Livestock Science 186 (2016) 41–45

Contents lists available at ScienceDirect

Livestock Science

journal homepage: www.elsevier.com/locate/livsci

Short communication

Impact on digestibility, and blood and fecal parameters of replacing wheat bran with corn gluten meal in concentrate of adult horses

G.F. Correa [a], O.C.A. Nascimento [b], T.P. Mota [a], G.O. Hespanholo [a], C.G. Moreira [a], M.L. Menezes [a], I. Vervuert [c], J.C.C. Balieiro [d], I.C.S. Bueno [a], R.A. Brandi [a,*]

[a] Department of Animal Science, Faculty of Animal Science and Food Engineering, University of Sao Paulo, Pirassununga, Brazil
[b] Department of Veterinary Medicine, Faculty of Animal Science and Food Engineering, University of Sao Paulo, Pirassununga, Brazil
[c] Institute of Animal Nutrition, Nutrition Diseases and Dietetics, Leipzig University, Leipzig, Germany
[d] Department of Animal Nutrition and Animal Production, Faculty of Veterinary Medicine and Animal Science, University of Sao Paulo, Brazil

ARTICLE INFO

Article history:
Received 30 January 2015
Received in revised form
27 May 2015
Accepted 2 June 2015

Keywords:
Horse
Co-product
Digestibility
Blood parameters
Fecal parameters
Nutrition

ABSTRACT

The objective of this study was to assess the impact of replacing wheat bran with increasing levels (10%, 20% and 30%) of corn gluten meal 21 (CGM 21) in the concentrate of adult horses. Four adult horses were used in a 4 × 4 Latin square designed experiment. Total tract apparent digestibility (TTAD), and selected fecal (pH, buffering capacity, concentration of short-chain fatty acids) and blood (glucose, cholesterol, triglycerides) parameters were used as response parameters. The results showed that replacing wheat bran with CGM 21 did not affect ($p > 0.05$) TTAD, fecal pH, fecal buffering capacity, fecal concentration of short chain fatty acids or blood glucose. However, blood cholesterol and triglycerides decreased ($p < 0.05$) with increasing levels of CGM 21 in the concentrate.

1. Introduction

Adequate nutrition is one of the most important factors to maintain the health of horses (Frape, 2008) and can be achieved by proper diet formulation and feeding. There are studies in the literature that have investigated the feasibility of using alternative ingredients in the horse diet (Frape, 2008; Furtado et al., 2011). However, for many alternative ingredients the data available is limited which justifies further research.

Corn gluten meal 21 (CGM 21) is an ingredient rich in protein and fiber that results from the extraction of most of the starch, gluten and germ of the corn grain. CGM 21 has been successfully used in feeds for ruminants, and the incorporation of this ingredient into feedlots diets have increased intake and weight gain (Farran et al., 2006). For poultry, it was found that diets with inclusion of CGM 21 showed better results of weight gain and carcass variables (weight and yield) than control diet (Rabello et al., 2012). CGM 21 can be fed to gestating sows at high concentrations in the diet (greater than 90%) with no negative effects and excellent reproductive performance (Honeyman and Zimmerman, 1990). No studies evaluating CGM 21 digestibility or metabolic response in diets for horses were found in the literature.

This study evaluated different inclusion levels of CGM 21 in the concentrate of adult horses using total tract apparent digestibility, and selected fecal (pH, buffering capacity, concentration of short-chain fatty acids) and blood (glucose, cholesterol, triglycerides) parameters were used as response parameters.

2. Materials and methods

2.1. Animals and experimental design

Four adult crossbred horses, housed in individual stalls, with an average age of 2.8 years and weighing 445 (± 20) kg were used in 4 × 4 Latin square designed experiment. The experiment was divided into four 15-day periods, with four resting days between each period, and lasted for 72 days in total. Each period of 15 days consisted of 10 days of adaptation to the diet, followed by four days for total collection of feces and one day for blood sample

* Corresponding author.
E-mail addresses: graziani.correa@usp.br (G.F. Correa), olivia.nascimento@usp.br (O.C.A. Nascimento), thais.mota@usp.br (T.P. Mota), gabriela.hespanholo@usp.br (G.O. Hespanholo), camilla.moreira@usp.br (C.G. Moreira), madalima@usp.br (M.L. Menezes), ingrid.vervuert@vetmed.uni-leipzig.de (I. Vervuert), balieiro@usp.br (J.C.C. Balieiro), ivesbueno@usp.br (I.C.S. Bueno), robertabrandi@usp.br (R.A. Brandi).

http://dx.doi.org/10.1016/j.livsci.2015.06.001
1871-1413/

Table 1
Ingredient composition (%) of experimental concentrates.

Ingredients	CGM 21 level in the concentrate (%)			
	0	10	20	30
Ground corn	41.0	40.0	37.3	35.0
Wheat bran	35.0	27.7	22.7	17.2
Soybean meal	9.5	7.7	5.4	3.2
CGM 21	0	10.0	20.0	30.0
Molasses	10.0	10.0	10.0	10.0
Limestone	2.0	2.0	2.0	2.0
Common salt	1.3	1.4	1.4	1.4
Dicalcium phosphate	0.8	0.9	0.9	0.8
Mineral vitamin premix[a]	0.4	0.4	0.4	0.4
Total	100.0	100.0	100.0	100.0

[a] Supplement facts: Manganese monoxide (11400.0 mg); Antioxidant additive (25.0 mg); Calcium iodate (26.0 mg); Sodium selenite (48.0 mg); Vitamin B12 (2500.0 mcg); Calcium pantothenate (1500.0 mg); Biotin (20.0 mg); Vitamin B6 (764.0 mg); Choline chloride (12858.0 mg); Vitamin E (10000.0 UI/kg); Vitamin A (1500000.0 UI/kg); Vitamin K3 (240.0 mg); Vitamin D3 (150000.0 UI/kg); Iron sulfate (21780.0 mg); Zinc oxide (25000.0 mg); Copper sulfate (6250.0 mg); Cobalt sulfate (25.0 mg); Folic Acid (505.0 mg); Niacin (2512.0 mg); and Vitamin B2 (1250.0 mg).

collection.

The experiment was conducted in the Equine Sector of University of Sao Paulo (USP) in Pirassununga and was approved by the Ethics Committee on Animal Experimentation, College of Animal Science and Food Engineering (Faculdade de Zootecnia e Engenharia de Alimentos, FZEA), USP (Protocol CEP FZEA 14.1.542.74.7.).

2.2. Diets and feeding

The experimental diets were composed of hay (Jiggs) and concentrate (50:50 on energy basis), and were formulated to meet the maintenance requirements for adult horses according to NRC (2007). The concentrate contained different inclusion levels (0%, 10%, 20% and 30%) of CGM 21 (Tables 1 and 2).

On average, the daily allowance (as fed) was 6.0 kg of hay and 2.7 kg of concentrate. The hay was fed at 1:00 p.m. (one third of the daily allowance) and at 5:00 p.m. (two thirds of the daily allowance) and the concentrate was fed at 7:00 a.m. and 3:00 p.m. (half of the daily allowance at each meal.

2.3. Fecal parameters

Pooled fecal samples collected for the digestibility assays were used to evaluate the impact of diet on selected fecal parameters. Fecal consistency (1=extremely dry feces; 3=normal feces; 5=diarrheal feces) was determined as described by Berg et al. (2005) and fecal color (classified as green (normal), black, reddish or yellowish) as described by Godoi et al. (2009). The pH was determined using a bench pH meter introduced directly into fresh feces.

For assessment of buffering capacity (BC) at pH 5 and pH 6, 100 mL of distilled water was added to a 50-g aliquot of each fecal sample, homogenized and then filtered. An aliquot of 80 mL from the filtrate was titrated with 0.25 M acetic acid. Results were obtained according to the equation: BC (mmol/L)=volume (mL)× 3.125 (Zeyner et al., 2004).

The fecal short chain fatty acids (SCFA) were determined by collecting a 10-g feces sample daily, which was mixed with 30 mL of 1 N formic acid (Merck®104), placed in 120-mL plastic containers and frozen at −20 °C, until further use. The concentration of short-chain fatty acids (SCFA) was determined by gas chromatography according to the procedure described by Hussein et al. (2004).

2.4. Blood parameters

Blood samples were drawn from the jugular vein by venipuncture immediately before feeding the first meal of the day (concentrate at 7:00 a.m.) and at 1.5, 3, 4.5 and 6 h after this meal. The blood was centrifuged, and the serum/plasma samples were placed in Eppendorf tubes and stored frozen at −20 °C. Biochemical kits were used to determine cholesterol (Labtest Colesterol 76-2), triglycerides (Labtest Triglicerides 87-2) and glucose (Labtest Glicose 133-2) with a spectrophotometer. Serum SCFA was determined by gas chromatography according to the methodology described by Hussein et al. (2004).

2.5. Chemical analysis

Feed and fecal samples were analyzed for dry matter (DM), ash, ether extract (EE) and crude protein (CP) according to AOAC (1995). Starch was analyzed with a colorimetric method (Hendrix, 1993), and acid detergent fiber (ADF) and neutral detergent fiber (NDF) were analyzed according to Van Soest et al. (1991). Gross energy (GE) was determined using a bomb calorimeter.

2.6. Statistical analyses

The SAS software for Windows (SAS Institute, 2000) was used for the statistical analyses. The digestibility data were analyzed using the linear mixed model with inclusion level of CGM 21 (0%, 10%, 20% and 30%) as fixed factor and effect of animals within the Latin square (LS) as random effect. Regression analyses were performed when a significant effect was observed for inclusion level. Blood parameters were analyzed using a generalized linear mixed model with sampling time as fixed factor and animals within the

Table 2
Chemical composition (% of dry matter) of experimental concentrates.

Nutrient (%)	CGM 21 level in the concentrate (%)				Forage Jiggs hay	CGM 21
	0	10	20	30		
Organic matter	90.4	91.1	90.7	90.7	93.6	95.0
Ash	9.6	8.9	9.3	9.3	6.4	5.0
Crude protein	15.0	16.0	15.5	14.5	12.0	22.7
Ether extract	3.0	3.1	3.2	3.2	0.9	3.4
Nitrogen free extract	51.1	49.5	47.8	45.0	8.7	16.7
Starch	35.9	34.0	34.0	35.3	4.9	14.6
Neutral detergent fiber	21.3	22.5	24.3	28.0	72.0	52.1
Acid detergente fiber	5.7	6.3	6.5	7.1	30.0	14.2
Gross energy (kcal/kg)	3963.0	3987.0	3952.0	4034.0	4275.0	3289.0[a]

[a] Estimated by NRC (2007).