ORIGINAL RESEARCH

Effect of Yeast Culture Supplementation on Digestibility of Varying Forage Quality in Mature Horses

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ABSTRACT

Supplementation of yeast culture to equine diets has improved digestion of nutrients in some studies but not others. Improving the digestibility of lower-quality forages could be advantageous both for the producer and for the horse's health. The objective of this study was to evaluate the effect of yeast culture on digestibility of high- and low-quality forage in mature horses. Sixteen geldings (483.6 ± 25.5 kg and 6.8 ± 3.2 years), of Quarter Horse (n = 14) and Thoroughbred (n = 2) breeding, were used in a 4 × 4 Latin square design with 28-day treatment periods. Russell Bermuda grass hay of either high (13.1% crude protein (CP), 73.1% neutral detergent fiber (NDF), 35.3% acid detergent fiber (ADF), and 6.0% ash) or low (8.1% CP, 75.3% NDF, 37.6% ADF, and 4.3% ash) quality was offered at 1.35% of body weight (BW, dry matter [DM] basis). Diets consisted of high-quality forage with the addition of yeast culture (HY), high-quality forage without yeast culture (HC), low-quality forage with the addition of yeast culture (LY), and low-quality forage without yeast culture (LC). All horses were fed a commercial grain mix (12.6% CP, 25.4% NDF, 12.1% ADF, and 4.0% ash) offered at 0.45% of BW (DM basis) daily. Yeast culture was added to the grain mix during the morning feeding at a rate of 56 g per horse. Body weight was measured weekly and feed intake was adjusted accordingly. Fecal samples were obtained every 6 hours on the last 3 days of each treatment period. Horses receiving low-quality hay (LY and LC) had greater ($P < .01$) intake expressed as a percentage of BW compared with horses receiving high-quality hay (HY and HC). No influence of yeast culture supplementation was seen on intake of grain or forage ($P < .23$ and $P < .62$, respectively). Digestibility of DM, organic matter (OM), CP, and NDF were greater ($P < .01$, $P < .01$, $P < .01$, and $P < .01$, respectively) for the diets with high-quality forage compared with the diets with low-quality forage. Dry matter, CP, and NDF digestibilities were greater ($P < .09$, $P < .03$, and $P < .05$, respectively) for horses receiving LY compared with LC. Supplementation of yeast culture to mature horses improved digestibility of lower-quality Bermuda grass hay.

Keywords: Yeast culture; Forage quality; Horse; Digestibility

INTRODUCTION

Previous research has shown that fermentation products may be stimulatory to equine hindgut digestion and can beneficially alter microbial population. However, results with yeast culture supplementation have been variable and inconsistent. Research indicates that adding yeast culture to the diet of horses can improve nutrient digestibility,[1,2] increase microbial populations,[3,4] and maintain cecal pH.[3,5] However, other reports observed no improvement in nutrient digestibility when yeast culture was supplemented to horses in vivo[6,7] and in vitro.[4]

Dietary treatments vary greatly among equine studies involving yeast culture, ranging from high-starch to high-fiber diets. Improvement in cecal environment and digestibility has been seen in both high-starch[5,8] and high-fiber diets.[1,9] To our knowledge, no studies have investigated the influence of yeast culture supplementation on digestibility of forage when quality is limiting. Previous research involving the use of yeast culture in high-fiber diets has varied with the type of forage used. No studies have investigated the use of yeast culture in low-quality grass forage. Therefore, the purpose of this experiment was to evaluate the effect of yeast culture supplementation on nutrient utilization of Bermuda grass–based diets containing varying forage quality.

MATERIALS AND METHODS

Care, handling, and sampling of animals defined herein were approved by the University of Georgia Animal Care and Use Committee.

Horses and Dietary Treatments

Quarter horse (n = 14) and Thoroughbred (n = 2) geldings from the University of Georgia Equine Unit were

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used in a replicated 4 × 4 Latin square design. Horses ranged from 2 to 16 years of age (average age, 6.8 ± 3.2 years) and weighed between 405 and 581 kg (average body weight [BW], 483.6 ± 25.5 kg). Vaccinations and deworming practices were consistent with farm protocol. Horses were vaccinated annually for tetanus, Western equine encephalitis, Eastern equine encephalitis, West Nile, influenza, equine herpes virus (EHV-1, EHV-4), strangles, and rabies. Horses were dewormed every 2 months with non-boticide in the spring and summer and a boticide in fall and winter.

All horses received a mixed sweet feed (Sweet Horse Feed, Godfrey's Warehouse, Madison, GA containing grain products, plant protein products, roughage products, cane molasses, calcium carbonate, and salt) fed at approximately 0.45% of BW (DM basis) daily, and either a high-quality Russell Bermuda grass hay or a low-quality Russell Bermuda grass hay fed at approximately 1.35% of BW (DM basis) daily. Hay quality was determined by stage of maturity and fiber composition (NDF and ADF). Both the high- and low-quality hays were harvested from adjacent fields of the University of Georgia in May 2006. Horses were fed twice daily in 2.4 m × 1 m individual feeding stalls and allowed access to the diets for approximately 2.5 hours for each feeding. During the remainder of the day, horses were allowed ad libitum access to water, a mineral supplement (12% Ca, 12% P, 12% NaCl, 0.05% Mg, 100 ppm I, 28 ppm Se, 515 ppm Zn, 125 ppm Cu, 500 ppm Mn, 220,000 IU/kg vitamin A, 11,000 IU/kg vitamin D, 44 IU/kg vitamin E), and free exercise. Body weight was measured weekly, and diets were adjusted accordingly for the treatment period.

Before initiation of the study, geldings were blocked by age and BW and were randomized within blocks to each treatment group. Treatments consisted of: (1) high-quality forage with the addition of yeast culture (HY); (2) high-quality forage without yeast culture (HC); (3) low-quality forage with the addition of yeast culture (LY), and (4) low-quality forage without yeast culture (LC). Yeast culture (Diamond V XP Yeast Culture, Diamond V Mills Inc., Cedar Rapids, IA) was added to a grain mix during the morning feeding at a rate of 56 g per horse.

Table 1. Latin Square Experimental Design Designating Horses to Treatment and Fecal Collection Groups

	Treatments[a]							
	Fecal Collection Group[c]				Fecal Collection Group 2			
Wk[b]	R 1, 3	Y 1, 3	G 1, 3	B 1, 3	R 2, 4	Y 2, 4	G 2, 4	B 2, 4
1								
2	LY	LC	HY	HC	LY	LC	HY	HC
3								
4								
5	LC	HY	HC	LY				
6					LC	HY	HC	LY
7								
8								
9	HY	HC	LY	LC				
10					HY	HC	LY	LC
11								
12								
13	HC	LY	LC	HY				
14					HC	LY	LC	HY
15								
16								
17								

Abbreviations: HC, high-quality hay without yeast culture; HY, high-quality hay with yeast culture; LC, low-quality hay without yeast culture; LY, low-quality hay with yeast culture.

[a] Horses assigned to dietary treatment groups (R = red, Y = yellow, G = green, and B = blue) and numbered within the group. Odd-numbered horses assigned to fecal collection group 1 and even numbers assigned to fecal collection group 2.

[b] Wk = week of trial.

[c] Fecal collection groups began fecal collections 1 week apart because of availability of fecal harnesses.

Sample Collection

Two horses within each treatment group were assigned to one of two fecal collection groups (Table 1). Total fecal collections occurred 1 week apart between these two groups. Horses remained on each treatment for 28 days during each treatment period. Days 1 through 25 were used for diet acclimation, with total fecal collections occurring on days 26 through 28. At the end of each 28-day treatment period, horses were switched (within fecal collection group) to a different treatment that they did not receive previously. This procedure continued until all horses received every treatment.

During the 3-day collection period, horses were fitted with fecal collection harnesses (Equisan Marketing Pty. Ltd., South Melbourne, Victoria, Australia) and housed in individual stalls (3.0 m × 3.0 m) with ad libitum access to water. Fecal samples were removed from the collection harnesses every 6 hours. For each 6-hour collection, a 10% subsample was collected, placed in individual bags, and frozen for further analysis. Consumption of grain, hay, and water was recorded for each 24-hour period. Samples of grain and hay were also obtained throughout the collection period and stored at −20°C for subsequent analysis.

Preparation of Samples for Analysis

Hay and grain sampled during the collection period were ground through a 2-mm screen in a Wiley Mill (Thomas Scientific, Swedsboro, NJ). Fecal samples from the 6-hour collections were thawed at room temperature and mixed. A 100-g subsample for each 24-hour period was taken, 25 g from each 6-hour collection time, and dried in an oven at 55°C for 72 hours. Fecal samples were then allowed to air-equilibrate for 12 hours and ground through a 2-mm screen.

Chemical Analyses

Hay, grain, and fecal samples were analyzed for DM, OM, and CP (Kjeldahl N × 6.25) according to Association of Official Agricultural Chemists (AOAC) protocols.[10] All samples were analyzed for NDF, ADF, lignin, cellulose, and hemicellulose according to procedures described by Van Soest et al,[11] and modified[12] for use in an Ankom fiber apparatus (Ankom Technology, Fairport, NY). Gross energy content was determined by bomb calorimetry using a Parr isoperbal calorimeter (Parr Instrument Co., Moline, IL).

Statistical Analysis

All data were analyzed using the PROC GLM procedures of SAS (SAS Inst. Inc., Cary, NC) with treatment, period, and horse in the model statement. Least squares means and standard errors were obtained according to treatment effects on the parameters tested. Data were analyzed for four treatments (HC, high-quality hay without yeast culture; HY, high-quality hay with yeast culture; LC, low-quality hay without yeast culture; and LY, low-quality hay with yeast culture). Treatment means were compared using preplanned single degree of freedom orthogonal contrasts: yeast culture (HY + LY) versus no yeast culture (HC + LC), high-quality forage (HC + HY) versus low-quality forage (LC + LY), and interaction between yeast culture and forage quality. When significant yeast culture × forage quality interaction occurred, protected ($P \leq 0.10$) Fisher's LSD were used to separate treatment means. Probabilities of <0.10 were considered statistically significant, and probability values between 0.10 and 0.15 were considered to be trends toward significance.

RESULTS AND DISCUSSION

Diet Composition

Chemical composition of the grain and hays used in the dietary treatments is listed in Table 2. The two sources of Russell Bermuda grass hay used in this study differed in quality as evidenced by the chemical composition. The lower-quality hay possessed greater amounts of fiber (75.35% vs. 73.08% NDF and 37.59% vs. 35.22% ADF) and indigestible components (6.08% vs. 4.38% lignin), and lower CP (8.08% vs. 13.13%) when compared with high-quality hay. However, the hay described as low quality in this study is typical of mature, warm season grass hay fed to horses. Despite the variation in quality between the two hay sources, all dietary treatments (25:75 concentrate to hay) supplied greater amounts of CP and digestible energy (DE) than recommended for a mature horse at maintenance (8% CP and 2.0 Mcal/kg DE[13]). Chemical composition of the high-quality Russell Bermuda grass hay used in this study was similar to values obtained at 28 days of growth, and the low quality was similar to hay harvested at 42 days by Dore.[14] A search of the literature failed to reveal information on the nutritional value of Russell Bermuda grass for horses, and it is not included in a report by the National Research Council (NRC).[13] However, percentages of NDF, ADF, and CP for the high-quality Russell Bermuda grass hay used in the current study are similar to values reported by the NRC[13] for sun-cured Coastal Bermuda grass at 15 to 28 days' growth (73.0% NDF, 34.0% ADF, and 12.0% CP). Low-quality hay was similar to Coastal Bermuda grass harvested after 29 to 42 days' growth (75.0% NDF and 36.2% ADF), whereas the CP content of the lower-quality hay was similar to coastal Bermuda grass harvested at 43 to 56 days of growth as reported by the NRC (7.8% CP).[13] Additionally, both sources of hay were similar in composition to other reported values in the literature for coastal Bermuda grass hay fed to horses.[6,15,16]

Voluntary Intake and Body Weight

Although hays and concentrate were fed at restricted levels, differences in intake occurred, primarily because of some hay refusals (Table 3). Values for least squares means of total dry matter intake (DMI) expressed as a percentage of body weight increased ($P < .002$) when horses were fed diets containing low-quality hay (Table 3). This increase ($P < .001$) in intake of low-quality hay may be an attempt by the horses to maintain caloric intake by increasing DMI of the ration that is less energy dense, as observed in other monogastric species.[17] This observation contradicts evidence that voluntary consumption of forage in ruminants is limited by the digestibility of components.[18] Dry matter intake of hay in our study is lower than the consumption of Coastal Bermuda grass reported by LaCasha et al[16] in yearling horses and Aiken et al[15] in mature horses (2.1% and 2.0% of BW, respectively). However, our study supplied a source of grain (0.45% BW) and the amount of hay offered was restricted to 1.35% of BW. There was no influence ($P > .23$) of yeast culture supplementation on grain or hay intake expressed as a percentage of BW. Least squares mean values for BW were not affected by yeast culture supplementation ($P < .49$) or quality of hay ($P < .47$).

Digestibility

Apparent digestibilities of dietary treatments are listed in Table 4. Dry matter and OM digestibility were greater ($P < .0001$) for horses receiving high-quality hay compared with those consuming low-quality hay. Apparent digestibility of Russell Bermuda grass hay has not been previously reported in horses to our knowledge, but apparent digestibility of coastal Bermuda grass has been investigated in horses. Dry matter digestibility of Russell Bermuda grass and grain by geldings in our study was similar to the 43% observed by Aiken et al[15] for mature geldings consuming only coastal Bermuda grass hay and the 46% observed by LaCasha et al[16] when coastal Bermuda grass hay was fed to yearlings. Apparent digestibility of DM in our study was lower than that observed by Switzer et al[2] and Webb et al[6] (60%–61% and 58%–59%, respectively) when horses were fed a 50:50 ratio of concentrate to forage. The lower DM digestibility in the current study may be because of a greater ratio of forage to concentrate (75:25) and differences in hay varieties. Previous studies

Table 2. Chemical Composition of Grain and Russell Bermuda Grass Hay Used in Mature Horse Diets

		Hay		Diets (calculated)[a]	
	Grain	High	Low	LC and LY	HC and HY
DM, %	90.49	89.59	89.43	89.69	89.81
NDF, %	21.82	73.08	75.35	61.97	60.27
ADF, %	10.62	35.22	37.59	30.85	29.07
Lignin, %	2.39	4.38	6.08	5.16	3.88
Ash, %	3.91	6.00	4.33	4.23	5.48
CP, %	12.56	13.13	8.08	9.20	12.99
GE, Mcal/kg	4.34	4.19	4.17	4.21	4.23
DE, Mcal/kg[b]	—	—	—	1.94	2.12

[a] Diet designation represents quality of hay (L = low, H = high) and presence (Y = yeast culture) or absence (C = control) or yeast culture; diets composed of 25:75 grain to hay ratio.
[b] DE of diets calculated from chemical composition of dietary components and digestibility of dietary treatments.

Table 3. Dry Matter Intake and Body Weight of Mature Horses Receiving Diets of Grain and Russell Bermuda Grass of Varying Quality and Yeast Culture Supplementation[a]

	Diet					*P*-values		
	LY	LC	HY	HC	SEM	H vs. L	C vs. Y	Interaction[c]
Total intake, % BW[b]	1.68	1.67	1.63	1.62	0.014	0.002	0.50	0.86
Grain intake, % BW	0.45	0.45	0.45	0.45	0.002	0.42	0.23	0.28
Hay intake, % BW	1.23	1.22	1.18	1.17	0.014	0.001	0.62	0.98
BW, kg	485.3	484.2	484.3	487.1	25.505	0.47	0.49	0.11

Abbreviations: HY, high-quality forage with the addition of yeast culture; HC, high-quality forage without yeast culture; LY, low-quality forage with the addition of yeast culture; LC, low-quality forage without yeast culture.
[a] Each mean represents 16 individually fed horses.
[b] Diets were offered based on weekly BW measurements.
[c] Interaction between forage quality and yeast culture supplementation.

have used coastal Bermuda grass hay, and digestibility of Russell Bermuda grass hay in horses has not been reported. Additionally, horses were moved to individual stalls and fitted with a fecal collection harness during each fecal collection period. This may have influenced feeding behavior and passage of digesta, but no differences were seen between the first and last collection periods when horses were accustomed to the harnesses.

Pitman and Willis[19] observed that in vitro dry matter digestibility (IVDMD) of Russell Bermuda grass (60.2%) was lower than Stargrass (63.4%), Jiggs (62.6%), and Tifton 85 (64.5%) varieties when ground hay samples were incubated in ruminal fluid inocula. However, IVDMD often overestimates the value of grass forages in ruminants and horses.[16,20] The current study did not measure IVDMD.

No influence of yeast culture supplementation on DM and OM digestibility was seen ($P < .55$ and $P < .58$, respectively), but when yeast culture was added to low-quality forage diets, DM digestibility tended to increase ($P < .09$). Other investigations have yielded conflicting results, with some studies observing increased DM digestibility when live yeast[21] or yeast culture[1] was fed to mature horses, and others observed no influence of yeast culture supplementation on DM digestibility.[2,6,22] However, previous investigations with yeast culture supplementation in horses have not used forage of varying quality, and those who have observed increases in DM digestibility have fed diets with a greater proportion of forage or forage with greater cell wall content.[1,21]

Crude protein digestibility was greater ($P < .0001$) for horses receiving high-quality hay compared with horses consuming low-quality hay. This agrees with other studies that have seen a decrease in CP digestibility as the percentage of NDF increases in forage.[16,23] Digestibility of CP in the current study was lower than that observed by McCann et al[24] when coastal Bermuda grass was fed to mature horses and when LaCasha et al[16] fed coastal Bermuda grass to yearlings (65.4% and 64%, respectively). However, McCann et al[24] did not report the cell wall content of the coastal Bermuda grass hay used. LaCasha et al[16] used coastal Bermuda grass hay that was lower in NDF (52%) and ADF (26%) than the Russell Bermuda grass hay fed in the current study. Digestibility of CP was greater than the 50.7% observed by Aiken et al[15] when coastal Bermuda grass was fed to mature geldings, and the NDF and ADF contents (70.5% and 31.9%, respectively) were similar to that of the Russell Bermuda grass used in our study.

Table 4. Apparent Digestibility (%) of Diets Containing Grain and Russell Bermuda Grass of Varying Quality and Yeast Culture Supplementation Offered to Mature Horses[a]

Item	Diets				SEM	*P*-values		
	LY	LC	HY	HC		H vs. L	C vs. Y	Interaction[b]
DM, %	40.9[c]	37.7[d]	44.6[e]	46.2[e]	1.3	<.0001	.55	.07
OM, %	42.8	40.0	46.4	47.7	1.3	.0001	.58	.14
NDF, %	30.4[f]	25.1[g]	36.6[h]	37.8[h]	1.8	<.0001	.26	.08
ADF, %	19.4	18.5	28.0	29.6	2.3	.0001	.88	.58
Cellulose, %	31.1	25.7	38.9	37.1	2.2	.0001	.11	.41
Hemicellulose, %	41.1[f]	35.8[g]	46.0[h]	48.6[h]	1.3	<.0001	.30	.004
GE, %	46.5	46.0	49.6	50.9	1.8	.0104	.78	.54
CP, %	52.3[f]	47.5[g]	56.3[h]	57.6[h]	1.5	<.0001	.24	.05

Abbreviations: HY, high-quality forage with the addition of yeast culture; HC, high-quality forage without yeast culture; LY, low-quality forage with the addition of yeast culture; LC, low-quality forage without yeast culture.

[a] Each mean represents 16 individually fed horses.

[b] Interaction between forage quality and yeast culture supplementation.

[c-e] Means within a row lacking a common subscript differ ($P < .10$) based on Fisher's LSD when variables showed a significant ($P < .10$) interaction.

[f-h] Means within a row lacking a common subscript differ ($P < .05$) based on Fisher's LSD when variables showed a significant ($P < .10$) interaction.

No influence of yeast culture supplementation on CP digestibility was seen ($P < 0.24$), but when yeast culture was added to low-quality forage diets, CP digestibility increased ($P < .03$) from 47.5% to 52.3% (Table 4). This agrees with Switzer et al,[2] who reported an increase in CP digestibility when yeast culture was added to a ratio of 50:50 concentrate to forage. However, other investigations have observed no influence of yeast culture on CP digestibility.[6,21] To our knowledge, no other trials have investigated the use of yeast culture with forages of varying quality.

Digestibility of NDF, ADF, cellulose, and hemicellulose was greater ($P < .0001$) for horses receiving high-quality hay compared with geldings consuming low-quality hay. This agrees with Crampton,[18] who observed that rate of digestion decreased in sheep when cell wall content and lignification increased with maturity in forages. Neutral detergent fiber digestibility of the low- and high-quality hay (27.8% and 37.2%, respectively) used in the current study is lower than the 54.6% observed by McCann et al,[24] the 52% observed by LaCasha et al,[16] and 45.5% observed by Aiken et al.[15] However, McCann et al[24] did not report chemical composition of the coastal Bermuda grass hay fed, and Aiken et al[15] fed coastal Bermuda grass that was lower in NDF and ADF (70.4% and 31.9%, respectively) than the hay used in the current study. LaCasha et al[16] fed yearlings coastal Bermuda grass similar in NDF and ADF to the hay used in the current study; however, difference in NDF digestibility may be explained by difference in hay variety. Digestibility of ADF was also lower than the 56.5% reported by McCann et al[24] and similar to values reported by Aiken et al[15] and LaCasha et al[16] (35% and 26%, respectively). Cellulose and hemicellulose digestibility were much lower than the 61% and 75% reported by LaCasha et al,[16] but similar to the 42% and 58.7% reported by Aiken et al.[15]

No influence of yeast culture supplementation on NDF, ADF, or hemicellulose digestibility was seen ($P > .26$), but cellulose digestibility tended to increase ($P < .11$) when yeast culture was added to the diet. When yeast culture was added to low-quality forage, NDF and hemicellulose digestibility increased ($P < .05$). Glade and Biesik[7] also reported an increase in hemicellulose digestibility when yeast culture was added to yearling diets of whole corn and pellets, and NDF and ADF digestibility was improved when mature mares were fed yeast culture.[9] Webb et al[6] and Switzer et al[2] observed no effect of yeast culture supplementation on cell wall digestibility, but both of these studies used diets containing 50:50 ratio of concentrate to high-quality coastal Bermuda grass hay. Results of the current study suggest that digestibility of the lower-quality forage can be improved by yeast culture supplementation, possibly because yeast culture created a favorable large intestinal environment capable of more efficient fermentation. However, the current study did not evaluate microbial populations and cecal environment. Further research is needed to evaluate the effectiveness of yeast culture relative to forage quality and large intestinal environment. Long-term feeding also should be investigated to confirm the effectiveness of yeast culture on low-quality forage digestibility.

SUMMARY

Efficiency of forage utilization by horses is influenced by the quality of forage. Low-quality forage decreased DMI and total tract apparent digestibility of nutrients. Supplementation of yeast culture in horse diets containing low-quality forage tended to increase DMI and increased digestibility of NDF, hemicellulose, and CP. Yeast culture can be used to improve forage utilization in horses when forage quality is compromised.

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