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Original Research

Soybean Hulls in Equine Feed Concentrates: Apparent Nutrient Digestibility, Physicochemical and Microbial Characteristics of Equine Feces

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ABSTRACT

The aim of this study was to evaluate the soybean hulls inclusion in concentrates for horses as an alternative fiber source, through the apparent digestibility of nutrients and physicochemical characteristics of the feces. Five mares (3.5 ± 0.8 year old; 492.5 ± 44.5 kg) were used in a 5 × 5 Latin square design. Experimental diets were formulated for animals at maintenance and were composed of 60% energy from forage (Coastcross hay) and 40% from a concentrate, with increasing levels of soybean hulls (0, 7, 14, 21, and 28%). The inclusion of soybean hulls at any level in the concentrate had no effect ($P > .05$) on the following parameters: apparent digestibility coefficients of nutrients in the diet; feces pH, buffering capacity (BC) to pH 5 (BC 5) and to pH 6 (BC six), and ratios of short-chain fatty acids (SCFAs) as well as *Streptococcus* spp. and *Lactobacillus* spp. Diets with up to 28% soybean hulls in the concentrate can be used as equine feed without negatively affecting digestibility, the SCFAs concentrations or selected microbiota, and physicochemical characteristics in the feces.

1. Introduction

The digestion and metabolism of structural carbohydrates from forage in the large intestine of equines can supply the energetic needs of the animals during maintenance [1]. To maximize the growth and productivity of these animals, diets with high percentages of grains are commonly used [2]. Using starch-rich foods in equine nutrition can result in large changes in the intestinal microbiota of the animals and subsequently in the digestibility of the nutrients [3]. The maximum recommended starch level of 1 g/kg of body weight per meal to avoid high undesirable increases in plasma glucose and insulin may lead to future metabolic disorders in horses [4]. It was suggested that the starch intake >1 g/kg body weight (and meal) contributes to increased risk of gastric problems in horses [5]. According to these cited studies, commonly used concentrate diets have high levels of grains, and alternative sources of energy have been sought, such as energy derived from the fermentable fiber.

The excessive use of starch in equine diets can lead to fermentation of the ingested material by amylolytic bacteria in the large intestine resulting in an increase in

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lactic acid production, decreased pH, and increased production of short-chain fatty acids (SCFA) [6], which can favor intestinal disorders such as colic [6,7] or laminitis. Furthermore, fiber digestibility is negatively influenced [8].

Foods rich in nonamylaceous polysaccharides (e.g., beet pulp, soybean hulls and citrus pulp) have been used as energy sources for horses. The inclusion of these "super fibers" [9] promotes a decrease in starch levels without compromising the caloric density of the feed [10]. Studies on the inclusion of soybean hulls in equine diets have shown promising results [11–13]. It was suggested that it is possible to substitute bermudagrass hay by soybean hulls up to 100% and demonstrated a linear increase in dry matter (DM), neutral detergent fiber (NDF), and acid detergent fiber (ADF) digestibilities [12]. These findings corroborate the results of a study that used soybean hulls in 30% of the reference diet and did not observe any negative effects on digestibility of DM, ADF, or NDF [13]. No effect was found on DM, hemicellulose, ADF, or NDF digestibilities when soybean hulls were used in up to 75% of the diet consisted of alfalfa/bromegrass hay with the replacement of either 0, 25, 50, or 75% soybean hulls [11]. However, the authors reported a mild decrease in intestinal pH as a function of soybean hulls added to the diet and alterations in the ratio and in the concentration of SCFAs in the contents of the cecum.

This study aimed to evaluate the effects of increasing levels of soybean hulls in equine concentrate feed on the apparent digestibility of nutrients and the following fecal parameters: pH, SCFA ratios, buffering capacity (BC), and microbiota (*Streptococcus* spp. and *Lactobacillus* spp.).

2. Materials and Methods

2.1. Animals

The procedures used in this study were submitted to and approved by the Committee on Animal Research and Ethics of the College of Animal Science and Food Engineering of the University of Sao Paulo (Faculdade de Zootecnia e Engenharia de Alimentos da Universidade de São Paulo [FZEA-USP]) under process number 2012.1.1326.74.4.

The experiment was performed in the Equine Sector of FZEA/USP at Pirassununga campus.

Five mares without defined breed (crossbred) that were approximately 3.5 ± 0.8 year old and weighed 492.5 ± 44.5 kg were used and housed in individual stalls during the trials.

2.2. Experimental Feeds

The experimental diets were formulated to meet the nutritional requirements recommended by the National Research Council (NRC 2007) [14] for horses at maintenance. The diets were composed of 60% of energy from forage (Coastcross hay, which came in two batches that arrived one after the other during the study—hay one and hay two) and 40% of the energy from concentrate with increasing levels of soybean hulls (0, 7, 14, 21, and 28%; Tables 1 and 2). The amounts of ground corn, soybean meal, and wheat bran were adjusted to keep all diets isocaloric at each different inclusion rate of soybean hulls. The amounts of limestone, dicalcium phosphate, and potassium chloride were adjusted to maintain the same concentrations of calcium, phosphorus, and potassium between all diets (Tables 1 and 2). The soybean hulls used had the following measured composition: DM 90.0%, CA 3.3%, ether extract (EE) 1.1%, crude protein (CP) 10.9%, ADF 54.0%, and NDF 74.3%. The animals were fed two times a day, receiving the average amount of 2.0 kg of concentrate and 4.6 kg of hay per day, divided in equal portions.

Table 1
Measured composition of the experimental concentrates.

Ingredient	Soybean Hulls Inclusion Level (%)				
	0	7	14	21	28
Ground corn	58.5	58.2	57.1	56.8	51.8
Soybean meal	5.9	7.1	8.1	9.2	9.4
Wheat bran	30.0	22.0	15.0	7.0	5.0
Soybean hulls	0.0	7.0	14.0	21.0	28.0
Premix[a]	0.7	0.7	0.7	0.7	0.7
Sodium chloride	0.9	0.9	0.9	0.9	0.9
Limestone	3.1	2.7	2.3	1.9	1.8
Dicalcium phosphate	0.9	1.4	1.8	2.3	2.4
Potassium chloride	0.1	0.1	0.1	0.2	0.1

[a] Assurance levels: Linoleic acid: 3,630 mg/kg; oleic acid: 3 mg/kg; calcium (min): 150 g/kg; calcium (max): 170 g/kg; phosphorus: 80 g/kg; sodium: 121 g/kg; potassium: 10 g/kg; sulfur: 4,954 mg/kg; cobalt: 30 mg/kg; tyrosine: 34 mg/kg; copper: 1,400 mg/kg; iodine: 200 mg/kg; chrome: 12 mg/kg; lysine: 4,000 mg/kg; magnesium: 7,225 mg/kg; manganese: 1,400 mg/kg; phosphatidylcholine: 1,000 mg/kg; methionine: 14 mg/kg; selenium: 27 mg/kg; iron: 2,000 mg/kg; zinc: 3,500 mg/kg; vitamin A: 85,000 KUI/kg; vitamin C: 200 mg/kg; vitamin D: 8,500 KUI/kg; vitamin E: 200 mg/kg; *Saccharomyces cerevisiae*: 0.01500×10^7 CFU/kg.

2.3. Experimental Protocol

The experiment was performed according to a 5 × 5 Latin square design. The collection period was composed by seven acclimation days (mares in individual stalls with shavings bedding), followed by 3 days of total feces produced collection (immediately after defecation and directly from the ground of the stall that was without any bedding). After that, a 3-day washout period was performed when horses ate only hay and stayed in collective paddocks. The short adaptation period was assigned because of the similarity between diets.

To evaluate the nutritional composition of the horse feces, aliquots from a composed sample of each animal were created by storing (freezing) 10% of daily feces production each day and, after all, taking 10% of the feces production in each period. It was sent to the laboratory to be analyzed. Samples were thawed at room temperature and dried in a laboratory kiln at 65°C.

Analyses of DM, ash (A), EE, and CP in feeds and feces were performed according to the methodology described by the AOAC [15]. ADF and NDF analyses were performed according to Van Soest et al [16]. Gross energy in the feces and in the diet was measured using a bomb calorimeter. Bromatological analyses were performed in the Bromatology Laboratory of the Animal Science Department of FZEA/USP.

For pH, BC, and feces score and weight measures, samples were collected once a day (first feces of the day),