Short communication

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Buffering capacity of common feedstuffs used in ruminant diets¤

Capacidad amortiguadora de ingredientes comúnmente utilizados en la alimentación de rumiantes

Capacidade tampão dos ingredientes utilizados na alimentação de ruminantes

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Summary

Background: buffer substances are commonly used in cattle nutrition. However, factors such as buffer type and amount added do not take into account the intrinsic buffering capacity of other dietary ingredients. **Objective:** to determine the buffering capacity (BC) of 25 commonly used energy and protein feedstuffs as well as additives, silages, and forage ingredients. **Methods:** BC was measured using the technique described by Jasaitis *et al.* (1988). Results are expressed in milliequivalents of hydrochloric acid required to generate a unit change in pH in the original feed sample. **Results:** the results of this study are in agreement with those reported by other authors. **Conclusion:** protein feedstuffs resulted in the highest BC values, followed by forages, while energy ingredients showed the lowest results.

Key words: *buffering value index, cattle, nutrition.*

Resumen

Antecedentes: la utilización de sustancias amortiguadoras es común en nutrición bovina, sin embargo, factores como la cantidad y tipo de amortiguador utilizado no tienen en cuenta la capacidad amortiguadora intrínseca de los ingredientes utilizados en la dieta. **Objetivo:** evaluar la capacidad amortiguadora (CA) de 25 ingredientes de tipo energético, proteico, ensilados, aditivos y forrajes comúnmente utilizados en dietas para

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rumiantes. **Métodos:** la CA se determinó mediante la técnica descrita por Jasaitis *et al.* (1988) expresando los resultados en miliequivalentes de ácido clorhídrico requerido para producir un cambio en una unidad de pH de la muestra original de alimento. **Resultados:** los resultados obtenidos son similares a los reportados por otros autores. **Conclusiones:** los ingredientes que fueron clasificados como proteicos presentan una CA elevada, los forrajes presentan una CA intermedia, en comparación con los energéticos que presentan una CA baja.

Palabras clave: *índice de capacidad tampón, ganado, nutrición.*

Resumo

Antecedentes: a utilização de substâncias tampão em gado é comum, no entanto, fatores como a quantidade e o tipo de tampão utilizado não ter em conta a capacidade tampão intrínseca dos ingredientes utilizados na dieta. **Objetivo:** avaliar a capacidade tampão (CA) de 25 ingredientes de tipo energético, proteico, silagem, aditivos e pastagens comunmente utilizados em dietas para ruminantes. **Métodos**: o CT é determinado pela técnica descrita por Jasaitis *et al.* (1988) apresentando os resultados em miliequivalentes de ácido clorídrico necessário para produzir uma mudança em uma unidade de pH da amostra original do alimento. **Resultados:** os resultados obtidos foram similares com outros estudos anteriormente reportados por outros autores. **Conclusões***:* os ingredientes que foram classificados como proteicos apresentam um alto CT, aqueles que sua origem é o forragem têm uma CT intermediária, e os ingredientes energéticos têm um baixo CT.

Palavras chave*: índice de capacidade tampão, gado, nutrição.*

Introduction

Non-structural carbohydrates comprise several main components of diets. Their fermentation reduces ruminal pH, which in turn reduces total tract digestibility of milk-fat and fiber (Garret *et al*., 1999; Oetzel, 2001; Montañez *et al*., 2006). Antibiotics, ionophores, and buffers are usually added to diets to help animals cope with the adverse effects of high level of dietary carbohydrates, which in turn improves fermentation, reduces by-products, and enhances the ruminal environment. The use of feed additives in high concentrate diets helps the buffer systems in the rumen of dairy and fattening cattle, but produces variable fermentation responses. The buffering capacity (BC) of the diet is related to the ingredients that it contains, so the individual impact of single ingredients is usually not taken into account (Sears and Walsh, 1998; Staples and Lough, 1989) and not typically assessed. Therefore, the goal of the present study was to determine BC of feedstuff ingredients commonly used in ruminant feeding.

Materials and Methods

The twenty-five most commonly used ingredients in ruminant feeding were collected and chemically analyzed (dry matter, crude protein, fat, calcium, phosphorus, and ash). Analyses were conducted in triplicate using standard procedures (AOAC, 1990). Fiber fractions were analyzed using the Van Soest *et al.* procedure (1991). Samples of each ingredient were assessed for BC using the method described by Jasaitis *et al.* (1988). 5 g of each ingredient were suspended in 50 mL of deionized water (pH 7), stirred continuously and initial pH was measured with a pH-meter (Orion model 720A). The BC was determined by titrating a 30 mL solution under continuous stirring from its initial pH to pH 4, using 0.1 N HCl, and by further titrating the solution of the individual feedstuff. The BC was calculated by multiplying the amount of HCl by the normality, which was then expressed as milliequivalents (meq).

Results and discussion

Table 1, shows the nutrient content of the evaluated feedstuffs.

Table 1. Chemical composition of some commonly used feedstuffs (%).

	DM	CP	Fat	ADF	NDF	Ash	Ca	P
Energy								
Corn grain								
Ground	90.24	9.73	4.71	1.73	2.15	1.86	0.23	0.95
Rolled	90.24	8.20	3.71	1.73	2.15	1.86	0.23	0.95
Sorghum grain	88.80	10.21	2.25	2.80	4.20	1.60	0.04	0.30
Wheat	86.80	11.13	1.70	6.34	75.72	2.10	0.05	0.39
Forages								
Corn stalk[1]	67.93	8.80	1.02	33.36	55.44	15.25	0.35	0.78
Chick peas, whole plant	83.22	11.70	1.85	25.68	82.11	12.73	0.50	0.93
Oat straw	31.38	6.68	4.16	28.05	69.65	6.78	0.30	1.20
Corn and cob[2]	86.56	7.61	---	32.25	50.20	14.02	--	--
Wheat bran	91.61	15.01	2.58	9.62	69.96	12.79	0.96	0.66
Sorghum head plus panicle	88.80	9.27	2.25	2.80	4.20	1.60	0.04	0.30
Protein								
Blood meal	86.00	91.92	1.89	0.0	0.0	4.40	0.03	0.25
Fish meal	8.00	63.18	9.67	0.0	0.0	19.60	4.55	2.45
Coconut meal	85.14	22.99	9.62	30.36	68.02	18.05	0.76	1.36
Cotton seed meal	97.14	43.93	6.50	17.62	16.87	13.67	0.60	1.44
Canola	87.66	34.27	1.19	18.43	39.61	7.30	0.68	1.01
Chicken droppings	82.18	24.44	1.50	25.01	64.20	28.27	1.00	1.76
Alfalfa	68.57	19.92	1.27	34.12	25.35	19.80	0.50	1.15
Corn gluten	93.16	56.51	2.16	1.39	22.48	10.49	0.74	0.17
Soybean meal	92.53	45.24	2.34	22.06	9.57	9.35	0.64	0.19
Fermented								
Corn silage	31.84	6.89	2.25	41.45	84.57	29.27	0.35	0.9
Oat silage	22.50	11.37	2.61	39.80	59.55	6.55	0.15	--
Sugar cane silage[3]	33.81	8.60	1.70	43.37	54.73	30.10	0.40	0.10
Additives								
Urea	90.10	281.00	--	--	--	--	--	--
Molasses	63.47	5.33	0.23	--	--	--	--	--

[1] Plant and dented corn cob; [2] Includes the cob + shell; [3] Treated with a 1% mixture (10% molasses, 1% yogurt, 5% broiler dropping, 0.5% urea, and 83% water); and 1% of mineral additive (1% urea, 0.1% ammonium sulphate, and 0.25% phosphorus).

Table 2, shows the BC of feedstuffs with small differences compared to results published by Jasaitis *et al*. (1988) and Montañez *et al.* (2006).

Table 2. Compared buffering capacity of feedstuffs.

INGREDIENTS	Present study		Montañez *et al.,* 2006		Jasaitis *et al.,* 1987	
	pHi[1]	BC[2]	pHi	BC	pHi	BC
Energetics						
Ground corn	5.77	11.62	6.83	33.00	5.25	63.00
Sorghum grain	6.17	11.05	7.14	16.60	6.40	27.00
Wheat	5.99	17.35	7.12	23.30	6.32	19.00
Roled corn	5.74	7.75	---	---	---	---
Forages						
Corn stalk	7.03	27.47	7.64	54.34	---	---
Chick peas, whole plant	5.23	95.70	---	---	---	---
Oat straw	5.59	66.95	---	---	---	---
Corn plant plus grain	5.25	21.95	---	---	---	---
Wheat bran	6.24	47.42	6.90	46.57	6.23	89.00
Sorghum head plus panicle	6.45	21.77				

(*continues*)

Table 2. Continued

INGREDIENTS	Present study		Montañez *et al.*, 2006		Jasaitis *et al.*, 1987	
	pHi[1]	BC[2]	pHi	BC	pHi	BC
Protein						
Blood meal	6.72	85.48	6.35	106.31	---	---
Fish meal	5.82	333.07	5.45	116.47	5.97	390.00
Coconut meal	5.44	92.41	---	---	---	---
Cotton seed meal	6.40	157.23	---	---	---	---
Canola	5.77	135.87	---	---	---	---
Chicken droppings	6.73	181.22	---	---	---	---
Alfalfa	6.36	140.27	6.49	134.00	6.28	124.00
Corn gluten	4.12	210.36	6.47	16.50	4.05	0.00
Full fat soybean meal	6.65	105.87	7.02	110.30	6.65	130.00
Silages						
Corn	3.75	0.00	5.82	86.70	3.94	0.00
Oat	4.44	51.07	---	---	---	---
Sugar cane	4.14	127.89	---	---	---	---
Corn	3.95	0.00	---	---	---	---
Oat	5.10	171.82	---	---	---	---
Additives						
Mineral mixture[3]	7.00	1542.41	9.43	534.87	---	---
Sodium bicarbonate	8.06	1465.00	8.90	2005.52	8.11	1521.00
Urea	6.66	1.67	---	---	5.85	3.00
Molasses	5.55	111.25	5.98	84.12	---	---

[1] Initial pH: sample dissolved in distilled water with a pH 7.01 ± 0.10; [2] Buffering capacity expressed as meq x 10^{-3} ; [3] Trace mineral mix with 10% zinc/kg; contains: Se 0.20 g, Co 0.10 g, I 0.30 g, Cu 10.00 mg, Fe 100.00 mg, Zn 100.00 mg, Mn 100.00 mg.

For the ingredients used as energy source, the BC values were higher than those reported by some authors (Jasaitis *et al.,*1988; Montanez *et al*., 2006; Moharrery 2007), but protein sources and fermented ingredients were quite similar, except for corn gluten. The BC in protein sources ranged from 85 to 333 × 10^{-3} meq, where soybean meal had the lowest values and fish meal had the highest. This difference is possibly related to the amino groups and bone calcium present in fish meal (Canale and Stokes, 1988; Jasaitis *et al.,* 2008; Van Soest *et al.*, 1984). The BC in energy ingredients ranged from 7.75 to 17.35, similar to feedstuffs with low fiber and highly fermentable feedstuffs which also contain low amounts of fiber. The BC in forages, on the other hand, ranged from 21.7 to 66.9. Additives and forage source influenced the BC of fermented ingredients (Crawford *et al*., 1983; Le Ruyet *et al*., 1992; Sniffen and Robinson, 1987; Bujňák *et al.*, 2011). The BC of concentrates was closely related to the source of minerals (Jasaitis *et al*., 1988; Moharrery, 2007). The natural buffering capacity of the ingredients was high (> 85 meq × 10^{-3}) in foods high in protein and legumes with more than 15% crude protein (blood meal, alfalfa), medium (> 21 meq ×10^{-3} and < 70 meq × 10^{-3}) in foods such as corn silage, and low (<17 meq × 10^{-3}) in grasses (maize, sorghum, barley). Buffering capacity is additive, making its use potential for formulated diets, allowing us to decide when to use or not a particular ruminal buffer by showing its potential effectiveness.

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