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IS THERE BENEFICIAL INFLUENCE FOR ADDING SODIUM AND POTASSIUM BICARBONATE IN RATIONS OF LACTATING COWS ?

A.A. Gabr[1], A.Z. Mehrez[1], I.S. Korriet[2] and R.M. Abou Aiana[2]

1-Departmant of Animal Production, Faculty of Agriculture, University of Mansoura, Egypt , 2- Animal Production Research Institute, Ministry of Agriculture, Egypt.

SUMMARY

Twelve lactating Friesian cows were used in a feeding trial of 4 treatments in switch-back complete design to investigate and compare the effect of supplementing a basal diet consisting of berseem hay, rice straw and concentrate feed mixture (CFM) with $NaHCO_3$ or $KHCO_3$ at 1% or both buffers together at 0.5% each, of CFM on feed intake, digestibility coefficients, rumen liquor parameters, plasma minerals, red blood cells (RBC), white blood cells (WBC), fat corrected (4%) milk yield and its composition.

Supplementation of both buffers separately or combined together, improved feed intake, nutrient digestibilities as well as nutritive value of the tested rations, compared with no buffered one (control). Generally, rumen and urine pH values, NH_3-N and total VFA's concentrations of rumen fluid, RBC and WBC number, plasma Na, K, Mg and Ca concentrations, milk yield and its composition were not significantly affected by buffers addition. However, 4% daily fat corrected milk yield was higher by 1.70, 0.90 and 1.0 Kg for groups fed on rations supplemented with 1% $NaHCO_3$, 1% $KHCO_3$ and 0.5% $NaHCO_3$ + 0.5% $KHCO_3$, respectively than the control group. The corresponding improvement in fat % was 0.26, 0.15 and 0.17 percentage unit, respectively. Addition of $NaHCO_3$ to the basal ration appeared to be more effective and economic than $KHCO_3$ or both in improving milk yield and its fat content.

Keywords: Friesian cows, lactation, bicarbonate, milk yield , milk composition

INTRODUCTION

The addition of bicarbonate and other buffers to rations of lactating dairy cows has been reported to have beneficial effects on improving feed intake (West *et al.*, 1991; Wagner *et al.*, 1993 and Tucker *et al.*, 1994), rumen pH (El-Bedawy *et al.*, 1989), rumen acetate, acetate to propionate ratio (Erdman *et al.*, 1982), milk production (Solorzano *et al.*, 1989; West *et.al.*, 1991 and Orozco-Hernandez *et al.*, 1994) and preventing of milk fat depression caused by feeding high concentrate rations (Harrison *et al.*, 1989 and Tucker *et al.*, 1992). However, the benefit and use of buffers in rations of ruminants, depends to large extent on many interrelated factors that may influence the efficiency of utilization from such buffers by the animals, including preparation, quality and quantity of diet, amount and type of buffers applied, age of animal, saliva secretion, ruminal digestion, physiological changes and others.

Therefore, objectives of this study were to measure the effects of addition of Na and K bicarbonate to rations of lactating cows on feed intake, nutrient digestibilities, nutritive value, and some characteristics of rumen liquor and blood and their subsequent influence on milk yield and its composition. Economic efficiency of using buffers was also studied.

MATERIAL AND METHODS

Twelve Friesian cows of 499.6 Kg average body weight were used. They were randomly chosen after the peak of lactation period from the herd of the Experimental Station of El-Karada, Anim. Prod. Res. Inst., Ministry of Agriculture where the experiment was conducted, during Summer season 1994. They were allocated according to the switch back design into four groups, three cows each. The experimental period lasted for 84 days divided into 3 periods, 28 days each, of which two weeks as a preliminary period and the others as a collection period. All cows were individually fed according to NRC (1984) recommendations, based on their live body weight, milk yield and its fat %. All groups were fed constant amounts of berseem hay (BH) and rice straw (RS) at the rate of 3 and 5 Kg/h/d, respectively along with concentrate feed mixture (CFM). The CFM contained, 6% undecorticated cotton seed cake, 45.2% yellow maize, 4.1% soybean cake, 38% wheat bran, 5% molasses, 1.2% limestone and 0.5% salt (Nacl). Chemical composition of the experimental feedstuffs and their rations are presented in Table (1).

Table 1.Chemical composition(%) of feed ingredients and experimental rations.

Diet	DM	Chemical composition (on, DM basis)						
		OM	CP	EE	CF	NFE	Ash	AIA*
Berseem hay	86.0	87.4	12.7	1.80	27.5	45.4	12.6	0.27
Rice straw	89.4	83.5	3.89	2.31	36.0	41.3	16.6	0.31
Concentrate feed mixture (CFM)	89.5	93.7	17.5	3.06	7.64	65.5	6.30	1.37
Calculated composition of tested rations (on, DM basis) :								
Control	88.8	89.3	12.3	2.70	20.3	54.0	10.7	---
A 1% $NaHCO_3$	88.9	90.1	13.2	2.70	18.0	56.2	9.90	---
B 1% $KHCO_3$	88.9	89.6	12.7	2.60	20.0	54.3	10.4	---
C0.5%$NaHCO_3$+0.5%$KHCO_3$	88.9	89.8	12.9	2.80	19.5	54.6	10.2	---

* Acid insoluble ash.

Two sources of bicarbonate namely sodium (Na) and potassium as buffers supplementation were used. Group1 was considered a control, while groups 2, 3 and

4 their diets were supplemented by 1% $NaHCO_3$, 1%$KHCO_3$ and 0.5% $NaHCO_3$+ 0.5% $KHCO_3$ of CFM given, respectively. The animals were weighed every week at the morning before drinking or offering the new feeds. Adjustments of CFM were made every week based on animal live body weight, milk yield and its fat %. The CFM was given in two equal meals after mixing with buffers at 8 am and 3 pm. Drinking water was available all times.

During the collection period, representative milk samples were taken from each cow twice a week and analysed for fat, protein, lactose, total solids (TS) and solid non fat (SNF) by a milk scan apparatus (133 BN. FOSS electronic, Denmark). Also, blood samples were taken 3 hrs after morning feeding from each cow in all groups twice a week. Total erythrocyte counts (red blood cells, RBC) and total leukocyte (white blood cells, WBC) were determined (Colse, 1967).

During the last 7 days of each period, daily faeces of cows were collected and samples were taken and kept for chemical analysis. Acid insoluble ash (AIA) technique (Van Keulen and Young, 1977) was used as an internal marker to measure the digestibility of tested rations. At the last two days of each digestion trial samples of rumen liquer were collected from each cow before and at 2, 4, 6 and 8 hrs after the morning feeding using a stomach tube and filtered through a double layers of cheese cloth. The pH was immediately determined using pH meter. The samples were then kept frozen (-20°C) for subsequent analysis. Concentration of ammonia-N (Conway and O'Malley, 1942) and total volatile fatty acids (VFA's) (Abou-Akkada and El-Shazly, 1964) were determined, samples of feeds and faeces were analysed (A.O.A.C., 1988). The data were statistically analysed using switch-back complete design (Lucas, 1956) and Duncan's multiple range test.

RESULTS AND DISCUSSION

Inspection of data presented in Table (2) it was clear that the addition of either buffers seperatley or combined together to the restricted-roughage rations was accompained by a small, non significant increase in concentrate consumption and accordingly total DM intake/h/d by cows, compared with the control group. Solorzano *et al.* (1989); West *et al.* (1991); Wagner *et al.* (1993) and Tucker *et al.* (1994) reported an increase in DM intake by cows fed buffered diets, while others (Ghorbani *et al.*, 1989 and Belibasakis and Triantos, 1991) showed no differences, and in another study DM intake was reduced (Erdman, 1988) compared with the controls. Such variable reported responses could be mainly related to many factors such as age of animal, feed ingredients, amount and type of buffers applied, type and amount of forage fed, physical form of feed, and others known to influence mastication, saliva amount and composition, VFA production and hence ruminal pH.

Generally, addition of buffers to tested rations improved most of nutrient digestibilities as well as their nutritive values in terms of TDN and DCP values, compared with unbuffered ration (Table 2). However, no significant difference between buffered ration A ($NaHCO_3$) and C ($NaHCO_3$ + $KHCO_3$) in all nutrient digestibilities and nutritive values was observed. Similar lack of significancy was also noticed between ration B ($KHCO_3$) and the control in this respect. The $NaHCO_3$ appears to be more effective than $KHCO_3$ or both together in enhancing nutrient digestibilities and nutritive value of tested ration A. Buffered rations A and C had significantly ($P<0.05$) higher CP digestibility values than the control, but the differences among rations A, B and C were not significant. Harrison *et al.* (1975) demonstrated that microbial synthesis and total amino acids in small intestine were increased with added buffers to ruminant rations as a result of increasing dilution rate of digesta and higher ruminal pH. Similar trend for increasing CP digestibility of buffered rations was also observed by Solorzano *et al.* (1989) and Hsu *et al.* (1990). Also, it was clear that the highest CF digestibility (51.4%) was observed in ration C which was supplemented by both buffers, followed by ration A (46.6%), while the lowest values (40.8 and 41.4%) were with ration B and the control.

Table 2. Average daily dry matter intake (DMI) digestibility coefficients and nutritive values of the experimental rations by cows.

Items	Experimental rations				
	Control	1% $NaHCO_3$ (A)	1% $KHCO_3$ (B)	0.5% $NaHCO_3$ + 0.5% $KHCO_3$ (C)	S.E
DMI, Kg/h/d from :					
CFM	7.68	8.22	7.92	8.07	0.50
BH + RS	7.05	7.05	7.05	7.05	
Total DMI Kg/h/d	14.7	15.3	15.0	15.1	0.21
Roughage : CFM ratio	48 : 52	46 : 54	47 : 53	47 : 53	
Digestibility, (%) :					
Dry matter	52.3^{b}	61.6^{a}	53.5^{b}	60.4^{a}	1.39
Organic matter	55.4^{b}	64.9^{a}	56.9^{b}	63.5^{a}	1.37
Crude protein	47.1^{b}	58.3^{a}	50.6^{ab}	57.0^{a}	2.60
Crude fiber	41.4^{b}	46.4^{ab}	40.8^{b}	51.4^{a}	3.33
Ether extract	60.4^{b}	67.2^{ab}	61.0^{b}	72.2^{a}	4.55
N. free extract	64.5^{b}	71.4^{a}	64.0^{b}	68.9^{ab}	1.25
Nutritive value, (%) :					
TDN	52.6^{b}	59.8^{a}	53.3^{b}	59.4^{a}	1.37
DCP	5.79^{b}	7.72^{a}	6.44^{ab}	7.33^{a}	0.24

[a, b] Means in the same row having unlike letters differ significantly ($P < 0.05$).

Rumen pH was relatively increased in all times of sampling when buffers were added (Fig. 1"A"), so the improvement response on CF digestibility is likely due to an increased buffering effect related to ruminal pH. El-Bedawy *et al.* (1989) reported that $NaHCO_3$ supplement in rations of goats raised rumen pH, improved CF digestibility and sustained cellulolytic bacteria and protozoa count. Mertens (1979) found that optimum pH for cellulose activity is between pH 6 and 7. The pH values obtained herein fall within the previous range, in spite of that the effect of buffers used on elevating the pH was not significantly high, compared with the control suggesting that higher levels of buffers than that used herein (1%) could be required for raising ruminal pH under this condition. However, the use of higher levels of buffers for long time may be accompained by adverse effects such as urinary calculi (Huntington *et al.*, 1977). Additional reasearch works under different nutritional conditions are needed to clarify this point.

Ruminal NH_3-N concentrations (Fig. 1"B") in all times of sampling tended to be higher with cows fed buffered rations than the control, but differences were not significant. Beneficial effects of high level of ammonia might be due to indirect effects on ruminal pH (Church, 1988) or indirectly via increasing the amount of substrate available for microbial protein synthesis in the rumen. The high CP digestibility and DCP values recorded herein for buffered rations (Table 2) may support this idea.

Despite these changes occuring within the rumen, these appear to be no consistent significant effect of added bufers on altering VFA concentrations, compared with the control (Fig. 1"C"). However, at 2 and 4 hrs post feeding VFA's tended to be slightly higher for buffered rations than the unbuffered one. Similar lack of response for added buffers on VFA's were also reported by Solorzano *et al.* (1989) and Wagner *et al.* (1993). In contrast, El-Bedawy *et al.* (1989) and Tucker *et al.* (1992) found that added buffers altered ruminal VFA's. It is of importance to point out that measuring VFA's at any given time represents the net of production, absorption and outflow.

Regarding the characteristics of blood and plasma, the results in Table (3) showed that number of RBC, WBC and plasma minerals (Na, K, Ca and Mg) were not significantly affected by added buffers. However, cows fed on ration B supplemented by $KHCO_3$ showed the highest Na, K and Ca contents in plasma, while the lowest values were recorded with group fed on ration C which contained the combined buffers. In this concern, El-Bedawy (1989) found no significant differences in blood pH, hemoglobin and packed cell volum (PVC) between goats fed all barley basal diet buffered by $NaHCO_3$ and the control, whereas Thomas and Wilkinson (1975) found that added buffers increased blood pH, plasma HCO_3 and urine pH of cows fed ensiled maize. Different variable responses of blood and plasma characteristics for adding buffers were recorded by Phillip and Hidalgo (1989), Belibasakis and Triantos (1991) and West *et al.* (1991). Such variability could be due to the several factors mentioned earlier.

As for daily urine pH (am and pm) the results in Table (3) indicated that there were no significant differences in urine pH values among the four groups, in spite of that urine pH of cows fed buffered ration were slightly higher than the control, suggesting that changes in acid - base status of fed buffered rations had occurred.

Phillip and Hidalgo (1989); Ghorbani *et al.* (1989) and Tucker *et al.* (1991) found an increase in urine pH as a result of addition of buffers due to increasing dietary cation - anion balance. However, Stokes *et al.* (1986) found no effect of buffers on the urine pH value of cows.

Table 3. Red and white blood cells, plasma minerals and urine pH of cows fed on the experimental rations.

Items	Experimental rations				S.E
	Control	1% $NaHCO_3$ (A)	1% $KHCO_3$ (B)	0.5% $NaHCO_3$ + 0.5% $KHCO_3$ (C)	
Blood :					
Number of RBC (mill./mm^3)	11.5	11.5	10.9	10.7	0.67
Number of WBC (x 10^3/mm^3)	8.59	8.50	8.64	8.41	0.43
Plasma minerals (mg/ L.) :					
Na	3178.9	3178.8	3183.9	3176.5	8.39
K	283.6	295.2	310.6	279.0	66.9
Ca	111.8	122.1	138.2	108.0	11.6
Mg	61.1	59.2	61.0	59.2	2.91
Urine :					
Urine pH (a.m.)	7.09	7.20	7.22	7.21	0.12
Urine pH (p.m.)	7.28	7.35	7.37	7.43	0.14

Concerning milk yield and its composition, the results in Table (4) showed that daily milk production was increased by about 1.1, 0.6 and 0.6 Kg/h, and the coressponding increases of 4.0%, FCM were 1.7, 0.9 and 1.0 Kg/h/d represented about 12.8, 6.80 and 7.50% for groups fed rations A, B and C, respectively, although the differences were not significant among them and when they were compared with the control. Solorzano *et al.* (1989); West *et al.* (1991) and Orozco-Hernadez *et al.* (1994) found an increase in 4.0%, FCM yield as a result of addition of buffers to diets of dairy cows, whereas others (West *et al.*, 1987 and Vicini *et al.*, 1988) showed no differences.

Buffers were effective in elevating milk - fat by about 0.26, 0.15 and 0.17 percentage units for rations A, B and C, respectively, with no significant differences in fat (%) among them and when they were compared with the control one (Table 4). This beneficial effect for adding buffers on altering milk fat suggest that changes in rumen fermentation are most likely to occure with the tendency towards increasing acetate, and also decreasing ruminal propionate (Bondi, 1987). West *et al.* (1991), Harrison *et al.* (1989) and Tucker *et al.* (1992) found an increase in milk - fat as a result of added buffers, whereas Vicini *et al.* (1988) and Belibasakis and Triantos (1991) showed no differences. However, El-Bedawy *et al.* (1989) found a decrease in milk fat (%) of goats fed barley + $NaHCO_3$, compared with those fed barley + hay (4.53 *vs.* 4.24), which was associated with the low acetate and high propionate level in rumen for the former diet.

Milk protein, total solids and solids non fat (SNF) tended to be slightly (non significant) higher for groups fed buffered rations than the control one. In this concern, Stokes *et al.* (1986); Vicini *et al.* (1988) and Belibasakis and Triantos (1991) found that milk total solids and SNF were not affected by buffers supplementations.

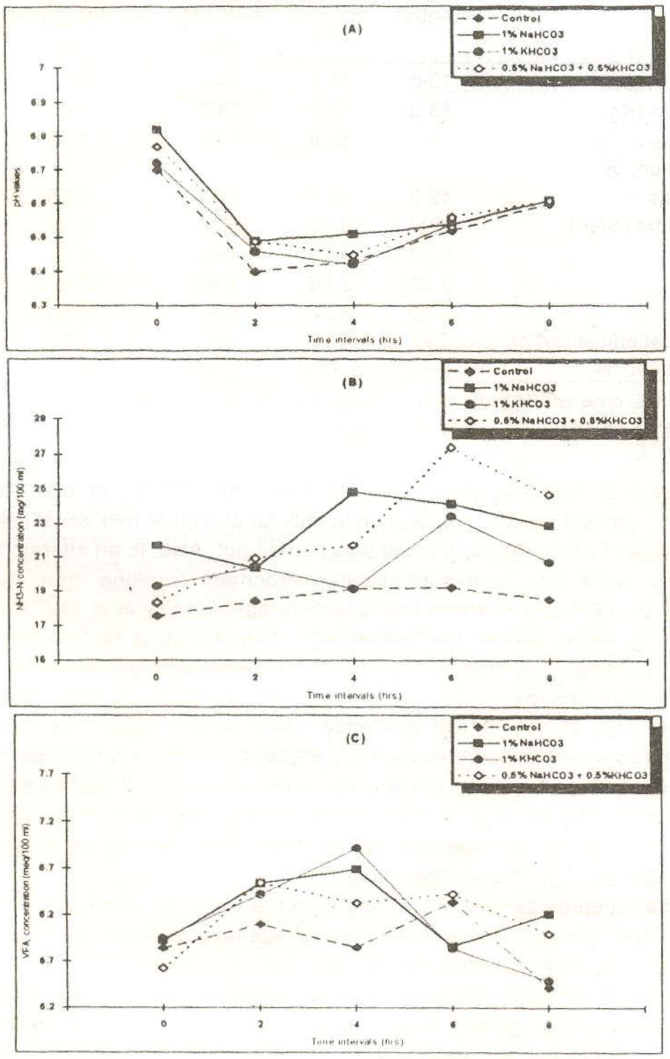

Figure 1. Effect of buffer supplementations on (A) pH values, (B) NH_3-N concentration (mg/100 ml) and (C) VFA's concentration (meq/100 ml) of rumen liquor of tested cows.

Table 4. Average daily milk yield, its composition and economical efficiency by cows fed the experimental rations.

Items	Experimental rations				
	Control	1% $NaHCO_3$ (A)	1% $KHCO_3$ (B)	0.5% $NaHCO_3$ + 0.5% $KHCO_3$ (C)	S.E
Milk yield (Kg/d)	13.6	14.7	14.2	14.2	0.53
4.0%, FCM (Kg)	13.3	15.0	14.2	14.3	0.72
Improvement, %	---	12.8	6.80	7.50	
Composition, % :					
Total solids	12.3	12.7	12.4	12.5	0.27
Solid non fat (SNF)	8.24	8.43	8.38	8.36	0.11
Fat	3.87	4.13	4.02	4.04	0.29
Protein	2.86	2.86	2.89	2.90	0.09
Lactose	4.82	4.85	4.82	4.83	0.07
Economical efficiency*,%	293	319	276	300	0.16
Improvement, %	---	+ 26.0	- 17.0	+ 7.0	

* Based on the price of 1 Kg rice straw, berseem hay, concentrates, $NaHCO_3$, $KHCO_3$ and FCM being 4.25, 20, 34.6, 100, 1200 and 90 PT, respectively.

It appears that $NaHCO_3$ was more effective than $KHCO_3$ or both together in elevating or preventing the depression in milk fat and other milk constituents under the conditions of which the experiment was carried out. Also, in an attempt to prevent the milk fat depression in a subtropical environment resulting from feeding high amount of concentrates to affect poor quality forage, Stanley *et al.* (1972) concluded that $NaHCO_3$ alone was more effective than when given plus MgO in elevating milk fat (%) of lactating cows when either a low or moderate amount, but not when a high amount of forage was fed.

Based on data of economical efficiency, the results in Table (4) showed that the highest improvement value for economical efficiency (26%) was recorded with ration A, followed by ration C (7.0%), while uneconomic ration B (-17.0%) caused by using $KHCO_3$ which has the higher price (1200 PT/Kg) than $NaHCO_3$ (100 PT/Kg). However, the highest improvement (%) in FCM yield the highest improvement in economic efficiency and the reverse versa.

Under the experimental conditions, and from the economic point of view it could be concluded that although concentrate : roughage ratio obtained herein for all tested rations did not exceed more than 54 : 46, addition of sodium bicarbonate to rations of cows was more effective and economic than potassium bicarbonate or both buffers together in improving nutrient digestibilities and nutritive value of tested rations, accordingly, enhancing milk yield as well as counteracting the depression of milk fat, without any adverse effects on blood or other milk characteristics and animal health in general.

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هل يوجد تأثير مفيد لإضافة بيكربونات الصوديوم والبوتاسيوم إلى علائق الأبقار الحلابة ؟

أحمد عبد الرازق جبر [1] ، أحمد زكى محرز [1] ، إسماعيل سعيد قريط [2] ،رجب محمد أبوعيانه [2]

[1] قسم إنتاج الحيوان - كلية الزراعة - جامعة المنصورة - مصر. [2] معهد بحوث الإنتاج الحيوانى وزارة الزراعة - مصر.

تهدف الدراسة إلى بحث ومقارنة تأثير إضافة يكربونات الصوديوم أو البوتاسيوم بمعدل ١٪ أو كليهما معاً بمعدل ٠,٥٪ لكل منهما من العلف المركز المقدم للأبقار الحلابة (١٢ بقرة فريزيان) ، مع علائق أساسية مكونة من دريس البرسيم وقش الأرز ومخلوط العلف المركز على المأكول من العليقة ومعاملات الهضم ، وكذلك قياسات سائل الكرش ومستوى معادن البلازما وعدد كرات الدم الحمراء والبيضاء ، وإنتاج اللبن معدل الدهن (٤٪) وتركيبه.

ولقد أوضحت النتائج أن إضافة المواد المنظمة منفردة أو مضافة معاً أدت إلى تحسن المأكول من العليقة ومعاملات هضم العناصر الغذائية المختلفة والقيمة الغذائية للعلائق المختبرة مقارنة بعليقة الكونترول. وبصفة عامة ، لم يتأثر معنويا كل من قيم pH البول وسائل الكرش وتركيز نيتروجين الأمونيا وتركيز الأحماض الدهنية الطيارة بسائل الكرش ، وعدد كرات الدم الحمراء والبيضاء وكذلك تركيز الصوديوم والماغنسيوم والكالسيوم والبوتاسيوم فى بلازما الدم ، وكذلك إنتاج اللبن وتركيبه نتيجة لإضافة المواد المنظمة. ومع ذلك كان متوسط الإنتاج اليومى من اللبن معدل الدهن أعلى بمعدل ١,٧ ، ٠,٩ ، ١,٠ كجم للمجموعات التى غذيت على بيكربونات الصوديوم وبيكربونات البوتاسيوم ومخلوطهما معاً على التوالى مقارنة بمجموعة الكونترول. والتحسن المقابل فى نسبة الدهن ٪ كان ٠,٢٦ ، ٠,١٥ ، ٠,١٧ على التوالى.

ولقد وجد أن إضافة بيكربونات الصوديوم كان أكثر كفاءة وإقتصادياً عن بيكربونات البوتاسيوم أو مخلوطهما على تحسن إنتاج اللبن ونسبة الدهن.