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EFFECT OF SODIUM BICARBONATE AND IONOPHORE SUPPLEMENTATION ON NUTRIENTS DIGESTIBILITY AND GROWTH PERFORMANCE OF LAMBS FED HIGH CONCENTRATE DIETS

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SUMMARY

Twenty crossbred male lambs (Finn-Ossimi) were randomly assigned to four nutritional groups, to receive one of the following experimental rations for 83 days. Treatments were; R1: 75% CFM +25% BS; R2: 75% CFM + 23% BS + 2% (NAHCO3) /kg DM; R3: 75% CFM + 25% BS + Monensin 33mg/kg DM and R4: 75% CFM + 23% BS + 2% NAHCO3 /kg DM + Monensin33mg/kg DM. Experimental rations used, based on concentrate pelleted feed mixture (CFM, 13.13% CP) and berseem straw (BS) as the daily roughage source. The main objective of the study was to evaluate the effect of dietary sodium bicarbonate and monensin supplementation to growing male lambs rations on ruminal fermentation activity and lambs growth performance. Animals live body weight, daily weight gain, feed intake (g/h/d) and feed conversion ratio (kg intake/kg gain) were estimated. A metabolic trial was conducted to evaluate experimental rations digestibility, Nitrogen balance (NB) and ruminal fermentation measurements. Results obtained indicated that addition of dietary (NAHCO3) 2% (T2), resulted in an increase ($P<0.05$) in total dry matter intake (TDMI) , different digestion transactions, pH value, concentrations of TVFA's , lambs FC ratio and daily gain(g) compared with the control group. However, rumen NH3-N and N balance were not affected, while total feed costs /Total kg gain (LE) ware increased. On the other side, with the addition of Monensin at 33mg/kg DM (T3), it resulted in an increase ($P<0.05$) in total feed costs /Total kg gain (LE) and an improvement in lambs FC ratio. On the contrarily, ruminal measurements and N balance were not affected. Dietary Monensin supplement led also to an improvement in lambs digestion coefficient and daily gain (g), but with lower ($P<0.05$) daily feed intake; while adding dietary (NAHCO3) 2% with Monensin 33 mg/kg DM (T4) led to increase ($P<0.05$) lambs pH value, lambs daily gain, different digestion coefficient and Total feed costs /kg gain. However, ruminal TVFA's, NH3-N, DMI/h/d and N balance were not affected. On the light of the present results, it could be concluded that, supporting growing male lambs ration with both of 2% sodium bicarbonate and/or monensin (33mg/kg DM) might lead to an improvement ($P<0.05$) in rations digestibility and nutritive value, lambs feed conversion ratio and maximize lambs net profit gain (LE).

Keywords: *high concentrate, Ionophore (monensin), sodium bicarbonate, ruminants.*

INTRODUCTION

Owing to the increase in sheep rearing that focuses on intense weight gain in a short period, animals are subjected to diets that include large amounts of concentrates (Silva *et al*., 2009, Oliveira *et al.*, 2015). Fattening lambs are generally fed rations containing over 800 g/ kg concentrate in order to achieve high levels of energy intake and daily weight gains (Normand *et al.*, 2001). These results in reduction of the molar proportion of acetate an increase in the molar proportion of propionate. However, diets containing high levels of concentrates may be also associated with digestive disorders as a result of decreases of the buffering capacity of the rumen and subsequent increases in rumen acidity (McKinnon *et al.*, 1990). Also, feeding high concentrate, low fiber pelleted diets or finely chopped forage diets to ruminants decreases salivary production because less mastication is required.

High concentrate diets that contain large quantities of soluble carbohydrate are rapidly fermented to volatile fatty acids in the rumen and lead to a decrease in ruminal pH value throughout the gastrointestinal tract (Linda and James, 1985). High concentrate diet is known to depress rumen pH and lower fiber digestibility due to alteration of rumen microbial population (Santra *et al*., 2003). Buffers are weak acids or alkalizes that pH changes can be prevented. The main action of the buffers is to increase pH or pH change resistance (Mutsavang, 1992, Rogers *et al*., 1982). Buffers in ruminant rations are compounds that neutralize excess acid within the animal's digestive system (Moharrery, 2007). Rumen buffering may provide constant rumen pH, which may decrease changes in dry matter intake that may either be a cause of acidosis (Crawford *et al.*, 2003).

Hence, and according to these determinants, the use of acidity regulators in the rumen, especially sodium bicarbonate, helps to maintain the rumen pH by equating it to the pH to the optimum level corresponding to the activity of cellulose-decomposing bacteria in diets.

Feed additives (buffers and ionophores) have been increasingly used worldwide to improve feed efficiency or to benefit the ruminal health, especially when greater animal growth performance is required, such as in feedlot systems (Oliveira and Millenm, 2014 and Samuslason *et al.*, 2016). Some salts, such as sodium bicarbonate, are routinely added to ruminant diets to buffer rumen pH and have been widely used for fattening lambs (Le Ruyet and Tucker, 1992). Ionophores have been used widely in the feedlot industry for many years, for the prevention of acidosis and bloat in feedlot, improve milk production, health and reproduction in ruminants. Ionophores such as monensin play an important role in reducing the incidence of subclinical ketosis in ruminants (Bagg, 1997). One positive effect of monensin supplementation is its ability to improve ruminant's performance, which leads to an increase in ruminal propionate production at the expense of ruminal acetate production (Bergen and Bates, 1984).

The aim of the present study was to evaluate the Effect of sodium bicarbonate and Ionophore supplementation to sheep rations on nutrients digestibility and growth performance of lambs fed high concentrate diets.

MATERIALS AND METHODS

The present study was carried out in the agriculture research farm, belongs to Faculty of Agriculture, Al-Azhar University, Cairo, Nasr City, Egypt, in June 2022. Twenty crossbred male lambs (Finn-Ossimi), with an average live body weight 34.6 kg and 7 months age, were randomly assigned into four nutritional groups (5 animals each).

***Experimental rations and animals management*:**

Experimental rations used, based on concentrate pelleted feed mixture (CFM, 13.13% CP) and berseem straw (BS) as the daily roughage source. Four experimental rations were formulated as follows:
R1: 75% CFM +25% BS.
R2: 75% CFM + 23% BS + 2% ($NAHCO_3$).
R3: 75% CFM + 25% BS + Monensin33mg/kg DM.
R4: 75% CFM + 23% BS + 2% NAHCO3 + Monensin33mg/ kg DM.

Experimental animals were group feeding, offered their respective rations *ad lib* according to (NRC recommendation, 2012). Daily feed residuals, if any were daily estimated. Animals were subjected to close veterinary care, while current fresh water and salt blocks were daily available all the daytime. Animals were kept in semi- opened pens during the field study, which lasted for 83 days.

Table (1): Composition of the experimental rations (%).

Content	Experimental ration				Price
	T1	T2	T3	T4	(LE/kg)
Concentrate feed Mixture (CFM) %	75	75	75	75	8.5
Berseem Straw %	25	23	25	23	1.5
Sodium bicarbonate (NAHCO3)* %	--	2	--	2	30
Monensin(mg/kg DM) **	--	--	33	33	150
Costs/kg DM	6.75	7.32	6.755	7.325	

**Sodium bicarbonate ($NAHCO_3$) buffer supplement (2%/kg DM).*
***Monensin as supplements (33mg/kg/DM).*

Experimental animals were biweekly weighed to adjust their daily feed intake and lasted consequently during the field study. Animals live body weight, daily weight gain, feed intake (g/h/d) and feed conversion ratio (kg intake /kg gain) were estimated. Rations chemical composition, digestibility and nutritive values were also measured.

Metabolic trials:

At the end of the growth performance study, a metabolic trial was conducted, using 12 adult rams (3animals / treatment), according to procedures technique (El shazly, 1963). Animal's nitrogen balance (NB) was also estimated. Animals were fed the tested experimental rations for 10 days before being suited in the metabolic cages, followed by three days preliminary and adaption period and 5 days for feces and urine collection. Samples of rations offered and residuals, if any were daily recorded during the collection period for further chemical analysis.

Ruminal measurements:

By the end of the metabolic trials, 100 ml rumen liquior samples were individually withdrawn, using rubber stomach tube technique, before feeding (zero time), 3 and 6 hours post feeding. Ruminal samples were strained through three layers of cheese cloth, treated with toluene and paraffin oil and were kept at -20 C˚ tell later chemical analysis. Rumen fluid pH was immediately measured using Orion 680 digital pH meter, Ammonia-nitrogen concentration (NH3-N) mg/100 ml was determined according to **Conway (1963)** and TVFA's were assessed by steam distillation, according to **Abou- Akkada and Osman (1967).**

Proximate chemicals analysis:

Samples of feedstuffs ingredients, complete mixed rations, residues and feces were analyzed for moisture, crude protein (CP), ether extract (EE), crude fiber (CF), Nitrogen free extract (NFE), ash and urinary nitrogen according to **A.O.A.C. (2012).**

***Economic efficiency*:**

An economic study was conducted to justify average daily feed cost/h/day and the corresponding net profit value, as the difference between feed costs and the current selling market price/kg live body weight in 2022=85 LE.

Statistical analysis:

Data obtained were statistically analyzed as a completely randomized design by analysis of variance (ANOVA) using the statistical package software SPSS version 16 (SPSS Statistics, version 25 (2017)). Comparisons between the treatment means were made by F-test and the least significant differences (LSD) at level $P = 0.05$. One- and two-way analysis of variance were adopted using the following equation:

$$Yi = \mu + Ti + ei$$

$$Yij = \mu + Ti + Sj + eij$$

Where: Yij : the observation of the parameter measured, µ: overall means ,Ti: the effect of dietary treatment, Sj : the time of sampling, and, eij : the random error term.

RESULTS AND DISCUSSION

Chemical analysis of the experimental rations:

Data presented in (Table 2) showed proximate chemical analysis of concentrate feed mixture (CFM), berseem straw (BS) and their mixture. *i.e.* (T_1, T_2, T_3 and T_4). Figures obtained were 92.49, 91.81, 11.92, 17.79, 4.84, 57.26 and 8.19% for DM, OM, CP, CF, EE, NFE and Ash, respectively. The mixture of CFM+BS was supplemented by 2% Sodium bicarbonate (NAHCO3) (T_2 and T4), and/or 33 mg monensin/ kg DM (T_3 and T_4).

Digestibility coefficients and nutritive values of the experimental rations:

Data presented in (Table 3) showed significant differences among different groups in daily DMI g/h/d. As shown, higher (p<0.05) DMI by T_2 group (NAHCO3 groups), *i.e.* 1432.77 g/h/d followed by both of T_4 and T_1(the control) but without significant difference between them, *i.e.1299.28* and 1257.83 g/h/d and later was T_3 (Monensin groups) which recorded the least daily feed intake *i.e.* 1143.18 g/h/d. Results of the present study were similar to that of **Wittayakun *et al*. (2015)** who reported that roughage intake was significantly increased due to NaHCO3 supplementation to dairy cow's rations. Furthermore, the addition of sodium bicarbonate to grass silage before feeding lambs increased the dry matter intake from 8 to 20% **(Sormunen *et al*., 2006; and Aguilera-Soto *et al*. 2008).** The improvement in nutrients digestibility with sodium bicarbonate supplement to ram's ration may be due to an increase of the total number of ciliate protozoa as well as cellulolytic bacteria **(Santra *et al*., 2003). Salles *et al.* (2008)** suggested that monensin reduced ruminal motility, thereby resulting in increased ruminal fill and reduced feed intake, improvements in feed efficiency with the use of monensin had been also reported.

Table (2): Proximate chemical analysis of different experimental rations on (DM basis %).

Nutrient	BS(2)	CFM(1)	CFM + BS
DM	92.47	92.49	92.49
OM	90.66	92.17	91.81
CP	8.10	13.13	11.92
CF	26.6	14.6	17.79
EE	2.79	5.49	4.84
NFE	53.17	58.95	57.26
Ash	9.34	7.83	8.19

DM*=dry matter,* ***OM****=organic matter,* ***CP****= crude brotein,* ***EE****= ether extract,* ***NFE*** *= nitrogen free extract,* ***CF*** *= crude fiber, (1)* ***CFM****: concentrate feed mixture, (2)* ***BS****: berseem straw.*

Table (3): Digestibility coefficients and Nutritive values of the experimental rations.

Item	Experimental ration			
	T_1	T_2	T_3	T_4
	Dry matter intake g/h/d			
Daily intake g/h/d	$1275.83^{b}\pm 11.49$	$1432.77^{a}\pm 16.98$	$1143.18^{c}\pm 10.96$	$1299.28^{b}\pm 29.35$
	Digestibility Coefficients %			
DM	$57.26^{b}\pm1.17$	$63.65^{a}\pm0.33$	$59.48^{b}\pm1.33$	$60.23^{b}\pm0.48$
OM	$63.28^{b}\pm1.28$	$67.55^{a}\pm.84$	$63.93^{b}\pm1.03$	$64.20^{b}\pm0.15$
CP	$67.49^{b}\pm1.24$	$73.18^{a}\pm0.26$	$68.04^{b}\pm0.87$	$70.64^{a}\pm0.30$
EE	$53.49^{b}\pm0.96$	$62.48^{a}\pm0.57$	$55.29^{b}\pm3.56$	$56.66^{ab}\pm1.27$
CF	$40.94^{b}\pm1.18$	$49.79^{a}\pm.94$	$44.17^{b}\pm0.88$	$44.54^{b}\pm1.42$
NFE	$67.17^{b}\pm1.32$	$72.24^{a}\pm1.48$	$69.98^{ab}\pm1.12$	$69.56^{ab}\pm0.69$
	Nutritive values %			
TDN	$59.76^{b}\pm0.8$	$65.77^{a}\pm0.8$	$62.02^{b}\pm1.1$	$62.33^{b}\pm0.14$
DCP	$8.09^{bc}\pm0.14$	$8.7^{a}\pm0.03$	$8.01^{c}\pm0.10$	$8.37^{b}\pm0.05$
C/P ratio	$7.39^{b}\pm0.04$	$7.56^{ab}\pm0.07$	$7.74^{a}\pm0.08$	$7.45^{b}\pm0.03$

a, b and c; means with different superscripts in the same row or column are significantly different from each other (p≤ 0.05).

As for digestibility coefficient of different rations, it was shown higher ($p<0.05$) digestibility values for T_2 in different terms in compare with the other different groups, *i.e.* 63.65 % DM. in compare with T_4, T_3 and T_1 which did not differ ($p<0.05$) from each other in such criteria, *i.e.* 60.23, 59.48% and 57.26%, respectively. Also, it was shown higher ($p<0.05$) OM digestibility value for T_2 in compare with the other groups, *i.e.* 67.55 %, in compare with T_4, T_3 and T_1 which did not differ ($p<0.05$) from each other, *i.e.* 64.2, 63.93% and 63.28%, *respectively*.

As for CP digestibility, it was shown higher ($p<0.05$) CP digestibility value for both of T_2 and T_4 groups in compare with T_3 and T_1 *i.e.* 73.18 and 70.64 *vs.* 68.04 and 67.49%, respectively. EE digestibility values indicated ($p<0.05$) differences among groups, however T_2, recorded the highest value (62.48%) in compare with the other groups, but without significant difference with T_4, while (T_3 and T_1) recorded the lowest ($p<0.05$) value 55.29 and 53.49%, respectively. As for CF digestibility, it was shown higher ($p<0.05$) CF digestibility value for T_2 in compare with the other groups, *i.e.* 49.79%. On the contrarily, T_4, T_3 and T_1 did not differ ($p<0.05$) from each other, *i.e.* 44.54, 44.17% and 40.94%, respectively. Results of the present study were similar to that reported by (Faulkner *et al.*, 1985) who showed that feeding monensin at high, low and intermediate levels in a diet that was 800 g cornstalks /kg (DM) , led to increase OM and neutral detergent fiber (NDF) digestion coefficient values, thereby contributing to a parallel increase feed efficiency. Similarly, Hadjipanayiotou *et al.* (1982), added sodium bicarbonate to a diet of sheep fed mainly concentrates and obtained an improvement in DM and NDF digestibility. NFE digestibility values, indicated ($p<0.05$) differences among groups, however T_2, recorded the higher value (72.24%) in compare with the other tested groups, but without significant difference with both of T_3 and T_4 ,while (the control) recorded the lowest ($p<0.05$) value 67.17%. As a general conclusion, it was noticed that sodium bicarbonate and monensin led to improve nutrients digestibility values in compare with that of the control ones, and sodium bicarbonate rations surpassed the corresponding monensin ones.

Experimental rations nutritive value, (Table 3):

Nutritive values of different experimental rations differed ($p<0.05$), in different nutritional terms, and confirmed the previous observations related to digestibility values; since dietary sodium bicarbonate group (T2) surpassed that of the corresponding monensin groups in dietary TDN value, *i.e.* 65.77%, TDN *vs.* 62.33, 62.02 and 59.76%, for T4, T3 and T1, respectively. DCP values indicated significant ($p<0.05$) differences among groups; T_2 group recorded 8.7% *vs* 8.37, 8.09, and 8.01% for T_4.T_1 and T_3, respectively. **Calorie/protein ratio** as a nutritional measurement, indicated significant differences ($p<0.05$) among different experimental rations , however T_3, recorded the highest value 7.74 in compare with the other groups, but without significant difference with T_2, while ($T_4$and T_1) recorded the lowest ($p<0.05$) values 7.45 and 7.39 ,respectively.

Effect of dietary sodium bicarbonate and monensin supplements on nitrogen retention (g/h/d) of crossbred male lambs:

As shown (Table 4), higher ($p<0.05$) NI was recorded for both of T_1 and T_2 groups, *i.e* 31,32 and 31,35 g/h/d; but lower ($p<0.05$) one was detected with both of T_3 and T_4 groups and without significant difference between them.

As shown, (T_1 and T_2) groups indicated almost similar and insignificant fecal N excreted/h/d, *i.e*. 10.14 and 10.20 g/h/d ,respectively and both were significantly differed with both of T_3 and T_4, which recorded lower ($p<0.05$) fecal excreted values, but without significance between them . Fecal N excretion was (8.5, 8.32 g/h/d) for both of T_3 and T_4, respectively.

Table (4): Effect of dietary sodium bicarbonate and monensin supplements on nitrogen retention (g/h/day) of crossbred male lambs.

Item	Experimental ration			
	T_1	T_2	T_3	T_4
N intake g/h/d	$31.32^a±0.15$	$31.35^a±0.20$	$29.05^b±0.15$	$29.08^b±0.11$
Fecal N g/h/d	$10.14^a±0.32$	$10.2^a±0.11$	$8.5^b±0.20$	$8.32^b±0.08$
N digested g/h/d	21.19±0.42	21.14±0.27	20.55±0.23	20.76±0.19
Urinary N g/h/d	6.13±0.14	6.02±0.175	6.2±0.04	6.25±0.053
Total excreted Ng/h/d	$16.26^a±0.18$	$16.22^a±0.08$	$14.69^b±0.25$	$14.57^b±0.11$
N balance g/h/d	15.06±0.28	15.12±0.13	14.36±0.27	14.52±0.22
% N balance /intake	48.08±0.73	48.25±0.12	49.43±0.86	49.89±0.57
% N balance/Digested	$71.09^{ab}±0.15$	$71.54^a±0.51$	$69.85^b±0.54$	$69.91^b±0.47$

a, b and c; means with different superscripts in the same row or column are significantly different from each other (p≤ 0.05).

Similar and insignificant urinary N excreted was also detected for different nutritional groups, irrespective of dietary sodium bicarbonate and monensin supplements. Such observations resulted consequently in almost similar and insignificant N balance for different experimental groups. However, (T_3 and T_4) groups, irrespective of sodium bicarbonate and Ionophore supplemental source indicated lower insignificant values. Higher N balance values, *i.e.*15.12 and 15.06 g/h/d, for both of (T_2) and (T_1) groups, respectively. In this regard, values of N intake, and its excretion value in both feces and urine, led to insignificant N retention. Similar results were reported by (Tripathi *et al.*, 2004). There was no effect on the nitrogen balance due to adding sodium bicarbonate to lambs rations (Bodas *et al.*, 2014). According to Faulkner *et al.* (1985), greater amount of nitrogen reaches the abomasum from the diet when ionophores are added. According to, Muntifering *et al.*, (1981) monensin decreased the contribution of bacterial N and increased the contribution of ruminally undegraded dietary N to total abomasal N. Data presented in (Table 4) indicated almost similar insignificant NB values, irrespective of significant dietary N intake/h/d in different groups (neither in sodium bicarbonate nor monensin) supplemented ones. Such results might conclude that neither CP content of the ration (Table 1), nor its availability and digestibility or rations nutritive values (Table 3) lead to significant influences on N retention/h/d under such rations formula and dietary probiotic supplements.

Effect of dietary sodium bicarbonate and monensin supplements on some ruminal measurements:

***pH**:*

Data presented in (Table 5), indicated significant differences among different groups in ruminal pH value. As shown, (T_2 and T_4) indicated almost relatively similar pH value, irrespective of the significant difference between them ($p<0.05$), *i.e.* 6.89 and 6.74 respectively, while (T_3 and T_1) groups showed lower ($p<0.05$) pH, *i.e.* 6.56 and 6.53, respectively and without significant difference between them. The latter observation may be related to sodium bicarbonate as dietary acidity regulators, hence resulted in lower ruminal acidity value. Similar results were reported by Farghaly *et al*. (2019), who found that adding sodium bicarbonate to rams rations, led to ($P<0.05$) ruminal pH values as compared with the control diet. According to Hossam *et al*. (2015), Monensin supplement did not affect pH value. As for the effect of time of sampling on pH value; it was shown higher ($p<0.05$) value, before feeding, which dramatically declined without significant difference at 3 and 6 hrs. post feeding *i.e.* 6.26 and 6.36, respectively.

NH3-N (mg/100ml):

Data presented in (Table 5) pointed out to insignificant differences among different groups in NH3-N value. As shown, T_1 showed higher NH3-N values and both the two monensin groups recorded higher insignificant NH3-N values in compare with (T_4 and T_2). With regard to the effect of time of sampling on NH3-N release, it was shown higher ($p<0.05$) NH3-N concentration, 3hrs post feeding *i.e.* 13.4 mg/100 ml; indicating the peak of NH3-N concentration in compare with lower ($p<0.05$) values before feeding (9.15mg/ 100ml) which increased ($p<0.05$) to (11.68 mg/100ml) 6 hrs. post feeding. Similar results were obtained by Hossam *et al*. (2015), who found that ammonia concentration due to dietary monensin supplement led to decrease ruminal protein breakdown and deamination, besides lower ruminal ammonia N; however (Askar *et al*., (2011) reported that ammonia concentration was not affected by dietary sodium bicarbonate (1.5 %), but the total concentration of volatile fatty acids tended to increase with buffer supplementation.

TVFA's (meq/100ml):

Total volatile fatty acid concentration indicated significant differences among different groups, recording higher ($p<0.05$) TVFA's values for T_2 group in compare with (T_1 and T_3) groups, but without significant difference with T_4. Such result might point out to an obvious influence of sodium bicarbonate, rather than monensin supplement on TVFA's production. Similar results were reported by Askar *et al.* (2011), who indicated that ammonia concentration was not affected by dietary sodium bicarbonate (1.5 %), but the total concentration of volatile fatty acids tended to increase with buffer supplementation; while Martins *et al.* (2018), observed that the use of 25 mg of monensin kg^{-1} of DM in diets containing a high level of flint corn ground for lambs did not affect the ruminal concentration of short chain fatty acids. As for the effect of time of sampling, it was shown higher ($p<0.05$) TVFA's production at 3 hrs. post feeding (41.45 meq/100 ml) reaching the peak, declined ($p<0.05$) to (37.31 meq/100 ml) at 6 hrs. post feeding, while the least ($p<0.05$) TVFA's concentration was detected before feeding (23.9 meq/ml).

Such results, coincide with the similar trend previously noted with NH3-N concentration in its mode, as time of sampling affected NH3-N and TVFA's production in a normal distribution mode, indicating lower ($p<0.05$) values, before feeding and 6 hrs. post feeding, but higher ($p<0.05$) one at 3 hrs.

Effect of dietary sodium bicarbonate and monensin supplements on growth performance and feed conversion ratio of growing crossbred male lambs:

Data presented in (Table 6) indicated insignificant differences among different experimental groups in terms of *Initial and final live body body wt.*(kg), being insignificantly higher for T_2, T_4 and T_3 groups ,respectively in compare with T_1, however significant differences ($p<0.05$) were detected in total body weight gain (kg) and avg. daily gain (g/h/d) for T_2 ,T_4 and T_3 ,respectively .Moreover, sodium bicarbonate groups (T_2 and T_4) surpassed (T_1), but without significant difference with the monensin group (T_3) . Similar results were reported by Tripathi *et al.* (2004), who reported that total live body weight gain and average daily gain were higher in lambs supplemented with sodium bicarbonate. Similarly, Duffield *et al*. (2012) reported that, in diets containing a high concentration of readily fermentable carbohydrates (*i.e.*, feedlot diets), ionophores generally influence feed efficiency by improving or maintaining body weight gain and reducing daily feed intake. Such results (Table 6) might be related to the higher palatability, nutritive value and digestibility coefficient values, of the former groups (Table 3) *i.e.* T_2 &T_4, respectively.

Growth rate as percentage of initial LBW (kg); indicated significant differences ($p<0.05$) among different nutritional groups and favored T_2 group as the most heavier weight and faster gain, but without significant differences with T_3 and T_4 groups. Moreover, T_2, T_4 and T_3 groups indicated higher growth rate percentage in compare with the control (T_1), *i.e.* 60.7, 57.16 and 55.07 %, respectively *vs* 47.35 %, for T_1. Regarding daily feed intake (g/h/d), significant differences ($p<0.05$) were detected among different nutritional groups. As shown T_2 indicated higher ($p<0.05$) daily feed intake value. Moreover, both the two sodium bicarbonate groups *i.e.* T_2 and T_4, recorded higher ($p<0.05$) daily feed intake in compare with T_3 *i.e* the monensin group. Nutritional terms of daily feed intake as DMI, TDNI and DCPI/h/d, indicated significant differences among different experimental groups.

Regarding the effect of dietary sodium bicarbonate and monensin supplements on crossbred male lambs feed conversion ratio as kg DMI, TDNI and DCPI/kg LBW gain, it was shown significant differences ($p<0.05$) among different nutritional groups.

Table (5): Effect of dietary sodium bicarbonate and monensin supplements on some ruminal measurements.

Items	time (hrs)	Experimental rations T_1	T_2	T_3	T_4	Overall mean	SE
pH	0	7.27	7.57	7.42	7.38	7.41^a	
	3	6.09	6.47	6.10	6.40	6.26^b	0.39
	6	6.23	6.64	6.15	6.43	6.36^b	
	Overall mean	6.53^c	6.89^a	6.56^c	6.74^b		0.04
NH3–N (mg/100ml)	0	10.00	8.67	9.01	8.94	9.15^b	
	3	13.68	13.31	13.64	12.98	13.40^a	0.3
	6	12.76	12.45	12.99	12.53	12.68^a	
	Overall mean	12.15	11.48	11.88	11.48		0.35
TVFA' s (meq/100 mL)	0	23.14	23.99	24.09	24.38	23.9^c	
	3	40.60	44.63	40.49	40.09	41.45^a	0.59
	6	35.53	40.20	34.30	39.21	37.31^b	
	Overall mean	33.09^b	36.27^a	32.96^b	34.56^{ab}		0.68

a, b and c; means with different superscripts in the same row or column are significantly different from each other ($p\leq 0.05$).

However, both of T_3 and T_4 groups surpassed ($p<0.05$) T_1 and T_2 groups in their feed conversion ratio and being more efficient in converting DM, TDN and DCP intakes to live body weight gain. Results of FC ratio indicated reverse results with previous trends, since both of T_2 and T_4 groups, surpassed T_1 and T_2 groups in different growth performance criteria. As shown T_3 (monensin group) was the most efficient one, while (T_1) group was the least efficient (Table 6). Such results might be referred to the lower ($p<0.05$) feed intake for both of T_3 and T_4 groups with relatively higher ($p<0.05$) daily gain. On the contrarily, T2 (bicarbonate group) and the control T_1 recorded lower ($p<0.05$) feed conversion ratio, which might be referred mainly to the higher ($p<0.05$) daily feed intake for the former and the lower ($p<0.05$) daily gain for the later (the control). Similar results were reported by **Duffield *et al*., (2012)** who stated that, Ionophores generally influence feed efficiency by improving or maintaining body weight gain and reducing feed intake, while **Tripathi *et al* (2001)** concluded that incorporation of $NaHCO3$ to a high concentrate diet fed to weaned lambs improved lambs growth by 35% at 15.0 g $NaHCO3$ per kg DM feed by improving both of feed intake and fiber digestibility.

Effect of dietary sodium bicarbonate and monensin supplements on economic efficiency of growing male lambs:

Results obtained in (Tables 6 & 7) indicated significant differences ($p<0.05$) among different crossbred male lambs groups in FC ratio as (kg DMI/kg gain). As shown, higher ($p<0.05$) FC ratio for male lambs raised on monensin group (T_3) , but without significant difference with T_4, while both of (T_3 and T_4) surpassed T_2 (sodium bicarbonate group) and the control one; values obtained were 5.1, 5.6, 6.02 and 6.67 kg/DMI/kg gain for T_3,T_4,T_2 and T_1, respectively. Feed cost/ kg gain indicated significant differences ($p<0.05$) among different groups, being higher for both of T_1, T_2 and T_4 groups, respectively in compare with T_3 (monensin group).

Hence, the net profit value/group indicated significant values, being higher ($p<0.05$) with the lower feed cost/kg gain, *i.e.*T_3 and *vice versa* for the corresponding higher feed coasted groups, *i.e.* T_4, T_2 and T_1, respectively.

Table (6): Effect of dietary sodium bicarbonate and monensin supplements on growth performance and feed conversion ratio of growing crossbred male lambs.

Item	Experimental ration			
	T_1	T_2	T_3	T_4
Initial body wt. (kg)	34.6±3.03	34.8±2.92	34.6±2.94	34.6±2.99
Final body wt. (kg)	50.5±3.05	55.1±2.59	53.1±2.96	53.9±3.43
Total body gain (kg)	15.9^{b}±0.29	20.3^{a}±1.69	18.5^{ab}±0.16	19.3^{a}±0.56
Daily gain (g)	191.57^{b}±3.51	244.58^{a}±20.39	222.89^{ab}±1.91	232.53^{a}±6.76
Growth rate (%)	47.35±4.05	60.7±8.62	55.07±4.76	57.16±4.33
Daily feed intake (g/h/d)				
DM intake	1275.83^{b}±11.49	1432.77^{a}±16.98	1143.18^{c}±10.96	1299.28^{b}±29.35
% DMI /Control	100^{b}±0	112.3^{a}±1.33	89.8^{c}±0.86	101.84^{b}±2.23
TDNI	762.43^{C} ±6.87	942.33^{a}±11.16	709^{d} ±6.8	809.84^{b}±18.29
DCPI	103.22^{c}±0.93	124.65^{a}±1.48	91.57^{d}±0.88	108.75^{b}±2.46
Feed conversion ± SE(Kg intake/kg gain)				
DMI / kg gain	6.67^{a}±0.12	6.02^{ab}±0.49	5.13^{c}±0.07	5.6^{bc}±0.11
%Kg DMI /kg gain /cont	100^{a}±0	90.2^{ab}±7.31	76.92^{c}±1.64	83.89^{bc}±1.64
TDNI / Kg gain	3.96^{a}±0.07	3.96^{a}±0.32	3.18^{b}±0.04	3.49^{ab}±0.07
DCPI / Kg gain	0.54^{a}±0.01	0.52^{a}±0.04	0.41^{b}±0.01	0.47^{ab}±0.01

a, b,c and d; means with different superscripts in the same row or column are significantly different from each other (p≤ 0.05).

Table (7): Effect of dietary sodium bicarbonate and monensin supplements on economic efficiency of growing crossbred male lambs.

Item	Experimental ration			
	T_1	T_2	T_3	T_4
T.LBW gain (Kg)	15.9^{b}±0.29	20.3^{a}±1.69	18.5^{ab}±0.16	19.3^{a}±0.56
DMI /kg gain	6.67^{a}±0.12	6.02^{ab}±0.49	5.13^{c}±0.07	5.6^{bc}±0.11
Feed cost /Kg gain (LE)	45.01^{a}±0.81	44.04^{a}±3.57	34.65^{b}±0.47	40.99^{a}±0.80
T. Net profit (L.E /head/group	636.72^{b}±24.04	855.00^{ab}±148.92	931.57^{a}±15.56	850.57^{ab}±36.63

a, b,c and d; means with different superscripts in the same row or column are significantly different from each other (p≤ 0.05). Current market price (LE/kg live body wt.) in 2022 =85 LE.

The higher ($p<0.05$) feed cost /Kg gain was mainly related to either the higher ($p<0.05$) daily feed intake/h/day in one hand (T_2 &T_1) or to the lower ($p<0.05$) gain on the other hand (the control group). Hence, the net profit value/group differed ($p<0.05$) due to FC ratio of each group, being higher ($p<0.05$) for both of T_3 and T_4 and lower ($p<0.05$) for T_1 and T_2, respectively. The least net profit value was recorded by T_1 group. Total feed costs/group and the net profit values (LE/group) indicated similar trends, with higher ($p<0.05$) net income for T_3 and lower one with the control group. Similar results were reported by (Van Nevel and Demeyer, 1977), economic benefits derived from feeding Ionophores include improved feed efficiency, increased weight gain and a reduction in morbidity and mortality rate. On the other hand, (Tripathi *et aI.*, 2014), reported that total live weight gain and average daily gain were higher in lambs supplemented with sodium bicarbonate. Thus, inclusion of NaHCO3 might have been increased due to ruminal efficiency of microbial N capture, which would have resulted in an increment in average daily gain, carcass quality and the FC ratio.

CONCLUSION

It was shown that supplementing growing lambs rations with sodium bicarbonate, helps to maintain rumen pH by equating it to an optimum level corresponding to the bioactivity of bacteria that analyze cellulose and rations rich in their overload content of concentrates and leading in turn to an acceptable concentration of TVFA's, which consequently was reflected on improving lambs productive performance. Philosophy of using Ionophores as food additives to ruminant rations had a positive impact on accelerating lambs growth rate and had a positive role in improving the efficiency of feed conversion ratio due to reducing daily feed intake, even with the stability of lamb's growth rate.

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تأثير التدعيم ببيكربونات الصوديوم والايونوفورات على كفاءة الهضم والنمو في الحملان المغذاة علي علائق غنيه بالمركزات

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أجريت هذه الدراسة بمحطة البحوث الزراعية التابعة لقسم الإنتاج الحيوانى بكلية الزراعة جامعة الأزهر بمدينة نصر بالقاهرة وتم إستخدام عشرون من ذكور الحملان الهجين(فنلندى أوسيمى) ، تم توزيعهم عشوائياً على أربع مجموعات غذائية لمدة 83 يوماً. وكانت الحصص التجريبية المستخدمة كالتالى ، المجموعة الأولى (كنترول): 75% علف مركز + 25 % تبن برسيم , المجموعة الثانية:75%علف مركز +23% تبن برسيم +2% بيكربونات صوديوم , المجموعة الثالثة:75%علف مركز +25% تبن برسيم +33 ملليجرام/كجم مادة جافة (موننسين) , المجموعة الرابعة :75 %علف مركز +23% تبن برسيم +2% بيكربونات صوديوم +33 ملليجرام/كجم مادة جافة (موننسين) ، على أساس خليط العلف المركز (13.13٪ بروتين خام) وتبن البرسيم كمصدر للمادة خشنة. كان الهدف من الدراسة هو التقييم الغذائى لدعم علائق الحملان النامية، الغنية بالمركزات ببيكربونات الصوديوم كمنظم للحموضه والمونينسين كمنشط نمو، وتأثير ذلك على كفاءة التخمرات بالكرش وكفاءه آداءالحملان النامية. تم تقدير بعض مقاييس التخمر بالكرش وكذا معدلات نمو الحملان النامية وكفاءة التحويل الغذائى لها.

وأشارت النتائج المتحصل عليها إلى أن إضافة بيكربونات الصوديوم بنسبة 2٪ أدى إلى زيادة معنوية عند مستوى 5% على كمية المادة الجافة المأكولة ، ومعاملات الهضم المختلفة ، وقيم الأس الهيدروجيني ، وتركيزات الأحماض الدهنية الطيارة ، والكفاءة التحويلية للحملان, وإن لم يتأثرمستوى الأمونيا بالكرش . أدت إضافة المونينسين بمعدل 33 ملجم / كجم مادة جافة إلى زيادة معنوية عند مستوى 5% فى تحسين الكفاءة التحويلية للحملان. وعلى العكس من ذلك ، لم تتأثر قياسات الكرش ولا ميزان النيتروجين ، حيث أدت إضافة المونينسين للعلائق إلى تحسين معامل الهضم وزيادة معدل النمو اليومى للحملان (جرام) ، ولكن مع انخفاض معنوى عند5 % للمأكول اليومي من العلف ، زيادة على ذلك فقد أدت إضافة (بيكربونات الصوديوم 2٪ مع المونينسين بمعدل 33 ملجم / كجم مادة جافة) إلى زيادة معنوية عند5 % فى الكفاءة التحويلية ، قيمة الأس الهيدروجيني ، النمو اليومي للحملان ، معاملات الهضم المختلفة ولكن مع إقتران ذلك بزيادة معنوية فى تكاليف التغذية / كجم زيادة وزنية. ومع ذلك لم تتأثرتركيزات الأحماض الدهنية الطيارة ولا الأمونيا بالكرش وقيم ميزان النيتروجين للحيوانات.

الإستنتاج : بناء على النتائج المتحصل عليها فإنه يوصى بإضافة بيكربونات الصوديوم أو الموننسين أو كليهما (بالمعدلات السابق إختبارها) لعلائق الحملان النامية المغذاه على علائق غنية بالمركزات ، نظراً لما ثبت بالدراسة من جدواها إنتاجياً وإقتصاديا على زيادة معدلات النمو ورفع كفاءة التحويل الغذائى للحملان مما إنعكس أثرة لاحقا على تعظيم صافى أرباح المربين.