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Original Research

Fecal Gas Production of Ten Common Horse Feeds Supplemented With *Saccharomyces cerevisiae*

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ABSTRACT

The study aimed to assess the nutritive value of 10 feeds (grains and forages) commonly used in horse nutrition in Mexico, on the basis of their chemical composition, in vitro organic matter digestibility (IVOMD) and in vitro gas production measurements with or without the supplementation of *Saccharomyces cerevisiae* (SC) at 4 mg/g DM. Fecal inoculum was obtained from 4 adult English Thoroughbred horses fed on restricted amount of concentrate and oat hay ad libitum. Substrates tested were: 6 concentrates (corn gluten meal, soybean meal, steam-rolled corn, steam-rolled barley, oat grain, and wheat bran) and 4 roughages (soybean hulls, corn stover, alfalfa hay, and oat hay). Gas production (GP) was recorded at 2, 4, 6, 8, 10, 12, 14, 24, 48, and 70 hours using the pressure transducer technique. Some ingredient × yeast interactions were observed ($P \leq .020$) for the asymptotic GP and GP at 48 and 70 hours of incubation. Yeast addition increased ($P < .001$) the asymptotic GP of concentrates compared to roughages. Concentrate feeds had higher ($P < .05$) GP and lower ($P < .001$) rate of GP compared to roughages without yeast. From 24 to 70 hours of incubation, forages with or without yeast had lower ($P < .05$) GP compared to concentrates supplemented with SC. Forages had higher fermentation pH compared to concentrates but lower ($P < .05$) metabolizable energy, IVOMD, and microbial protein production compared to concentrates. Supplementation with SC increased ($P < .05$) the asymptotic GP of oat grain, soybean meal, soybean meal, steam-rolled barley, steam-rolled corn, wheat bran, corn stover, and oat hay, without affecting the rate of GP or lag time of oat grain, soybean meal, wheat bran, corn stover, and oat hay. Moreover, supplementation with SC increased ($P < .05$) metabolizable energy, IVOMD, and microbial protein production of steam-rolled barley, wheat bran, and corn stover, without affecting ($P > .05$) the fermentation of other feeds. Supplementation with SC improved fermentation of feeds with higher effects on concentrates compared to roughages. It was concluded that although SC mainly improves concentrate utilization by horses, it also improves fiber digestion when used on high-roughage diets fed to horses.

1. Introduction

In Mexico, the horse industry within the agriculture economy has become a strong sector. For top performance, horses must be fed adequately. A well-balanced ration in terms of energy, protein, minerals, and vitamins should be

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provided to fulfill their nutritional needs for good health and performance [1]. Horse rations can be made from locally available ingredients including roughages (e.g., hays and crops) and concentrates (e.g., grains and meals) [2]. The choice of feed ingredient for horse feeding depends on the horses' requirements, availability, and cost of commercially prepared feeds, and horse activity.

Concentrate feeds are required for growing and working horses which require extra energy and protein to support higher production levels. To prevent metabolic disorders associated with high-grain concentrate feeding, concentrates should be fed as a supplement to a forage-based diet and should not be more than 50%–60% of the total diet [1,2]. Oat, corn, and barley are the most widely used grains in horse diets in Mexico. Grains can be cracked, coarsely ground, rolled, or steam flaked. Wheat bran is one of the most valuable feed ingredient in the nutrition of horses due to its mild laxative effect and its bulky nature [1,2].

Concentrate feeds are needed when a horse cannot meet its energy and protein requirements from forage alone. Straws and hays are the most popular and less expensive sources of fiber for horses. Moreover, forage feeding to horses can provide many of the essential nutrients and prevent nutritional disorders because forage fibers maintain gastrointestinal health and well-being of horses [2]. Increasing dietary fiber to at least 1% of the horse's body weight with decreasing starch and sugar levels can reduce such disorders [2]. Therefore, feeding adequate amounts of fibrous feeds is required for normal digestive system function.

Addition of yeast (e.g. *Saccharomyces cerevisiae*) to the horse's diet has been shown to improve feed utilization and nutritive value [3–5] with positive effect on the hindgut microbial population [4]. Moreover, in vitro experiments [3,6,7] showed improved digestion and fermentation kinetics of feeds. The improved feed utilization is related to increased total number and activity of hindgut microorganisms, especially cellulolytic bacteria [8]. In addition, raising fermentation pH or at least maintaining fermentation pH with yeast feeding is another justification for using yeast [9]. On the other side, Lattimer et al [8] in an *in vitro* study and Glade and Biesik [10] in an *in vivo* study reported no effect of yeast-treated feed in horses, probably because the fermentation process used (Daisy II incubator) is a closed system and therefore does not allow for a continuous flow of microbes and nutrients. This may also be related to different yeast culture products and different diet types used [6,7].

The evaluation of the nutritive value of feed ingredients in each country is very important for nutritionists for establishing feed inventory and for formulating diets for horses. Therefore, the present experiment aimed to evaluate the fermentative capacity of 10 feed ingredients commonly used in equine feeding in Mexico in the presence or absence of *S. cerevisiae*.

2. Materials and Methods

2.1. Substrate and Yeast Cultures

Ten common horse feeds were used as incubation substrates (Table 1). The incubated concentrates included corn gluten meal (*Zea mays*), soybean meal (*Glycine max*), steam-rolled corn (*Zea mays*), steam-rolled barley (*Hordeum vulgare*), oat grain (*Avena sativa*), and wheat bran (*Triticum aestivum*). The incubated forages included soybean hulls (*Glycine max*), corn stover (*Zea mays*), alfalfa hay (*Medicago sativa*), and oat hay (*Avena sativa*). Procreatin 7 (Safmex/Fermex S.A. de C.V., Toluca, Mexico) yeast product of *S. cerevisiae*, in powdered form, containing 1×10^{10} cells/g of the product, was used at 0 and 4 mg/g of feed dry matter (DM).

2.2. In Vitro Incubations

Before the morning feeding, fecal contents were collected from the rectum of 4 adult English Thoroughbred horses of 7–9 years of age and weighing 490 ± 20 kg at the animal hospital of Faculty of Veterinary Medicine, University of the State of Mexico, Mexico, and these were used to inoculate fermentation with different substrates. The donor horses were fed 2 kg of commercial concentrate (Pell Rol Cuarto de Milla, Mexico; 26.7 g crude protein (CP)/kg DM) and oat hay *ad libitum*. About 100 g of fecal contents was collected from each horse and equally mixed and homogenized and then mixed with the Goering and Van Soest [11] buffer solution without trypticase at 1-g feces to 4-mL buffer. The incubation media were then mixed and saturated with CO_2 for about 20 minutes and then strained through 4 layers of cheesecloth into a flask with an O_2-free headspace. After filtration, the filtrates were used to inoculate 3 identical runs of incubation at 50-mL solution in 120-mL serum bottles containing 0.5 g DM of substrate and yeast at either 0 or 4 mg/g DM.

A total of 180 bottles (2 yeast levels $\times$ 3 replicates $\times$ 3 runs $\times$ 10 substrates) plus 3 bottles without substrate and yeast were used as blanks. After filling, bottles were flushed with CO_2 for 1 minute and immediately closed with rubber

Table 1
Chemical composition (g/kg DM) of the feed ingredients used as substrates.

	Concentrate						Roughage			
	Corn Gluten Meal	Soybean Meal	Steam-Rolled Corn	Steam-Rolled Barley	Oat Grain	Wheat Bran	Soybean Hulls	Corn Stover	Alfalfa Hay	Oat Hay
Organic matter	918	927	989	979	968	877	952	941	883	940
Crude protein	211	398	76	132	117	168	121	65	220	83
Ether extract	11.9	16.2	6.5	14.3	41.8	53	8.3	11.2	26.8	18.3
Neutral detergent fiber	425	251	234	410	250	429	637	700	337	530
Acid detergent fiber	99	61	21	53	66	126	438	385	215	361
Nonstructural carbohydrates	271	263	672	423	559	227	185	164	299	309