Energy and protein metabolism and nutrition

EAAP publication No. 124, 2007
Vichy, France
9-13 September, 2007

Venous blood gas in Holstein steers fed diets with different concentrate to alfalfa hay ratios

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Introduction

In ruminants, feeding diets high in grain and other highly fermentable carbohydrates increases the risk of ruminal and blood acidosis. Although, ruminal pH varies considerably within a d, cows possess a highly developed system to maintain ruminal pH within a physiological range. However, if the acid production from fermentation is more than the system which can be buffered, ruminal pH compensation fails and it may drop drastically (Krause and Oetzel, 2005). An arterial and/or venous blood gas (ABG and VBG, respectively) is a clinical tool for determining pulmonary and metabolic status in animals. However, most blood tests are done on a sample of blood taken from a vein due to the following: (i) Collecting blood from an artery is more painful than collecting it from a vein because the arteries are deeper and have more nerves, (ii) Artery may be inaccessible due to periarterial tissues (overlying muscle, connective tissue, or fat). The importance of venous blood gas measurements in the ruminant is useful to predict some health problems such as ruminal parakeratosis, erosion ad ulceration of the ruminal epithelium (Garry, 2002), laminitis, sole abscesses and ulcer (Nocek, 1997). Therefore, the determination of ABG or VBG in ruminal acidosis can prevent some health problems (Garry, 2002). ABG and VBG provide a direct measurement of partial blood pressures of carbon dioxide (PCO_2) and oxygen (PO_2), hydrogen ion activity (pH), total hemoglobin (Hb total), oxyhemoglobin saturation (HbO_2) and bicarbonate ion concentration (HCO_3^-). The objective of the present experiment was to investigate the effect of diets providing different concentrate to alfalfa hay ratios on partial blood pressures of carbon dioxide ($PaCO_2$) and oxygen (PO_2), hydrogen ion activity (pH), oxyhemoglobin saturation (HbO_2) and bicarbonate ion concentration (HCO_3^-) in Holstein steers.

Material and methods

Holstein steers (initial body weight= 261 ± 15 kg, n=30) were adapted to experimental diets for one wk. Then, for 120 d, steers were fed 10 kg of DM of diets differing in concentrate (155 g CP/kg of DM; 30% maize, 34% barley, 8% soybean meal, 5% sugar beet pulp, 10% wheat bran, 12% cottonseed meal, 0.3% $CaCO_3$, 0.5% mineral and vitamin premix, 0.2% salt) to alfalfa hay (155 g CP/kg of DM) ratios as 60:40 (C_{60}:L_{40}) and 80:20 (C_{80}:L_{20}) in a completely randomized design. The animals were housed in individual pens, and fed the experimental diets as total mixed rations twice daily at 08.00 and 20.00 h. They had free access to drinking water. At d 60 and 120 of the experiment, blood samples were taken from the jugular vein 4 h after the morning feeding. Samples were analyzed for VBG (blood pH, PO_2, PCO_2, HbO_2 and HCO_3^-) by an automatic blood gas system (AVL 995, Switzerland). Data of sampling d were analyzed as repeated measures using the PROMIX of SAS (y = Mean + Treatment + Animal (Treatement) + Time + Treatment × Time + residual) and the means were compared by the Duncan (P<0.05) test.

Results and discussion

Data of pH and venous blood gases in Holstein steers fed diets differing in concentrate: alfalfa hay ratios are presented in Table 1. Blood pH, PO_2, PCO_2, HbO_2 and HCO_3^- were all similar among the diets at each sampling d (P>0.05). However, PO_2 was numerically higher in animals fed C_{80}:L_{20} compared with those fed C_{60}:L_{40} on d 120 of the experiment (35.33 vs. 38.37 mmHg, P=0.05). The

results of the present study demonstrated that the increasing of concentrate in the diets of Holstein steers did not significantly affect blood pH. In mixed metabolic acidosis the rate of increasing in plasma bicarbonate appears to be a function of the rate of increasing in plasma PCO_2. In addition, for compensating respiratory acidosis, increasing in plasma [HCO_3^-] paralleled the increase in plasma [PCO_2]. The results of the present study indicate that blood HCO_3^- (mEq/L) and PCO_2 (mmHg) did not significantly change when steers were fed high concentrate diets. However, HCO_3^- was significantly affected by time ($P<0.05$). Therefore, it was concluded that the increasing of concentrate from 60 to 80 percent could not cause a mixed metabolic acidosis in steers in our conditions.

Table 1. Venous blood gases in Holstein steers fed diets differing in concentrate: alfalfa hay ratios.

Item	Concentrate:alfalfa hay ratio[1]				Treatment effect		Time effect	
	C_{60}:L_{40}		C_{80}:L_{20}		60 d		120 d	
	60 d	120 d	60 d	120 d	SEM[2]	P[3]	SEM	P
Blood pH	7.33	7.38	7.35	7.36	0.01	0.97	0.01	0.05
PO_2, mHg	37.31	35.33	35.41	38.37	1.17	0.76	1.02	0.67
PCO_2, mmHg	56.95	55.85	57.28	65.80	2.63	0.19	2.35	0.22
HCO_3^-, mEq/L	29.61	31.50	30.80	35.24	1.23	0.19	1.1	0.03
O_2 saturation, %	62.34	60.23	60.67	64.16	1.84	0.74	1.46	0.05

[1]C_{60}:L_{40}= 60% concentrate + 40% alfalfa hay, C_{80}:L_{20}= 80% concentrate + 20% alfalfa hay
[2]SEM= Standard Error of Mean; [3] P=Probability

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This research was supported by a grant from Ferdowsi University of Mashhad and Excellence Center for Animal Science.