Wageningen Academic Publishers, EAAP 2005, (11) :36-39
ISBN 9076998663
ISSN 1382-6077

Evaluation of buffering capacity for ruminant ration formulation and its effects on rumen fluid

A. Moharrery, Animal Science Department, Agricultural College, Shahrekord University, Shahrekord, Iran
email:alimoh@mailcity.com

Abstract

The usual ruminant's feed samples were divided to seven groups as: forage, silage, straw, protein concentrate, grain, by-product materials, and feed supplements. Buffering capacity (BC) and buffer value index (BVI) were determined on these samples.
Six totals mixed rations (TMR) for dairy cows formulated using the above feedstuffs with known BC or BVI. The study on rumen fluid pH was conducted using 5 simple rations on 5 adult sheep. The rumen fluid sample was collected after 21 days adaptation period. Correlation was calculated between rumen fluid pH and fiber or ash content of the diets.
Results showed that higher BC for forage comparing to grain material but the pattern of each feed in reaction to acid or base addition was different. The analyzed BC appeared to be lower than calculated values for each diet ($P< 0.05$). The analyzed BVI also was two times higher than the calculated BVI for each diet ($P< 0.05$). In spit of this, the correlation between calculated and analyzed values were 0.933 (P=0.0066) and -0.107 (P=0.840) for BC and BVI, respectively.
Rumen fluid pH decreased as NFC increased in the ration, but rumen degradable protein in the ration did not revealed any significant correlation with ru men fluid pH ($p> 0.05$).
In conclusion, BC and BVI of rations must be considered before feeding of any ration to dairy cows.

Key words: Buffering capacity, buffering value index, ruminant, feedstuffs.

Introduction

Buffers in ruminant rations are compound s that neutralize excess acid within the animal's digestive system. The ruminant animal has a complex acid-base regulation system that differs from other animal species. The rumen pH has been directly related to rumen VFA concentration (Kohn and Dunlap, 1998). The prediction of ruminal pH has been a major concern of ruminant nutritionists for many years and HCO_3^- is thought to be an important buffer of ruminal pH (Erdman, 1988) and of most in vitro media used for fermentation studies (Goering and Van Soest, 1970). Buffering capacity (BC) refer to the number of moles of H^+ that must be added to 1 L of solution to decrease the pH by 1 unit (Segel, 1976). This value depends on the buffer system and on the pH. In this regard, buffer value index (BVI) is related directly to BC but inversely to H^+ (acidity). Jasaitis et al., (1987) evaluated the pH and BC of different feedstuffs. Feedstuffs influence the ruminal acid-base status through their pH, BC, stimulation of salivation, and the component has been evaluated (Le Ruyet et al., 1992). Tucker et al., (1992) reported that BVI could be used to evaluate the pH and BC of either the diet or the ruminal fluid. If the total dietary BVI predict the ruminal fluid status, this index could be utilized as tools to predict whe n supplemental dietary buffers would be most beneficial.
The objective of this study was firstly to evaluate the relationships between calculated and analyzed dietary BC and BVI, and secondly, finding any relation among the total dietary BVI, and ruminal fluid pH.

Materials and methods

The usual ruminant's feed samples were divided to seven groups as: forage, silage, straw, protein concentrate, grain, by-product materials, and feed supplements. The buffering capacity, defined as the resistance to change in pH from 7 to 5. In preparation for BC determination, individual feedstuffs were dried and ground (1-mm screen). To avoid VFA loss during drying, BC of silage was determined with a wet sample in an amount equivalent to 0.5 g of DM. For other feeds, 0.5 g of Dm dispensed into a 100-ml beaker and mixed with 30 ml of distilled, deionized water. The initial pH of feed was recorded after allowing 2 min for equilibrium. Buffering capacity was determined by titrating the 30-ml solution with continuous stirring from its initial pH to pH of 5 with 1 *N* HCl and by titrating a similar prepared solution of feedstuff from its initial pH to pH of 7 with 1 *N* NaOH. If the initial pH was higher than 7, only the volume of acid required to reduce the pH from 7 to 5 was recorded. The BC was converted to milliequivalents per liter as follows:

BC = ((milliliter of 1 N HCl) + (milliliter of 1 N NaOH)) × 10^3/30. The BVI was calculated according to the formula of Tucker et al., (1992) as follow:

BVI = ((((antilog_{10} (-STPH)) – (antilog_{10} (-SAPH)))/(antilog_{10} (-STPH)) + (SABC – STBC)/STBC)) × 10) + 100, where STPH = a standard pH of 6, SAPH= the feed sample pH, SABC= the feed sample BC (milliequivalents per liter), and STBC= a standard BC of 50 meq/L.

Six totals mixed rations (TMR) for dairy cows formulated using the feedstuffs with known BC or BVI. The BVI and BC calculations for the TMR were determined from individual feedstuffs and measured for each one of six rations separately (Table 1).

The study on rumen fluid pH was conducted using 5 simple rations (Table 2) on 5 adult sheep. The rumen fluid sample was collected after 21 days adaptation period. Correlation was calculated between rumen fluid pH and fiber or ash content of the diets.

The paired t-test of SAS , (1988) has been used for comparing calculated or analyzed BC and BVI. The correlation among parameters acids was determined and correlation coefficients were tested using a t-test (SAS, 1988).

Result and Discussion

Analyzed dietary BVI and BC were markedly higher than BV I and BC values calculated from individual dietary components (Table 1 and Figure 1). This contrasts with Jasaitis et al. (1987), who were able to predict the BC of a TMR from the individual feed BC; but, in their analysis, the silage was dried before it w as mixed with other ingredients, a broader pH range was used to calculate BC, and the complete dietary BC was determined immediately after mixing.

Table 1. Composition of dairy cattle rations (DM basis).

	Ration (%)						Ingredient	
	A	B	C	D	E	F	BC	BVI
Alfalfa hay	17	20	25	13.3	35.06	31.58	5.32	95.693
Corn silage	30	25	20	26.5	11.69	21.05	10.18	-543.618
Barley grain	3	11	32	20.8	21.62	21.05	0.97	90.421
Corn grain	15.5	15.5	13.5				0.71	98.215
Beet pulp	15	1.5	2		11.69	10.53	6.48	-970.223
Wheat bran	2	3	1	19	14.03	10.53	2.09	99.054
Fish meal	4	0.5	0.2				6.85	87.604
Cotton seed meal	0.5	20	2	18.5	5.84	5.26	2.24	96.775
Soybean meal	10.5	1	0.5				4.74	99.399
Urea		0.2	1.5				0.24	99.982
Salt	0.7	0.7	0.7	0.4			0.19	94.349
Limestone	0.5	0.5	0.5	1.1	0.07		317.0	163.40
Dicalcium phosphate	1.05	0.86	0.85				58.67	-1626.06
Sodium bicarbonate	0.25	0.25	0.25	0.4			188.8	136.493
PH	5.70	5.74	5.84	6.32	5.69	5.38		

Table 2. Ingredient and composition of sheep diets (DM basis).

	Diet (%)				
Ingredient	**A**	**B**	**C**	**D**	**E**
Alfalfa	100	80	70	80	70
Soybean meal		20			
Barley			30	20	
Wheat bran					30
Composition[a]					
ADF (%)	38.89	31.11	29.47	32.63	31.78
CF (%)	28.89	24.43	22.04	24.33	23.65
RDP (%)	12.00	13.68	11.36	11.58	12.03
NFC (%)	23.48	23.85	34.52	30.84	26.62
Rumen fluid pH	6.50	6.32	6.06	6.83	6.88
BC (meq/Kg of DM)	3.461	3.378	2.530	2.840	2.771
BVI (calculated)	101.340	101.265	101.105	101.367	101.159

[a] ADF: acid detergent fiber, CF:crude fiber, RDP: rumen degradable protein, NFC: non-fiber carbohydrate, BC: buffering capacity, BVI: buffering value index.

Table 3. Coefficient of correlation between rumen fluid pH and other parameter related to sheep diets.

	BC	BVI	RDP%	ADF%	CF%	NFC%
Rumen fluid pH	-0.0014[a]	0.3960	0.2660	-0.4230	-0.1270	-0.2590
	0.9983[b]	0.5090	0.6650	0.4780	0.8390	0.4700

[a] Coefficient of correlation.
[b] Probability.

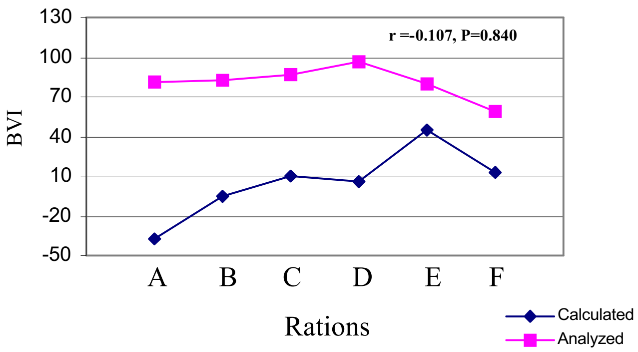

Figure 1. BVI of six TMRs formulated for dairy cows.

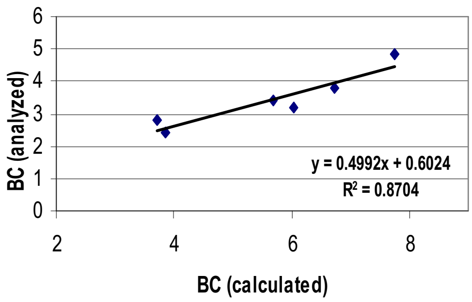

Figure 2. Relationship between calculated and analyzed BC.

In agreement with these results, Le Ruyet et al. (1992) found similar relationships between calculated and analyzed dietary BVI. However, their samples were frozen for 4 month's before analysis. The analyses in present study were conducted after the samples were taken. Results from present study, showed that the BVI and BC for individual dietary ingredient did not show cumulative effect on TMR. However, the correlation between calculated BC and analyzed BC is high (r= 0.93) and significant ($P<0.05$, Figure 2).
Dietary BVI, ADF, CF and RDP (Table 2) did not affect Ruminal fluid pH. In this regard dietary NFC and BC have been showed better relationship with ruminal fluid pH to compare other component which is mentioned earlier. The high BC or low NFC diets increased ruminal fluid pH. However, no significant ($P>0.05$) correlation has been found between

ruminal fluid pH and dietary components (Table 3). In contrast with this results, Erdman (1988) in his literature review has been showed linear relationship between dietary ADF or crude fiber and rumen pH, although the regression equation for prediction of ruminal pH from ADF is not enough strong (R^2=0.30).

Conclusions

In summary, the BC and BVI of the six TMR differed from those predicted by summing the values for the individual fe edstuffs. All analyzed BVI and BC were higher than calculated values. No significant correlation has been found between ruminal pH and dietary RDP or fiber.

References

1- Erdman, R. A. 1988. Dietary buffering requirements of the lactating dairy cow: a re view. J. Dairy Sci. 71: 3246.

2- Goering, H.K., and P.J. Van Soest. 1970. Forage fiber analyses (apparatus, reagents, procedures, and some applications). Agric. Handbook No. 179. ARS, USDA, Washington, DC.

3- Jasaitis, D. K., J. E. Wohlt, and J. l. Evans. 1987. Influence of fed ion content on buffering capacity of ruminant feedstuffs in vitro. J. Dairy Sci. 70:1391.

4- Kohn, R.A., and T.F. Dunlap, 1998. Calculation of the buffering capacity of bicarbonate in the rumen and in vitro. J. Anim. Sci., 76:1702.

5- Le Ruyet. P., W. B. Tucker, J. F. Hogue, M. Aslam, and M. Lema. 1992. Influence of dietary fiber and buffer value index on the ruminal milieu of lactating dairy cows. J. Dairy Sci. 75:2394.

6- SAS User's Guide: Statistics, Version 6.03, 4th Ed. 1988. SAS Inst., Inc., Cary, NC.

7- Segel, I. H. 1976. Biochemical Calculation. (2nd Ed.). John Wiley & Sons, New York.

8- Tucker, W.B., J.F. Hogue, M. Aslam, M. Lema, M. Martin, F.N. Owens, I.S. Shin, P. Le Ruyet, and G.D. Adams. 1992. A buffer value index to evaluate effects of buffers on ruminal milieu in cows fed high or low concentrate, silage, or hay diets. J. Dairy Sci., 75:811.