Effect of feeding different levels of monensin on the productive performance of Awassi lambs: Weight gain and feed conversion ratio

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Abstract
This study was carried out at Animal field of Animal Production Department- Agriculture College - Al-Qasim Green University for 100 days to investigate the effect of feeding monensin to Awassi lambs at levels of 15, 30 and 45 mg/kg concentrate diet on weight gain and conversion ratio in treatments 2, 3 and 4 respectively. Lambs in control treatment (T1) were fed concentrate diet without monensin. Sixteen lambs were used with mean live body weights (LBW) of 24.84 kg and 4-6 months of age at 4 lambs per each treatment. Concentrate diet was offered at level of 2.75% of LBW divided into morning and evening meals. Ground wheat straw was offered ad libitum. Results revealed that final weight of lambs was not affected by monensin feeding, whereas significant increase ($P<0.05$) was recorded in total weight gain from 9.66 for control treatment to 11.17 and 11.35 kg, and daily weight gain from 138.09 for control treatment to 159.63 and 162.14 g/day due to feeding monensin at levels of 30 and 45 mg/kg concentrate diet respectively. Feed conversion ratio calculated on basis of total dry matter, organic matter and crude protein intakes was significantly ($P<0.05$) improved when monensin was introduced into concentrate diet at levels of 30 and 45 mg/kg.

Key words: Lambs, Monensin, Weight gain, Feed conversion ration

Introduction
Sheep are pastoral animals capable of eating agricultural residues and providing humans with a raw protein of high biological value as a result of the balance of the essential amino acids that the body needs and the high digestion with the ease of absorption of their digestible products as well as the presence of essential fatty acids, some mineral elements and vitamin B group [2]. Breeding systems based mainly on concentrated feeds are economically costly and quantitatively unsustainable.

Monensin is one of the most important polycarboxylic compounds (Ionophore) used in feeding ruminants, and it is produced by *Streptomyces cinnamons,* which increases propionate production while reducing methane [9]. Modification in the diversity of microbial groups in the rumen as a result of reducing methane-producing ciliates can also be occurred [8]. Rutkowski and Brzezinski [24] indicated the use of monensin as a growth promoter for ruminants and its targeting of certain bacterial groups in the rumen, which leads to an increase in production efficiency. This was attributed to improving the efficiency of energy and nitrogen metabolism of bacteria in the rumen, which positively affects the animal's performance in utilizing feed and increasing growth rates [28].

Several studies concluded that there was an improvement in the digestion of crude protein as a result of adding different levels of monensin to ruminant diets [5]. Increasing the proportion of dietary protein passing from the rumen to the lower parts of the alimentary tract due to the effect of monensin that inhibits bacteria responsible on deamination process of amino acids and production of ammonia in the rumen [12]. Based on the foregoing, the current study was conducted to investigate the direct effect of feeding different levels of monensin on the productive performance of Awassi lambs, represented by weight gain and feed conversion ratio.

Methods and materials

Animals and experimental relationships

The current study was conducted in the Animal field of Animal Production Department- College of Agriculture- Al-Qasim Green University with two stages. The first stage included a preliminary period of 30 days followed by a trial period of 70 days. Sixteen local Awassi male lambs were used with an average weight of 24.85 ± 0.83 and 4-6 months of age. Lambs were housed in semi-open pen and randomly distributed into individual cages with 4 lambs per each of the four treatments included in the study. Concentrate diet was offered to lambs at a 2.75% of LBW in two meals, at 8.00 am. and 4.00 pm., while wheat straw was offered to all animals *adlibitum*.

In the second, third and fourth treatments, the concentrate diet was supplemented with monensin at levels of 15, 30, and 45 mg/kg dry matter, respectively, while it was free of monensin in the first treatment, which was considered as the control treatment. Diets were chemically analyzed in the nutrition laboratory of the Department of Animal Production according to AOAC [4] methods. Metabolizable energy (ME) content of diets was estimated according to MAFF [18] equation with subsequent conversion of its values from MJ/kg DM to MJ/100 g DM in consistence with chemical composition based on percentage determinations:

ME (MJ/ Kg DM) = 0.012 CP + 0.031 EE + 0.005 CF + 0.014 NFE.

Rumen degradable nitrogen (RDN) content was estimated according to previous studies in which the ruminal effective degradability (ED) of protein fraction in the different ingredients of concentrate diet had been determined as follows: 80% and 60% for barley and yellow corn respectively [14], 70% for soybean meal [1], and 67% for wheat bran [21]. Urea was added at level of 0.65% to ensure existence of a standard ratio of 1.34 g RDN/MJ of ME. The calculated percentage of RDN was about 1.79 g / 100 g DM of the concentrate diet. NaCl and mineral-vitamin mix were added to concentrate diet at rate of 1% for each. Chemical analysis of diets is shown in Table 1.

Table 1. Ingredients and chemical composition of diets (%)

Ingredients, %		
Barley	44.35	
Corn	18	
Wheat bran	30	
Soybean meal	5	
Urea	0.65	
NaCl	1	
Vit. Min. Mix	1	
Chemical composition	Concentrate	Wheat straw
Dry matter, DM	89.75	91.19
Organic matter, OM	95.13	91.09
Crude protein, CP	14.47	2.69
Crude fiber, CF	4.10	37.44
Ether extract, EE	4.43	2.13
Nitrogen free extract, NFE	72.13	48.83
Metabolizable energy, ME, MJ/100 g DM	1.34	0.97

Estimates and calculations

The intake of experimental diets was estimated by weighing the offered and remaining quantities of concentrate diet and straw every day at 8:00 am. The lambs were weighed weekly to follow up on their growth performance and determine the amount of concentrate diet to be offered during every week of the trial period. The last weight of the preliminary period was considered the initial weight of the lambs and the beginning of the experimental period, while the weight of the lambs in the tenth week of the experimental period was considered their final weight, and the difference between the two weights represented the total weight gain (TG). The daily weight gain (ADG) was calculated by dividing the total weight gain in grams by 70 days. With regard to feed conversion ratio, it was calculated by dividing the average total intake of DM, OM or CP by the ADG.

Statistical analysis

The data were statistically analyzed according to the Completely Randomized Design (CRD) to study the effect of the level of monensin feeding using the statistical program, SAS (2010) [27].

Results and discussion

Effect of monensin feeding level on weight gain data of Awassi lambs

Table 2 shows the effect of the level of monensin feeding with the concentrate diet on the data on the weight gain of Awassi lambs. The results indicate that higher (P>0.05) final weight of 38.27 kg was achieved by the lambs in the fourth treatment in which monensin was offered at a level of 45 mg/kg concentrate diet as compared with 36.25, 36.98 and 37.97 for final weight of lambs in the first, second and third treatments in which concentrate diet was offered to lambs free of monensin and with the addition of monensin at a level of 15 and 30 mg/kg concentrate diet, respectively. Similar results were reported by other studies conducted on sheep [22,25]. On the other hand, Heydari et al. [15] observed a significant (P<0.05) increase in the final weight of the Arabian lambs due to the addition of monensin at a level of 30 mg/kg. Al-Shemary [3] showed that feeding monensin to Awassi lambs at a level of 30 mg/kg concentrate diet offered at a level of 3% of LBW, significantly (P<0.05) increased in the final weight from 30.35 to 38.57 kg. However, a significant decrease (P<0.05) was found in the final weight of lambs from 36.3 to 33.0 kg as a result of feeding monensin at a level of 30 mg/animal/day in another study [15]. It is likely that the difference between those studies and the current study is due to the feeding levels of monensin and concentrate diet.

Table 2. Effect of the level of monensin feeding on the weight gain of Awassi lambs (mean ± SE)

Growth Items	Monensin, mg/kg concentrate				*P*
	0	15	30	45	
Initial weight, IW, kg	26.58 ±2.00	26.71 1.64 ±	26.80 0.69 ±	26.92 ± 0.46	NS
Final weight, FW, kg	36.25 ±2.07	36.98 1.93 ±	37.97 0.98 ±	38.27 0.89 ±	NS
Total gain, TG, kg	9.66[b] 0.16 ±	10.26[ab] 0.60 ±	11.17[a] 0.37 ±	11.35[a] 0.44 ±	*
Average daily gain, ADG, g/day	138.09[b] 2.33 ±	146.67[ab] 8.69 ±	159.63[a] 5.39 ±	162.14[a] 6.40 ±	*

Means in the same row with different superscripts are significantly different

*** (P<0.05) NS= Non significant**

The results showed that lambs in the third and fourth treatments gained higher ($P<0.05$) increases in the total (TG) and daily weight gain (ADG) of about 14% and 15% as compared with those the first treatment. This is consistent with the findings of Heydari et al. [13]. The Arabian lambs gained higher ADG ($P<0.05$) of about 13.05% as a result of adding monensin to the diets at a level of 30 mg/kg. Al-Shemary [3] obtained similar results as a result of feeding monensin to Awassi lambs at a level of 30 mg/kg of concentrated diets, regardless to the level of concentrate feeding, 2.5% or 3% of LBW.

The positive effect of monensin feeding on the TG and ADG may be due to its role in the balance of ruminal anaerobic fermentation, in which volatile fatty acids and methane are produced as their main products. This situation enhances that fermentations and the use energy produced from the oxidation of organic materials by electrons transport (hydrogen) to the receptors.

The balance between rumen fermentation products requires an increase in propionate production accompanied by a decrease in methane production [31]. The conversion of hydrogen into other end products results in gaining more digestible energy from fermented feed materials [13]. Moreover, the use of sodium monensin may affect the activity of the ruminal microorganisms through its effect on the ruminal pH, which in turn improves the metabolism and absorption of nutrients [30].

However, Khorshidi et al. [17] reported that adding monensin at the level of 20 and 40 mg/kg dry matter to the diets of Zel lambs did not significantly affect the ADG, mean values were 214.88 and 247.62 g/day, respectively, as compared with 228.10 g/day for the lambs group fed monensin free diet. Similar results were obtained by Sadeghi et al. [25]. The addition of monensin at a level of 25 mg/kg of the diet led to a slight increase in the ADG of Moghani lambs from 161 g/day to 169 g/day. Moreover, Soares et al. [29] showed that adding monensin to the rations of Santa Ines × Texel lambs at a level of 78 mg/kg dry matter led to a significant decrease ($P<0.05$) in the ADG from 164 to 86 g/day. This was attributed to the low intake of feed materials due to the undesirable flavor of monensin, which harms palatability, especially when fed to young animals after weaning.

Effect of monensin nutrition level on the feed conversion factor

Table 3 shows the effect of the level of monensin feeding on the feed conversion ratio (FCR). The results showed that there was a significant improvement ($P<0.05$) in the FCR calculated on the basis of the total dry matter intake (TDMI) as a result of adding monensin at the levels of 30 and 45 mg/kg feed concentrate. Mean values were 6.15 and 6.59, respectively as compared with 7.83 g of TDMI/g of ADG recorded by lambs in the control treatment. The values of the FCR calculated on the basis of the total organic matter intake (TOMI) followed a similar pattern, where the lowest ($P<0.05$) values of 5.82 and 6.22 were associated with lambs fed concentrate diets supplemented with monensin at a level of 30 and 45 mg/kg respectively as compared with 7.44 g of TOMI/g of ADG for the group of lambs in the control treatment. The values of the FCR calculated on the basis of the total crude protein intake (TCPI) recorded similar results, where feeding monensin at the level of 30 and 45 mg/kg of concentrate diet led to a significant improvement ($P<0.05$) in the FCR from 0.85 in the control treatment to 0.72 and 0.74 g TCPI/ g ADG for the two mentioned levels, respectively.

Table 3. Effect of the level of monensin feeding on the feed conversion ratio (g intake/g of daily weight gain ± SE)

Feed conversion ratio data[1]	Monensin, mg/kg concentrate				*P*
	0	15	30	45	
g TDMI/g ADG	7.83^{a} 0.45 ±	6.78^{ab} 0.36±	6.15^{b} 0.20±	6.56^{b} 0.29 ±	*
g TDDMI/ g ADG	5.74 0.34 ±	5.22 0.33±	4.98 0.19±	5.23 0.30±	NS
g TOMI/ g ADG	7.44^{a} 0.47±	6.41^{ab} 0.33±	5.82^{b} 0.19 ±	6.22^{b} 0.27 ±	*
g TDOMI/ g ADG	5.50 0.37±	5.04 0.30±	4.77 0.18±	4.99 0.28±	NS
g TCPI/ g ADG	0.85^{a} 0.05±	0.78ab 0.04±	0.72^{b} 0.02±	0.74^{b} 0.01 ±	*
g TDCPI/ g ADG	0.65 0.04±	0.61 0.03±	0.58 0.02 ±	0.60 0.02 ±	NS

[1]TDMI, total dry matter ; TDDMI, total digestible dry matter intake; TOMI, total organic matter; TDOMI, total digestible organic matter; TCPI, total crude protein ; TDCPI, total digestible crude protein.
Means in the same row with different superscripts are significantly different
*** (P<0.05) NS= Non significant**

The results of a current study agree with the findings of Safaei et al. [26], who observed a significant decrease (P<0.01) in the FCR from 7.47 in the control treatment to 6.30, 6.25 and 5.93 g TDMI/g ADG due to the supplementation of Ghezel lambs rations with monensin at levels of 10, 20 and 30 mg/kg DM, respectively. The results of a current study are also consistent with that obtained by Sadeghi et al. [25], where the addition of monensin to the diets of Moghani lambs at a level of 25 mg/kg of concentrate feed led to a significant (P<0.05) improvement in the FCR from 7.11 to 5.85 g TDMI / g ADG. Similarly, Al-Shemary [3] reported that adding monensin to the concentrate diet of Awassi lambs at a level of 30 mg/kg which offered at 2.5 and 3% of LBW improved FCR (P<0.05) from 6.69 to 4.82 and from 5.55 to 4.75 g TDMI/g ADG for the two levels of concentrate feed, respectively.

The improvement in the FCR in the current study may be due to the increase in digestible energy as a result of the enhancing effect of monensin on rumen fermentation and energy use [10]. Joyner et al. [16] emphasized the role of monensin in increasing the efficiency of the utilization of ME. This was attributed to the improvement of feeding efficiency by reducing the intake of DM [33]. Raun [23] stated that the net effect of monensin was to maintain the performance of ruminants while reducing the feed intake. Garcia et al. [11] and Baran and Zitnan [6] indicated that the addition of sodium monensin at a level of 20 mg/kg DM was associated with a decrease in the concentration of acetic acid and an increase in the concentration of propionic acid, which allowed an increase in the energy available to the animal.

Several studies on the addition of monensin to lambs' diets showed an increase in the efficiency of feed conversion and a significant effect on the growth rate [32]. Oliveira et al. [20] identified the goal of feeding ionophores to ruminants to improve the FCR by changing the activity of ruminal microorganisms leading to an improvement in the metabolism and production of absorbable nutrients and an improvement in the FCR accordingly [30].

The overall effectiveness of ionophore is similar despite the discrepancy in the results of studies that may differ depending on the level of nutrition, the ratio of concentrate to roughage, the nature of the roughage, the ingredients of the concentrate diet and many inherent animal factors inherent [19]. The composition of the diets affects the growth responses when monensin is added. Clary et al. [7] noticed that there was no significant effect of adding monensin on the net maintenance energy when 4% of the fat was added to the diets. The growth response may also be related to the level of roughage in the ration. The response decreases with the increase in the ME levels in the diet due to addition of monensin [33]. This partially explains the higher response to monensin in roughage-based diets.

Though the FCR calculated on the basis of the TDMI, TOMI and TCPI were significantly improved in the current study, the results showed that the FCR calculated on the basis of the total digestible DM intake (TDDMI) was not significantly affected by the addition of monensin. Although the lowest values of 4.98 were associated with the group of lambs fed concentrate diet supplemented with monensin at a level of 30 mg/kg as compared with the highest values associated with the group of lambs fed concentrate diet without the addition of monensin, which was 5.74 g TDDMI/g ADG. The FCR values calculated on the basis of total digestible OM intake (TDOMI) were decreased ($P>0.05$) from 5.50 for the control treatment to 5.04, 4.77 and 4.99 g TDOMI/g ADG for treatments 2, 3 and 4 respectively. Values of FCR calculated on the basis of the total digestible CP intake (TDCPI) were decreased ($P>0.05$) from 0.65 for the control treatment to 0.61, 0.58 and 0.60 g TDCPI/g ADG for treatments 1, 2 and 3, respectively. The absence of a significant effect of the addition of monensin on the FCR values calculated on the basis of TDDMI, TDOMI and TDCPI can be explained by the effect of adding monensin on the digestibility of these nutrients, considering that this will increase the values of the numerator, which represents the average intake at calculation of the FCR, with the denominator representing the average daily gain remaining unchanged.

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