of the present study indicated that either zeranol implantation or monensin caused significant improvement in feed conversion ratio of treated lambs. Zeranol implants effectively increased body gain and feed intake, while monensin intake exerted its effects through the reduction of feed intake. It is obvious that feeding monensin resulted in greater available energy from a given amount of feed because of the VFA shift to more propionate and less acetate (Surber and Bowman, 1998), and enhanced nitrogen retention (Van Nevel and DeMeyer, 1977). Thus, the hypothesis that feeding monensin in combination with zeranol implants might additively improves feed efficiency was examined and failed to be applicable in our study. However, it is apparent from the results that feed efficiency responses to monensin and zeranol was not additive.

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