Supplementation of Bicarbonate and Yeast on Intake, Digestibility and Rumen Fermentation of Sheep

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Abstract: This study was conducted to determine the effects of sodium bicarbonate and dry yeast in TMR with cassava peel on intake, nutrients digestibility and rumen fermentation of finishing lamb. Eight crossbreed lambs (Santa Inêsx Dorper x Indigenous) were randomly assigned into a 2×2 factorial arrangement in replicated Latin square design. They were given a total mixed ration as control diet (NA) at ad libitum daily feeding/lamb supplemented with 0.5% of Sodium Bicarbonate (SB) or 0.2% of dry Yeast (Y) or combination (Y/SB) during a 21-d experimental period. The results showed that dry matter intake and dry matter intake per body weight was significantly higher in Y and Y/SB than control and SB ($p<0.05$). Digestibility of dry matter, crude protein and NDF of Y and Y/SB were significantly higher than control ($p<0.05$). Ruminal pH, NH_3-N and total volatile fatty acid components of Y group were significantly higher than those control ($p>0.05$). It is suggested that supplementation of Y in diets containing high level of cassava peel did not affect voluntary feed intake of lamb but it could buffer the rumen pH and improving digestibility of nutrients and bacterial growth.

INTRODUCTION

The demand for food supplies has been intensified by recent advances in meat and animal protein. In most developing countries, high population increase with scarce capital is an important problem for the future of agriculture in the distribution of animal protein. Sheep are possible ruminant species which were supposed to become more roughage-dependent.

However, the high level of concentrate feed need to be used in fattening animal. This may lead to an increase in the amount of organic acid found in the rumen thus reducing the pH of the rumen and considered a threat to both the environment of the rumen and the health of the animals[1, 2]. In general, forage to stimulate chewing has been extensively investigated due to the association between chewing and the secretion of the salivary buffer in the rumen required to neutralize fermentation acids[3, 4].

An alternative to solving these issues was to change feeding management from traditional methods to the Total Mix Ration (TMR) and make animal diets nutritionally healthy. In general, TMR consists of both roughage (such as forage, crop residues and by-products), concentrate, mineral and vitamin types formulated according to the animal's overall nutrition requirements.

Cassava peel is available in large amount as a by-product for cassava starch production from the cassava root which produces approximately 1.5-2.0 million tonnes per year from cassava starch industry of Thailand[5]. There has increasingly been widely used in animal feed and is an 86.2% of a total carbohydrate content. Santos *et al*.[6] indicated that cassava peel becoming a replacement for corn in sheep with no effect on intake and performance. However, cassava peel consists of short particle and lower physically effective Neutral Detergent Fiber (NDF) which can influence the effectiveness of the rumen fermentation of finishing lamb. Limited data on whether TMR feed containing active dry yeast and bicarbonate with short or fine-particle fiber is feasible in fishing lamb were applicable. Therefore, this study aimed to determine the effects of feeding low fiber of TMR with active dry yeast or sodium bicarbonate on feed intake, nutrientdigestibility and rumen fermentation in finishing lamb.

MATERIALS AND METHODS

The study was conducted in Animal Science Research Farm (Kasetsart University, Chalermphrakiat Sakon Nakhon Province Campus, Thailand). The experimental protocol was performed in accordance with the practices outlined in the Guide for the Care and Use of Kasetsart University.

Animals and dietary treatments: Eight crossbred sheep (Santa Inêsx Dorper x Indigenous) with an initial Body Weight (BW) of 23.75±2.8 kg (6.5±0.3 mo of age) were randomly assigned to a 2×2 factorial in replecated Latin square design. All weaning lamb were kept in individual pens and clean fresh water and mineral blocks were available at all times. The dietary treatments were as followed T1) 0% Yeast (Y) (10^{10} cfu/g of DM, BIOSAF Sc 47, Lesaffre Feed Additives, Marquette-Lez-Lille, France)+0% $NaHCO_3$(SB),T2)0% Y+0.5% SB, T3) 0.2% Y+0% SB and T4) 0.2% Y+0.5% SB. The TMR was fed ad libitum twice daily at 07:00 and 16:00. The experiment was consisted of four 21-day time periods each. During the first 14 days, all animals were fed their respective treatments with *ad libitum* intake but during the last 7 days, they were moved to individual metabolism crates that facilitated separate collection of feces to assess nutrient digestibility. The proportion of ingredients in experimental diets are shown in Table 1.

Data collection and sample analysis: During the morning feeding, feed samples from dietary treatment were determined daily by measuring the feed offered and orts. Sample of the TMR mixture, refusals and feces were collected daily throughout the last 7 days of the experiment.

Table 1: The proportion of ingredients and chemical composition of dietary feed (%DM)

	0% Y		0.2% Y	
Items	0% SB	0.5% SB	0% SB	0.5% SB
Ingredients				
Fresh cassava peel	46.0	44.5	44.5	45.5
Cassava chip	17.7	18.7	18.5	17.5
Rice bran	9.0	9.0	9.5	9.5
Soybean meal (44% CP)	8.0	8.0	8.0	8.0
Palm kernel meal	6.0	6.0	6.0	5.5
Urea	1.5	1.5	1.5	1.5
Molasses	5.0	5.0	5.0	5.0
Salt	0.2	0.2	0.2	0.2
Mineral mix	0.5	0.5	0.5	0.5
Sulfur	0.1	0.1	0.1	0.1
Dicalcium phosphate	1.0	1.0	1.0	1.0
Rice straw	5.0	5.0	5.0	5.0
Y	0.0	0.0	0.2	0.2
SB	0.0	0.5	0.0	0.5
Chemical composition (% of DM)				
DM	54.89	56.10	55.29	56.19
CP	13.56	13.48	13.61	13.58
EE	2.47	2.58	2.27	2.67
ADF	26.72	26.03	25.21	25.92
NDF	46.11	46.38	52.31	52.18
Ash	11.28	14.34	12.62	15.16

Y = Active dry Yeast; SB = Sodium Bicarbonate

Fecal samples were collected during the last 7 days of experiment using the total collection method as the animals were in the metabolism crates to study nutrient digestibility. The fecal samples collected were about 5% of total fresh weight and divided into two parts; the rst part was used for DM analysis every day and the second part was pooled by animal at the end of each period and kept at -20°C for subsequent chemical analysis. Samples of feed offered, refusal and feces excreted by each lamb in each period were dried at 60°C for 72 h in a forced-air oven, ground through a 1 mm screen (Cyclotech Mill, Tecator, Hoganas, Sweden) and analyzed for DM, nitrogen, ash according to AOAC[7]. Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were analyzed by procedure of Van Soest *et al*.[8].

At the end of each period, rumen uid samples were collected after feeding at 4 h after feeding. Rumen uid was taken from the rumen by a stomach tube connected to a vacuum pump and filtered through 4 layer of cheese cloth. The filtrate of ruminal uid was immediately measured for pH using a portable pH temperature meter (HANNA Instruments HI 9025, Singapore) and ammonia-nitrogen (NH_3-N) using a Kjeltech Auto 1030 Analyzer. Rumen uid was used for direct counts of bacteria and protozoa using Galyean's methods[9]. Concentration of individual Volatile Fatty Acids (VFA) were analyzed using high pressure liquid chromatography (Agilent 1200 series, Agilent Technologies Inc. Santa Clara, CA, USA) with diode array detector, Zorbax Eclipse XDB-C18 column (4.6×150 mm, 5 µm) using 0.1M phosphate buffer as mobile phase according to the method of Samuel *et al*.[10].

Statistical analysis: Data from fermentation characteristics of silage were subjected to analysis of variance for a block completely randomized design using GLM procedure of SAS[11] (SAS Institute Inc., Cary, NC). The results are presented as mean values and standard error of the means. Significance has been defined as reflecting statistically relevant differences at $p<0.05$.

RESULTS AND DISCUSSION

Feed composition, intake and nutrients digestibility: The nutritional composition of the TMR fed to the lamb during the trial was relatively similar between treatments. All TMR's DM content averaged 55.62, 13.35% CP, 25.97 and 49.25% NDF. Lamb fed 0.2% Y but not 0.5% SB consumed more DM ($p<0.05$) than those fed TMR diet without supplement (NA). There was no difference in DMI ($p = 0.06$), %BW ($p = 0.09$), g/kg $BW^{0.75}$ ($p = 0.05$), OM ($p<0.05$) and CP ($p<0.05$). However, it was found interaction between Y and SB inclusion of TMR diet ($p<0.05$). The appearance digestibility of DM, OM and CP were significantly difference among treatments. Apparent DM digestibility was 64.83, 65.80, 68.48 and 69.23% for NA, Y, SB and Y/SB, respectively. Additionally, TMR diet with SB, NDF digestibility was higher than those Y or NA group ($p<0.05$). For NA, Y, SB and Y/SB, NDF digestibility was 51.48, 54.50, 53.85 and 55.98%, respectively. The result of this study was compared with the finishing lamb study by Kawas *et al*.[12] and Askar *et al*.[13] which showed that supplementation with sodium bicarbonate improved NFC intake whereas supplementation with yeast had little effect on intake and digestibility. However, Marden *et al*.[14] reported that sodium bicarbonate or yeast supplementation were not effect on total tract digestibility of dairy cow (Table 2).

Ruminal fermentation characteristic and microbes: Sodium bicarbonate and yeast had statistically significant different on the mean pH values while the pH of combination was highest than those for the buffered treatments (Table 3). The pH of Rumen ranged from 6.28-6.93 which may be suitable for fermentation efficiency and microbial activities. According to Cruywagen *et al*.[15] the rumen activity can not actually be limited if, on extremely fermentable diets, pH does not go past 6.1 and that it can only be affected if pH goes below the 5.5 threshold where SARA may be caused. This finding was supported by the study of Askar *et al*.[13] and Marden *et al*.[14] and Sun *et al*.[16] which showing that both additives had a pH stabilization effect but sodium bicarbonate could change the digestion of rumen.

Sodium bicarbonate had no effect on rumen NH_3-N concentration but yeast addition was significantly increased rumen NH_3-N concentration ($p<0.05$). This is in

Table 2: Effect of sodium bicarbonate and active dry yeast supplementation on intake and nutrient digestibility of sheep

	0% Y		0.2% Y			Contrast		
Items	0% SB	0.5% SB	0% SB	0.5% SB	SEM	Y	SB	Y×SB
DMI intake								
kg/day	0.72^{c}	0.78^{bc}	0.81^{ab}	0.90^{a}	0.04	0.04	0.02	0.32
%BW	4.04^{c}	4.31^{bc}	4.65^{ab}	4.98^{a}	0.22	0.09	0.03	0.15
g/kg $BW^{0.75}$	83.06^{c}	89.04^{bc}	94.90^{ab}	102.75^{a}	2.96	0.05	0.04	0.45
Nutrients digestibility (kg)								
DM	64.83^{b}	65.80^{a}	68.48^{a}	69.23^{a}	1.47	0.05	0.12	0.25
OM	68.97^{b}	69.18^{a}	70.64^{a}	71.27^{a}	0.77	0.08	0.17	0.11
CP	60.48^{b}	61.01^{a}	62.90^{a}	63.87^{a}	1.12	0.05	0.09	0.06
EE	58.38	59.63	58.65	59.73	1.69	0.45	0.41	0.82
NDF	51.48^{b}	54.50^{a}	53.85^{b}	55.98^{a}	1.50	0.26	0.04	0.76
ADF	37.55	38.03	39.23	39.15	2.17	0.19	0.18	0.93

$^{a-c}$Values within the same row with different superscript are differ ($p<0.05$)

Table 3: Effect of sodium bicarbonate and active dry yeast supplementation on ruminal pH and fermentation efficacy and microbes of sheep

	0% Y		0.2% Y			Contrast		
Items	0% SB	0.5% SB	0% SB	0.5% SB	SEM	Y	SB	Y×SB
pH	6.28^{b}	6.80^{a}	6.93^{a}	6.78^{ab}	0.15	0.05	0.07	0.04
NH_3-N	14.11^{b}	14.71^{b}	15.40^{a}	15.98^{a}	0.87	0.05	0.12	0.24
TVFA (mmol)	95.78^{b}	101.10^{a}	105.78^{a}	102.71^{a}	1.40	0.03	0.17	0.59
VFAs (mol/100mol)								
Acetate (C2)	65.09	66.51	65.79	65.74	2.16	0.94	0.87	0.90
Propionate(C3)	21.87	21.34	22.59	22.19	1.74	0.95	0.69	0.74
Butyrate (C4)	12.94	12.15	11.62	12.07	1.01	0.54	0.78	0.64
C_2:C_3	3.09	3.12	2.91	2.96	0.37	0.92	0.91	0.89
Rumen microbes (cell/mL)								
Bacteria (x 10^{10})	2.54^{c}	4.27b^{c}	5.88^{ab}	7.29^{a}	1.01	0.03	0.12	0.05
Protozoa (10^{6})	1.09	1.08	1.05	1.12	0.97	0.40	0.21	0.18
Fungal zoospore (10^{5})	3.31^{b}	5.63^{ab}	7.32^{a}	9.15^{a}	1.17	0.01	0.02	0.03

$^{a-c}$Values within the same row with different superscript are differ ($p<0.05$)

agreement with Askar *et al*.[13] who fed a the barlay grain with protein supplement diet with or without sodium bicarbonate to growing lambs. Rumen NH_3-N concentrations reported by these authors were similar to those observed in the current study. However, the effect of buffers on rumen NH_3-N concentrations does not appear to be consistent. Askar *et al*.[13] reported an increase in NH_3-N concentration whereas Alhidary *et al*.[17] reported that dietary sodium bicarbonate had no effect on rumen NH_3-N levels in growing lamb.

Total VFA concentration was higher for the Y/SB treatment than for control group ($p<0.05$) while porposion of individual VFAs were not effect. Askar *et al*.[13] reported higher total VFA values in the rumen fluid of growing lamb receiving high-concentrate diets that were buffered with sodium bicarbonate. Kawas *et al*.[12] reported that SB significantly reduced ($p<0.05$) percent molar acetate and increased ($p<0.05$) percent molar propionate whereas Alhidary *et al*.[17] found that bicarbonate addition decreased propionic acid whereas butyric acid was increased in the treatment groups ($p<0.05$) compared to the control.

Rumen bacteria and fungal zoospore were significantly increased by Y supplementation ($p<0.05$) but protozoa not effect. The effect on rumen microbes might be due to the pH stabilization of the rumen. Nocek[1] and Chaucheyras-Durand[18] pointed that *Saccharomyces cerevisiae* increases lactate utilization via stimulate growth of bacteria *Selenomonas ruminantium* and *M. elsdenii*. This contributes to increased ruminal activity and resulting in higher in ruminal pH. The findings of this study indicate that the use of active dry yeast in lamb diets has a direct impact on the increase of the quality of the fermentation of rumen and its microbes. Moreover, Sun *et al*.[16] suggested that ruminal pH effects on CH_4 emissions are possibly through medium-term changes in microbial and methanogenic communities in the rumen, rather than a direct, short-term impact on methanogens per se.

CONCLUSION

In conclusion, sodium bicarbonate can alter the digestion of rumen but it has declined to buffer the pH of rumen fluid. Active dry yeast supplementation did not affect voluntary feed intake of lamb but it could buffer the rumen pH, thereby improving digestibility of nutrients and bacterial growth.

It is suggested that active dry yeast can be used as a rumen-buffering agent at 0.2% of DM, showing promising results at this concentration and can to be used as a replacement for sodium bicarbonate in finishing lamb fed a diet with a high cassava peel.

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