Indian J. Anim. Nutr. 2025. 42 (1): 32-39
doi: 10.56093/IJAN.v42i1.5

Indian Journal of Animal Nutrition

Effect of Feeding Exogenous Buffer (Sodium Bicarbonate) as Feed Additive on the Performance of Feedlot Lambs

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ABSTRACT

In the current experiment sodium bicarbonate was used as exogenous buffer to assess its effect on growth performance, nutrient utilization, economics of feeding, blood-biochemistry and rumen fermentation pattern of finishing lambs. A total of fifteen (15) crossbred male lambs (around 11 months age, 20.49±0.74 kg body weight) were selected and randomly allocated in to 3 treatments equally. The lambs in control group (C) were fed basal diet containing roughage and concentrate (R:C) in the ratio of 60:40, while treatment groups fed feedlot rations having R:C ratio of 20:80 without (F) or with Sodium bicarbonate supplementation (FSB) @ 1% dry matter intake (DMI). A feeding trial of 74 days (including 14 days acclimatization period) was conducted, followed by a 10 days metabolism trial at the end of the experiment. The results revealed non-significant differences ($p>0.05$) in terms of dry matter intake (DMI), average daily gain (ADG, g), feed conversion ratio (FCR), and digestibility coefficients of nutrients. The digestible crude protein (DCP%) values of rations were significantly higher ($p\leq0.05$) in the FSB group, but no significant difference ($p>0.05$) was observed in total digestible nutrients (TDN%) values among treatments. Non-significant differences ($p>0.05$) were observed in digestible DMI (kg/d), DCP intake (g/d), and TDN intake (kg/d) between the experimental groups. Nitrogen balance showed non-significant differences ($p>0.05$) among the groups. In FSB group, the reduction in feeding cost and production cost per kg live weight was lesser than F and C group. The haemato-biochemical parameters viz., Haemoglobin (Hb), packed cell volume (PCV), blood glucose, alanine transferase (ALT), aspartate transferase (AST), alkaline phosphatase (ALP), and blood urea nitrogen (BUN) showed improved effect on incorporating Sodium bicarbonate as a feed additive in feedlot ration, however, the results were non-significant ($p>0.05$), but serum creatinine values were significantly higher ($p\leq0.05$) in feedlot groups than control. Rumen pH, total volatile fatty acids (TVFA), ammonia nitrogen, Trichloroacetic acid (TCA) precipitable nitrogen and non-protein nitrogen (NPN) values showed no significant difference ($p>0.05$) among the treatment groups, however, total nitrogen values of rumen liquor were significantly ($p\leq0.05$) higher in feedlot groups than control. So, the present experiment successfully demonstrates the positive effect of incorporating Sodium bicarbonate as a feed additive on the performance of feedlot reared lambs without any adverse effect.

KEYWORDS: Exogenous buffer, Feed additive, Feedlot, Lambs, Sodium bicarbonate

Article received: 10 July 2024; Article accepted: 16 January 2025

INTRODUCTION

India ranks 3rd in sheep production in the world having population of 74.26 million sheep contributing 13.87% to the total livestock population (20th Livestock census, 2019). To fulfil the increasing demand and the deficit, either the number of sheep reared should be increased or the carcass characteristics should be selectively improved according to the consumer demand. Mutton

production needs to be increased either by vertical expansion or by increasing the carcass weight through feeding technique like "feedlotting" (Sahib et al. 2023). The feedlot period is usually about 60 to 80 days and the animal will normally gain 15- 20 kg during this period. In feedlot system of rearing, ADG normally goes above 250g, however, 400 g/day or above can also be achieved by animals that have a higher weight gain potential which comes from genetic traits (Gallo et al. 2014).

Digestive problems account for between 14% to 42% of cattle mortality on feedlots, making them the second most common cause of death (Nagaraja and Lechtenberg, 2007). Laminitis, rumen ulcers, liver abscess, and thromboembolic respiratory illness, are examples of sequels to rumen acidosis that can each have a more severe effect on the health and welfare of animals than the original cause). Hence, upholding a proper ruminal pH is fundamental for the well-being of these animals (Calsamiglia et al., 2012). Sodium bicarbonate ($NaHCO_3$) is commonly supplemented to buffer rumen pH, although its buffering activity is reduced in condition of low rumen pH (5.5-5.8), as it has a pKa of 6.25 (Russell, 1998). In addition, $NaHCO_3$ rapidly solubilizes into rumen fluid, with a fast but not long-lasting buffering activity. Because of this, $NaHCO_3$ is required @ 0.7 to 1 % of the DM to buffer the rumen pH of cattle fed high-energy diets (Krause, 2008). Thus, the present study was undertaken to assess the impact of supplementing $NaHCO_3$ an exogenous buffer on nutrient digestibility, body weight and health status of lambs finished in feedlots.

MATERIALS AND METHODS

Experimental animals, diets and experimental design

A total of fifteen (15) healthy crossbred male lambs (nearly 11 months age, 20.49±0.74 kg body weight) maintained at Mountain Research Centre for Sheep and Goat (MRCS & G), Shuhama, Srinagar, Jammu and Kashmir were randomly divided into three treatment groups of five animals (n=05) each in a completely randomized block design (CRD). During the study period, the experimental animals were handled as per approved trial protocol regulations of the Institutional Animal Ethics Committee SKUAST-Kashmir (Registration no.: 1809/GO/ReBiS/ReL/15/CPCSEA) vide order number AU/FVS/PS-23/2022/19465; dated: 28-03-2022. The experimental animals were fed individually in pens. The animals in the control group (C) were fed 60% Oat hay as roughage and 40% concentrate. In contrast to C group, the animals in treatment groups were fed 20% roughage and 80% concentrate without (F) or with (FSB) $NaHCO_3$ supplement. The C and F groups were voided of $NaHCO_3$ supplement in their ration, but in the ration of FSB group $NaHCO_3$ was added @1% of dry matter intake. After grinding the ingredients for concentrate mixture, $NaHCO_3$ was mixed well to ensure uniform integration with the concentrate mixture. The ingredient composition (%) of the concentrate mixture was maize grain, 54; wheat bran, 12, mustard oil cake, 23, cowpea, 8, mineral mixture, 2 and salt, 1. The chemical composition of experimental ration is presented in Table 1. The animals were fed the calculated amount of concentrate and roughage in the morning (08:00 hrs) and evening (16:00 hrs) in equal proportion to meet their requirement (ICAR, 2013).

Table 1. Chemical composition (%) of experimental ration

Proximate principles	Concentrate mixture	Oat hay	TMR-1 (60R: 40C)	TMR-2 (20R: 80C)
Dry matter	89.1	84.9	86.6	88.3
Crude protein	18.9	6.56	11.5	16.4
Ether extract	4.91	1.20	2.68	4.17
Crude fibre	5.65	34.1	22.7	11.3
Nitrogen free extract	65.7	52.1	57.6	63.04
Total ash	4.74	5.92	5.44	4.97
Calcium	0.31	0.54	0.45	0.35
Phosphorus	0.59	0.15	0.33	0.49

Growth studies, metabolism trial and economics of feeding

A feeding trial of 74 days was conducted (including 14 days adaptation period). Fortnightly body weights were recorded. The actual influence of experimental feed was assessed by calculating total body weight gain, ADG (g/d), and FCR. At the end of feeding experiment, a metabolism trial of 7 days was conducted to estimate digestibility of nutrients, nutritive value of experimental feed and nitrogen balance. Representative samples of feeds offered and residue left were analysed for proximate principles (AOAC, 2005).

Haemato-biochemical parameters

The estimation of blood glucose was done on-spot by using Accu-Chek instant Glucometer. The haemoglobin (Hb) and packed cell volume (PCV) was estimated by using Sahli's method and Microhematocrit method, respectively. The estimation of ALT, AST, ALP, BUN and creatinine was done by using commercial diagnostic kits procured from Span diagnostics limited, Surat, Gujarat, India.

Rumen fermentation parameters

The samples of rumen liquor were collected from experimental lambs at initial and final day of trial (before feeding and watering in the morning hours) with the help of perforated stomach tube (50 mm). The pH of rumen liquor was determined immediately after collection of rumen liquor by using digital pH meter. For analysis of total volatile fatty acids (TVFA), ammonia nitrogen, Tricarboxylic acid (TCA) precipitable nitrogen and total nitrogen, the collected rumen fluid was strained using muslin cloth. The estimation of TVFA was done by following the protocols given by Barnett and Reid (1957), total nitrogen and ammonia nitrogen was estimated by Kjeldahl methods, and TCA precipitable nitrogen was estimated as per the method of Cline et al. (1958). The NPN content was calculated by subtracting TCA precipitable nitrogen from the total nitrogen.

Statistical analysis

The data obtained during experiment was subjected to one-way ANOVA (Snedecor and Cochran, 1994), using, SPSS Software, Base 23.0 for macOS, Marketing Department, SPSS Inc. Chicago, USA.

RESULTS AND DISCUSSION

Feed intake and gain in body weight

Dry matter intake (DMI, g/d) and body weight gain (kg) did not reveal any significant difference ($p>0.05$) between the treatments. Average daily gain (ADG, g/d) and FCR also showed no statistical difference ($p>0.05$) (Table 2). The smaller but insignificant improvement in the BW gain of animals fed feedlot diets supplemented with sodium bicarbonate as feed additive was also commensurate with the observations of Den hartog et al. (1989), Damir et al. (1990), Jackson and Hemken (1994), Fauchon et al. (1995) and Mandebvu and Galbraith (1999).

Table 2. Feed consumption and body weight gain

Parameter	Groups			SEM	p-value
	C	F	FSB		
DMI (g/d)	1032.36	858.44	1002.03	35.98	0.101
Initial BW (kg)	20.50	20.53	20.45	0.74	0.999
Final BW (kg)	29.61	29.95	31.68	1.05	0.719
Total Gain in BW (kg)	9.11	9.42	11.23	0.67	0.411
ADG (g/d)	123.10	127.29	151.76	8.95	0.411
FCR	7.53	7.14	6.20	0.32	0.252

Digestibility coefficient of nutrients, nutritive value of experimental rations, plane of nutrition, and nitrogen balance

No statistical significance ($p>0.05$) was observed in the apparent digestibility of dry matter, organic matter, crude protein, ether extract, crude fibre, nitrogen free extract, neutral detergent fibre, acid detergent fibre, cellulose and hemicellulose, moreover, apparent digestibility of nutrients also showed no significant difference between treatments (Table 3). The results of present study were in agreement with the observations of Phillip (1983), Hadjipanayiotou (1988), Santra et al. (2003), Sarwar et al. (2007), Soto et al. (2008), Farooq et al. (2014), Martins et al. (2016) and Suman et al. (2018).

The nutritive value of experimental diet revealed statistically significant difference ($p\leq0.05$) in terms of DCP (%) with highest value in FSB group, while

TDN (%) showed no statistical difference ($p>0.05$) among treatments (Table 3). Digestible dry matter intake (DDMI, kg/d), digestible crude protein intake (DCPI, g/d) and total digestible nutrients intake (TDNI, kg/d) also revealed no statistical difference ($p>0.05$) between the treatments, but comparatively higher values were witnessed in groups supplemented with sodium bicarbonate than that of control group. The balance of nitrogen revealed significant difference ($p\leq0.05$) between treatments, showing improved quantity of nitrogen absorbed in sodium bicarbonate supplemented feedlot groups than the control group (Table 3).

Table 3. Average digestibility coefficients, balance of nutrients, nutritive value of experimental rations and intake of digestible nutrients

Parameter	Groups			SEM	p-value
	C	F	FSB		
	Digestibility coefficient of gross nutrients				
DM	57.1	61.7	63.3	2.07	0.498
OM	68.9	69.9	72.09	1.11	0.542
CP	62.5	68.5	74.09	3.12	0.356
EE	58.09	59.4	74.4	5.59	0.461
CF	58.2	61.9	67.7	3.43	0.568
NFE	71.1	71.4	72.7	1.99	0.950
NDF	54.01	43.6	50.01	4.13	0.631
ADF	50.2	35.5	45.6	5.25	0.553
Cellulose	56.1	59.2	64.1	3.11	0.620
HemiCellulose	60.5	54.6	55.8	2.94	0.729
DCP (%)	7.21^{a}	11.2^{b}	12.2^{b}	0.78	0.005
TDN (%)	64.9	68.9	72.7	2.58	0.512
DDMI (kg/d)	0.85	0.84	0.86	0.04	0.998
DCPI (g/d)	92.8	137.50	144.04	10.5	0.085
TDNI (kg/d)	0.84	0.83	0.87	0.05	0.947
Nitrogen intake (g/d)	23.7^{a}	30.7^{b}	31.2^{b}	1.42	0.033
Fecal nitrogen (g/d)	10.6^{a}	12.2^{b}	10.4^{a}	0.31	0.015
Urinary nitrogen (g/d)	3.92^{a}	5.65^{b}	7.52^{c}	0.48	<0.05
Nitrogen balance (g/d)	9.10	12.8	13.2	1.13	0.283
Nitrogen retention (%)	38.3	41.7	42.3	2.28	0.845

Note: ^{abc} means bearing different superscripts within a row differ significantly ($p\leq0.05$).

Economics of feeding

The feed cost and production cost per kg live weight in feedlot groups with or without sodium bicarbonate as feed additive were reduced when compared with control (C) group (Table 4). In FSB group, the reduction in feeding cost and production cost per kg live weight was lesser than F and C group. The lower production cost was evident from the relatively better nutrient utilization, improved average daily gain and enhanced feed conversation results, which were shown by sodium bicarbonate supplemented feedlot group. The results of the present study show harmony with the findings of Gibb and Baker (1991) and Horn et al. (1992) who reported that supplementation feed additives in the ration of animals was cost effective in winter.

Table 4. Voluntary feed intake (DMI), total body weight gain, FCR, cost of feeding (Rs.) /kg gain and % reduction in cost of feeding/ kg gain of experimental animals

Attributes	Groups			p-value
	C	F	FSB	
Cost of TMR (Rs.)/kg	26.69	28.38	28.78	-
Total DMI (kg)	76.38±0.91	65.59±7.42	76.99±0.78	0.218
Total gain in body weight (kg)	9.11±0.56	9.42±1.68	11.23±0.96	0.411
FCR	7.53±0.32	7.14±0.80	6.20±0.23	0.252
Cost of feed (Rs.)/kg gain	201.23±8.73	202.71±22.87	178.54±6.47	0.268
% Reduction in feeding cost/ kg gain	-	-0.73	11.28	-

Haemato-biochemical parameters

The dietary treatments showed no significant effect ($p>0.05$) on Hb (g/dl), PCV (%), blood glucose (mg/dl), ALT (IU/L), AST (IU/L), ALP (IU/L), and BUN (mg/dl) (Table 5). However, the values of Hb (g/dl) and PCV (%) were higher in feedlot group supplemented with sodium bicarbonate as feed additive than control. The blood glucose was marginally higher in $NaHCO_3$ supplemented feedlot group than control but were within the physiological limits. Other research workers (de Valdez et al. 1997 and Abo El-Nor and Kholif 1998) reported improved blood glucose concentration with $NaHCO_3$ supplementation and it was attributed to improvement in gluconeogenesis and increased lactose absorption. Results of ALT and AST showed harmony with El-Marakby (2003) who observed no alterations in their concentration in serum. Among the treatment groups, lowest values of BUN were observed in sodium bicarbonate supplemented feedlot group and highest values was observed in feedlot group without feed additives. However, no significant difference ($p>0.05$) was observed in BUN among the treatment groups. Only the results of serum creatinine showed statistical difference ($p\leq0.05$) between treatments, revealing higher values in feedlot group supplemented with sodium bicarbonate (Table 5), this might be due to the higher protein intake in feedlot groups. However, creatinine values were within the normal range and no signs of kidney damage were observed in any of the treatment groups.

Table 5. Haemato-biochemistry of experimental animals

Parameter	Groups			SEM	p-value
	C	F	FSB		
Haemoglobin (g/dl)	8.66	8.48	8.89	0.13	0.499
Packed cell volume (%)	25.9	25.4	26.6	0.41	0.499
Blood glucose (mg/dl)	58.0	63.1	68.0	2.03	0.130
ALT (IU/L)	14.9	16.05	15.9	0.73	0.806
AST (IU/L)	93.5	98.8	96.1	2.34	0.686
ALP (IU/L)	115.14	121.6	119.72	1.99	0.424
Blood urea nitrogen (mg/dl)	15.7	16.4	15.04	0.60	0.652
Serum creatinine (mg/dl)	1.25^{a}	1.49^{b}	1.51^{b}	0.04	0.053

Note: ^{abc} means bearing different superscripts within a row differ significantly ($p\leq0.05$).

Rumen fermentation parameters

The results of rumen pH showed no statistical significance ($p>0.05$) between treatments (Table 6). The values of rumen pH were higher in sodium bicarbonate supplemented feedlot groups in comparison to feedlot group without feed additive, which may be due to conversion of stronger lactic acid to weaker propionic acid in bicarbonate supplemented feedlot groups. Previous researchers like Hadjipanayiotou (1988), Santra et al. (2003), Tripathi et al. (2004), Gonzalez et al. (2008), Apper bossard et al. (2010) and Ruchel et al. (2014), observed increase in rumen pH on sodium bicarbonate supplementation. The result of TVFA (meq/dl) also showed non-significant difference between treatments and the study conducted by Kawas et al. (2007) revealed that TVFA were not affected by addition of sodium bicarbonate in the diets of finishing lambs. The rumen total nitrogen was significantly higher (pd"0.05) in FSB, which may be due to higher CP content in the TMR compared to CG. Rumen ammonia nitrogen (mg/dl) was comparable between groups but, marginally higher value was observed in CG in comparison to treatment groups which indicated better utilization of ammonia nitrogen for synthesis of microbial protein in feedlot groups. The values of TCA perceptible nitrogen (mg/dl) and NPN (mg/dl) were non-significant ($p>0.05$) between groups.

Table 6. Rumen fermentation parameters

Parameter	Groups			SEM	p-value
	C	F	FSB		
Rumen pH	6.83	6.57	6.70	0.06	0.171
TVFA (meq/dl)	9.23	9.50	9.33	0.44	0.977
Total nitrogen (mg/dl)	112.00[a]	144.67[b]	158.67[b]	7.45	0.003
Ammonia nitrogen (mg/dl)	19.6	16.2	16.8	0.96	0.362
TCA precipitable nitrogen (mg/dl)	70.0	93.3	105.47	8.13	0.206
NPN (mg/dl)	42.0	51.3	53.2	6.06	0.775

Note: [ab] means bearing different superscripts within a row differ significantly ($p \leq 0.05$).

CONCLUSION

From the present study it could be concluded that sodium bicarbonate can be used as feed additive in the ration of feedlot sheep without any adverse effect on animals. Incorporation of sodium bicarbonate as feed additive (@1% of dry matter intake) in feedlot ration appears to improve the body weight indices and the health status of sheep.

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