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RESPONSE OF GROWING LAMBS AND GOAT KIDS TO DIETARY SODIUM BICARBONATE SUPPLEMENT

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SUMMARY

In 2x2 factorial experiment, the response of growing sheep and goats fed free choice concentrate and roughage to dietary supplement of sodium bicarbonate was evaluated. Animals consumed 77% concentrate and 23% hay when both berseem hay and concentrate mixture were free choice offered to sheep and goats.

No significant differences in nutrient digestibilites due to dietary supplement or species differences were detected. Sheep showed higher ($P<0.05$) ruminal pH, VFA's but lower ammonia concentrations. Dietary sodium bicarbonate increased ($P<0.05$) ruminal pH, ammonia and insignificantly the VFA's concentrations.

Sodium bicarbonate improved the average daily gain (ADG) and feed efficiency of sheep but had no significant effect on ADG of goats. The ADG was 192.9 and 213.2 g/day for sheep fed unsupplemented and supplemented rations, respectively. The corresponding values for goats were 89.45 and 79.12 g/day.

Goats showed insignificant less water consumption and excretion than sheep and sodium bicarbonate had no significant effect on water metabolism.

It could be concluded that the effects of buffer supplement on nutrient utilization and growth performance of sheep and goats were limited when they were fed rations containing 77% concentrates. However, sheep showed higher response to buffer supplement than goats.

Keywords: Sheep, goat, sodium bicarbonate, growth, digestibility, intake, rumen fermentation, water metabolism

INTRODUCTION

Supplementation with concenterate is important procedure in economical intensive meat and milk production specially from high producing animals.

Although feeding diet composed of roughage and concentrate may increase daily weight gain, readily fermentable carbohydrates present in the concentrates were reported to disrupt the normal digestion in the rumen, depress fiber digestion, lower ruminal pH, inhibit cellulolytic organisms and cause acidosis (Leventini *et al.*,1990).

Ruminal buffer specially sodium bicarbonate showd an ability to maintain ruminal pH at a level that was not inhibitory to cellulolytic activity and improved nutrient utilization by beef cattle (Trenkle *et al.*,1979).

The objective of the present study is to evaluate the effects of sodium bicarbonate as dietary buffer on nutrient utilization and growth performance of sheep and goats fed high concentrate diets.

MATERIALS AND METHODS

Twelve weaned Rahmani lambs and twelve Zaraibi goat kids with an average age of 6 months were used in 2 factor-factorial design to evaluate the effect of dietary sodium bicarbonate supplement on nutrient utilization and growth performance up to 9 months of age. Animals of each species were blocked by weight and randomly assigned to 2 pens (six animal/pen). The initial average body weight was 24.30 kg for lambs and 14.58 Kg for kids.

Concentrate mixture and berseem hay were offered *ad libitum*. Dry matter intake and roughage: concentrate ratio were daily recorded for 90 days experimental period. Animals were watered twice a day and daily *ad libitum* water intake was daily recorded.

Composition of feeds and experimental rations is shown in Table 1. Sodium bicarbonate was added to the concentrate mixture of the sodium bicarbonate supplemented ration at the rate of 2%. Animals were group fed and weekly weighed.

Four metabolism trails using twelve animals were conducted at the end of the experimental period to evaluate the effect of sodium bicarbonate on nutrient digestibilities and nitrogen and water balances by lambs and kids at the end of growth trial. Animals were individually housed in metabolic cages for 10 days where feces and urine were collected. Chemical composition of feed, feces and urine were determined according to A.O.A.C. (1980).

Rumen liquor samples were collected by using stomach tube from all animals at the end of the metabolism trails at 0, 3 and 6 hrs. after morning feeding. Ruminal pH, total volatile fatty acid's (Kromann *et al.*, 1967) and ammonia concentrations (Conway, 1963) were determined.

Data of nutrient digestibilities, nutritive value, nitrogen and water balances and body weight were subjected to 2 factor- factorial analysis of variance, while data of ruminal pH, VFA's and ammonia-N concentrations were analyzed as 3 factor factorial (SAS, 1984) according to the following models.

Duncan Multiple Range test (Duncan, 1955) was used to test the differences among means of treatments.

$X_{ij} = U + X_i + X_j + e_{ijk}$ and

$X_{ij} = U + X_i + X_j + X_k + e_{ijkl}$

where: X_i = effect of dietary treatment and i =1-2

X_j = Animal Specie effect and j= 1-2

X_k = Effect of sampling time and k=1-3

e_{ijkl} = experimental error

RESULTS AND DISCUSSION

Chemical composition of the experimental feeds and rations is presented in Table 1. Rations contained about 18% crude protein and 15% crude fiber. The relative low crude fiber content of the experimental ration is related to that sheep and goats consumed about 77% concentrate when berseem hay and concentrate were free choice offered. The slight lower values of all nutrient except ash content of the sodium bicarbonate supplemented ration is a direct result of incorporation of 2% sodium bicarbonate to that ration.

Table 1. Chemical composition of experimental feeds and ration

Item	Concentrate mixture*	Berseem hay	Experimental rations	
			Without buffer	With buffer
DM, %	89.40	88.70	89.26	89.58
Dry matter composition, %				
OM	94.50	85.90	92.80	92.22
CP	19.16	15.02	18.30	17.96
CF	11.10	34.00	15.70	15.36
EE	3.00	2.00	2.80	2.72
NFE	61.24	34.88	56.00	56.18
Ash	5.50	14.10	7.20	7.78

* Concentrate mixture composed of 32.5% yellow corn, 32.5% barley, 32.5% soybean meal, 1.8% limestone, 0.5% common salt and 0.2% vitamin-mineral mixture.

No significant effects due to animal species or buffer supplement were detected on nutrient digestibilities and nutritive value. However, sheep tended to have higher values than goats and buffer supplemented ration showed higher nutrient digestibilities except EE than the control one (Table 2).

Nutrient digestibilities and nutritive value of unsupplemented and buffer supplemented ration fed to sheep and goats are shown in Table 3. The lack of effect of sodium bicarbonate on total tract nutrient digestibilities are in agreement with those found by Hadjipanayiotou (1988) with Damascus goat kids, DePeters *et al.* (1984) and Orozco *et al.* (1995) using high concentrate

rations fed to dairy cows. However, Rogers *et al.* (1985) and El-Bedawy *et al.* (1989) using all barley diet reported an improvement in nutrient digestibilities specially carbohydrate due to incorporation of 2-3 % sodium bicarbonate in rations of dairy cow and goats, respectively. The contradicted effects of buffer supplement might be due to the variation in ration composition.

Table 2. Mean values of nutrient digestibilities and nutritive value of the experimental rations as affected by animal species and buffer supplement

	Mean effect of species		Mean effect of treatment		SE
	Sheep	goat	T1	T2	
Digestibility, %					
DM	77.45	75.94	75.80	77.61	1.28
OM	79.94	77.61	77.90	79.65	1.12
CP	76.40	73.07	73.49	75.99	1.44
CF	53.79	50.95	50.20	54.55	2.50
EE	71.67	68.84	73.12	67.39	3.25
NFE	88.89	87.80	87.85	88.84	0.73
Nutritive value, %					
TDN	76.23	73.93	74.35	75.81	1.34
DCP	14.02	13.32	13.41	13.94	0.25

Table 3. Effect of sodium bicarbonate supplementation on nutrient digestibilities and nutritive value by sheep and goats

Item	Without buffer		With buffer		SE
	Sheep	Goat	Sheep	Goat	
Digestibility, %					
DM	76.93	74.66	78.00	77.21	1.81
OM	79.39	76.40	80.48	78.82	1.59
CP	76.50	70.47	76.31	75.66	2.03
CF	52.63	47.76	54.94	54.15	3.54
EE	77.36	68.88	65.99	68.80	4.59
NFE	88.12	87.58	89.66	88.03	1.03
Nutritive value, %					
TDN	76.38	72.31	76.08	75.54	1.89
DCP	14.05	12.77	13.99	13.88	0.35

No difference in DM intake due to dietary treatment was detected (Table 4). Dry matter intakes by sheep were 1470 and 1477 g/h/day for the unsupplemented and buffer supplemented rations, and 701 and 697 g/h/day for the respective groups of goat kids. Figure 1 showed that sheep fed buffer

supplemented ration tended to decrease their concentrate intake during the first four weeks of the experiment. However, goats fed the same ration kept their concentrate intake parallel to that of the control group during the entire experimental period. No differences in roughage intake between the two dietary treatments was observed during the 13 week experimental period (Fig. 2). Hadjipanayiotou (1988) found no effect of dietary sodium bicarbonate supplement on feed intake. However, El-Bedawy *et al.* (1989) found 15% decrease in dry matter intake of all barley diet supplemented with sodium bicarbonate by lactating goats. The different response among the studies migh be due to the different used basal rations, type and concentrations of buffer and animal species.

Sheep fed buffer showed higher ($P<0.05$) average daily gain (ADG) than sheep fed the control ration (213.19 *vs.*192.86 g/day). This trend was not obvious for goats. Hadjipanayiotou (1988) found that goat kids fed sodium bicarbonate supplemented diets gained more body weight but differences were not significant.

Table 4. Effect of feeding sodium bicarbonate supplemented rations on growth performance of sheep and goats.

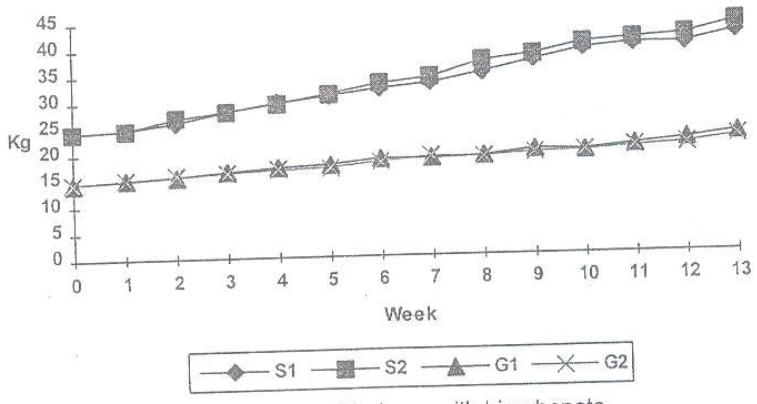
Item	Without buffer		With buffer		SE
	Sheep	Goat	Sheep	Goat	
DM intake, g/day					
Concentrates	1135	545	1135	536	
Hay	335	156	342	161	
Total	1470	701	1477	697	
Roughage, %	23	22	23	23	
Nutrient intake, g/day					
TDN	1123	507	1124	527	
DCP	207	90	207	97	
Initial Wt.,Kg	24.30a	14.58b	24.30a	14.58b	2.09
Final Wt, Kg	41.85a	22.72b	43.70a	21.78b	2.37
Total gain,Kg	17.55b	8.14c	19.40a	7.20c	0.47
ADG, g/day	192.86b	89.45c	213.19a	79.12c	5.18
Feed conversion ratio					
DM	7.62	7.84	6.93	8.81	
TDN	5.82	5.67	5.27	6.66	
DCP	107	101	97	123	

^{a,b,c}Means in the same row with different superscripts differ at $P<0.05$.

Sodium bicarbonate supplement improved feed conversion ratio calculated either as DM or TDN intake per gain for sheep but not for goats. The improved feed conversion of sheep might be due to that sodium bicarbonate increased (ADG) without significant effect on feed intake but an opposite trend was

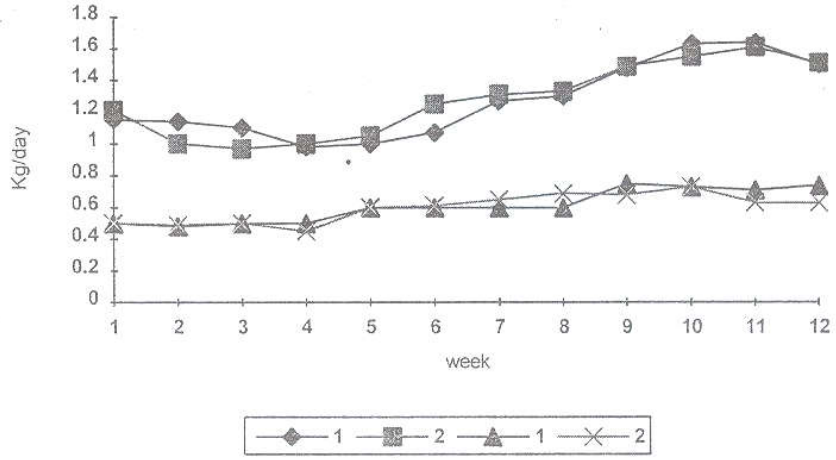
observed for goats. Results in Table 3 showed that there were species differences in the response to buffer supplement in growth and feed conversion since sheep responded positively to buffer supplement but goats showed negative response. The development in body weight during the experimental period is shown in Fig. 3. The species differences between sheep and goats response to dietary sodium bicarbonate was confirmed by the results obtained by Hadjipanayiotou (1988) who found no significant effect of dietary sodium bicarbonate on the ADG of goats but positive effect on ADG was reported in his earlier study on sheep (Hadjipanayiotou, 1982).

Goats showed less ($P>0.05$) water consumption, fecal loss and ($P<0.05$) urinary water loss than sheep. Sodium bicarbonate had no significant effect on water metabolism (Table 5). However, feeding sodium bicarbonate supplemented ration insignificantly decreased water intake and insensible water loss but increased urinary water loss by sheep (Table 6). The opposite trend was observed for goats. In contrary, Hadjipanayiotou (1988) found that water consumption increased by feeding sodium bicarbonate in lactating goats. Moreover, Diven (1975) concluded that water consumption is not adversely affected, and may be increased, when sodium bicarbonate is incorporated into the feed at reasonable levels.



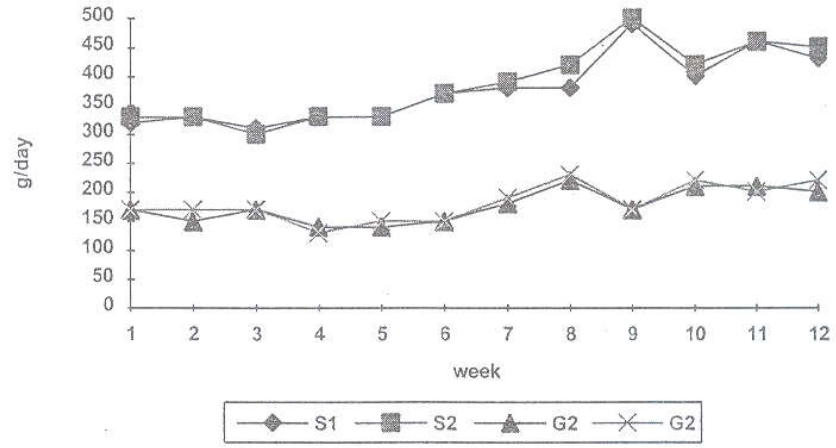
S1 sheep without bicarbonate S2 sheep with bicarbonate
G1 goats without bicarbonate G2 goats with bicarbonate

Figure 1. Effect of dietary sodium bicarbonate supplement on body weight of sheep and goats



S1 sheep without bicarbonate S2 sheep with bicarbonate
G1 goats without bicarbonate G2 goats with bicarbonate

Figure 2. Effect of dietary sodium bicarbonate supplement on concentrate intake by sheep and goats



S1 sheep without bicarbonate S2 sheep with bicarbonate
G1 goats without bicarbonate G2 goats with bicarbonate

Figure 3. Effect of dietary sodium bicarbonate supplement on roughage intake by sheep and goats

Table 5. Mean values of water metabolism (ml/KgW$^{0.75}$) as affected by animal species and buffer supplement

Item	Mean effect of species		Mean effect of treatment		SE
	Sheep	goat	T1	T2	
Intake	226	204	218	212	17
Fecal loss	15	11	13	13	2
Urinary loss	65^{a}	33^{b}	47	50	6
Insensible loss	146	161	158	149	11

^{a,b}Means in the same row with different superscripts differ at P<0.05.

Table 6. Effect of sodium bicarbonate supplementation on water metabolism ml/KgW$^{0.75}$ by sheep and goats

Item	Without buffer		With buffer		SE
	Sheep	Goat	Sheep	Goat	
Intake	235	201	217	207	24
Fecal loss	15	11	16	10	2
Urinary loss	59	35	70	30	8
Insensible loss	161	155	131	167	16

The mean effects of animal species, buffer supplement and sampling time on ruminal pH, VFA's and ammonia-N concentrations (Table 7) showed that sheep had higher (P<0.05) ruminal pH values and VFA's but lower ammonia-N concentrations than goats. Buffer supplement increased (P<0.05) ruminal pH, decreased ammonia-N but had no significant effect on VFA's concentrations. The 2h post-feeding ruminal pH and ammonia-N concentrations were lower (P<0.05) but total VFA's concentrations were higher (P<0.05) than those before feeding.

Table 7. Mean effects of animal species, buffer supplement and sampling time on ruminal fluid pH, VFA's (m. eq./100 ml) and ammonia-N (mg/100 ml) concentrations.

Parameter	Animal species		Buffer		Sampling time	
pH	Sheep	6.85^{a}	without	6.53^{b}	0	6.96^{a}
	Goat	6.55^{b}	with	6.87^{a}	2	6.51^{b}
					4	6.62^{b}
VFA's	Sheep	11.30^{a}	without	10.23	0	8.10^{b}
	Goat	8.47^{b}	with	9.54	2	10.60^{a}
					4	10.96^{a}
Ammonia-N	Sheep	5.41^{b}	without	7.05^{a}	0	6.79^{a}
	Goat	7.17^{a}	with	5.53^{b}	2	6.43^{ab}
					4	5.65^{b}

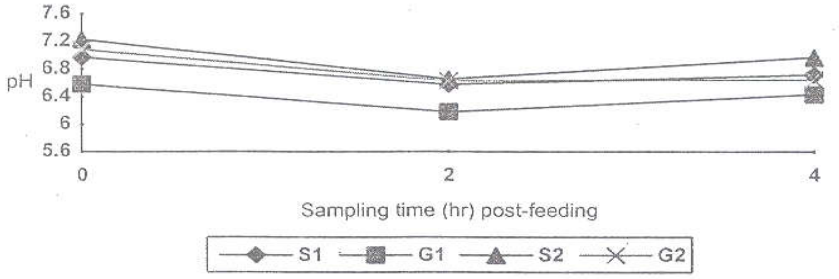
^{a,b}Means in the same column within each trait with different superscripts differ at P<0.05.

The response of sheep and goats to buffer supplement at different sampling times is presented in Table 7 and illustrated in Fig. 4,5 and 6. The increase in ruminal pH of sheep due to buffer supplement was greater than goats at all sampling times (Fig. 4). However, sheep and goats showed similar response in ruminal VFA's and ammonia-N concentrations to buffer supplement at all sampling times. Hadjipanayiotou (1988) found that addition of sodium bicarbonate at a level of 4% of concentrates fed to goat kids significantly increased ruminal pH but did not alter ruminal VFA's and NH_3-N concentrations. However, Gabr *et al.* (1996) found that ruminal pH and ammonia-N concentrations increased but VFA's concentrates had not been significantly affected by feeding buffered diets to lactating cows.

Table 8. Effect of sodium bicarbonate supplementation and sampling time on ruminal fluid pH, ammonia-N (mg/100 ml) and total VFA's concentrations (m.eq./100 ml) of sheep and goats

Sampling time, hr.	pH		Ammonia-N		Total VFA's	
	Sheep	Goats	Sheep	Goats	Sheep	Goats
Without buffer						
Before feeding	6.93^{abcd}	6.58^{d}	7.93	8.17	11.28^{ab}	6.17^{cd}
2 hrs post-feeding	6.58^{d}	6.18e	6.49	8.65	12.40^{a}	9.70^{ab}
4 hrs post-feeding	6.72^{bcd}	6.43e	5.05	6.01	11.43^{ab}	10.37^{ab}
With buffer						
Before feeding	7.23^{a}	7.08^{ab}	4.33	6.73	9.80^{ab}	5.13^{d}
2 hrs post-feeding	6.66^{cd}	6.63^{cd}	4.33	6.25	11.70^{a}	8.58^{bc}
4 hrs post-feeding	6.97^{abc}	6.65^{cd}	4.33	7.21	11.18^{ab}	10.87^{ab}
SE	0.157		0.6158		0.9151	

^{a,b,c,d} Means in the same column within each trait with different superscripts differ at $P<0.05$.



S1 sheep without bicarbonate S2 sheep with bicarbonate
G1 goats without bicarbonate G2 goats with bicarbonate

Figure 4. Effect of dietary sodium bicarbonate supplement on ruminal pH of sheep and goats

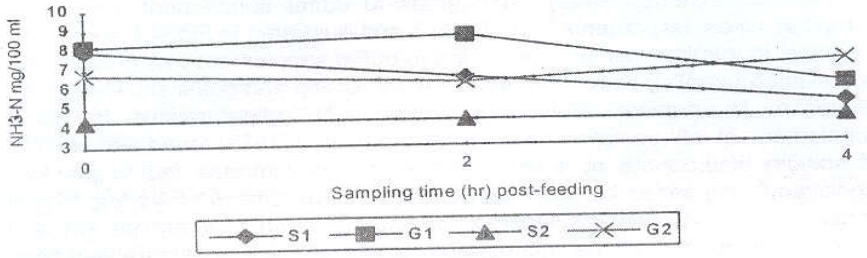


Figure 5. Effect of dietary sodium bicarbonate supplement on ruminal ammonia nitrogen of sheep and goats

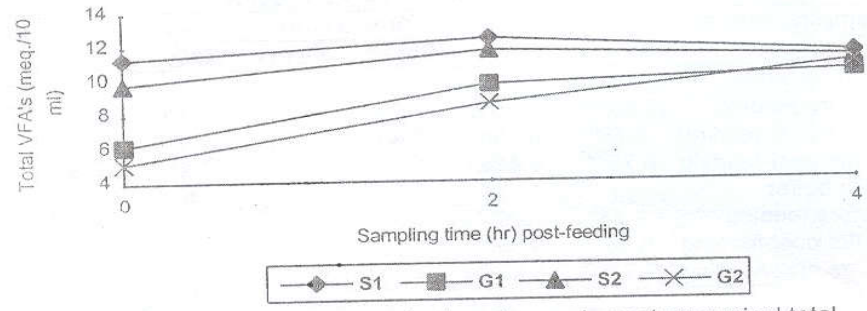


Figure 6. Effect of dietary sodium bicarbonate supplement on ruminal total VFA's concentrations of sheep and goats

It could be concluded that the effects of buffer supplement on nutrient utilization and growth performance of sheep and goats were limited when rations contained 23% roughages and 77% concentrates. However, sheep showed higher response to buffer supplement than goats.

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إستجابة الحملان والجداء النامية لإضافة بيكربونات الصوديوم فى العليقة

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قيمت إستجابة الحملان والجداء المغذاة لحد الشبع على كل من مخلوط مركز و دريس برسيم لاضافة بيكربونات الصوديوم، أستهلكت الأغنام والماعز عليقة تحتوى على ٢٣٪ دريس و٧٧٪ مخلوط مركز عندما تركت لتتغذى بحرية على كلا المادتين. وأظهرت النتائج عدم وجود تأثير لبيكربونات الصوديوم أو نوع الحيوان على معاملات الهضم. ومن حيث مقاييس الكرش فقد أظهرت الأغنام درجة حموضة وتركيزات أحماض دهنية طيارة أعلى وأمونيا أقل. بينما أدت التغذية على العلائق المضاف اليها البيكربونات الى زيادة معنوية فى درجة حموضة سائل الكرش والأمونيا وغير معنوية فى تركيزات الأحماض الدهنية الطيارة.

كما أدت إضافة بيكربونات الصوديوم الى تحسين الزيادة اليومية فى الوزن والكفاءة التحويلية فى الأغنام دون الماعز. وكانت الزيادة اليومية فى الوزن ٢١٣,١٩ جم/يوم فى الأغنام المغذاة على عللى عليقة تحتوى بيكربونات مقابل ١٩٢,٨٦ جم/يوم فى تلك المغذاة على عليقة لاتحتوى البيكربونات. بينما كانت الأرقام المقابلة فى جداء الماعز ٧٩,١٢ و ٨٩,٤٥ جم/يوميا.

لم يتاثر تمثيل الماء بإضافة بيكربونات الصوديوم وكانت جداء الماعز أقل إستهلاكاً وإفرازا للماء عن الحملان. وقد أمكن إستنتاج أ نأثير إضافة بيكربونات الصوديوم كمادة منظمة محدودا على الإستفادة من الغذاء وصفات النمو فى الحملان والجداء عندما غذيت على عليقة تحتوى على ٧٧٪ مخلوط مركز و٢٣٪ دريس البرسيم . هذا على الرغم من أن الحملان قد أظهرت استجابة أعلى نسبيا لإضافة بيكربونات الصوديوم الى العليقة عن الماعز.