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Effect of various levels of dietary starch on glycogen replenishment in the light working horse

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ABSTRACT

Nine Quarter Horses were used in a 3 × 3 Latin square with replication to determine the effect of various levels of dietary starch on glycogen replenishment in the light working horse. Horses were fed Coastal bermudagrass hay at 1% BW/d with remaining calories met by a high (HS), medium (MDS), or low starch (LS) concentrate. Horses were transitioned to 1 of 3 diets over 7 d for a 14-d treatment period where they were then worked to fatigue in a standardized exercise test. Total diets provided an average of 1,206.67, 844.61, and 263.13 g of starch/d in HS, MDS, and LS, respectively. Horses were lightly exercised for 30 min 3 d/wk. Skeletal muscle biopsies were taken from the biceps femoris at rest, immediately after the standardized exercise test, and 24 and 48 h after exercise. Venous blood samples were taken at rest, immediately after exercise, 10 min after recovery, and 24 h after exercise. There was a greater resting muscle glycogen concentration ($P = 0.009$) when comparing HS with MDS (10.25 vs. 8.28 μg/mg wet weight). There was a greater concentration of glycogen 24 h after exercise ($P = 0.04$) when comparing LS with HS (9.52 vs. 7.68 μg/mg wet weight). High starch used more glycogen than MDS or LS. A slight reduction in glycogen after exercise for MDS and LS indicated that fat or protein may have been used as substrate for exercise. Results indicated that feeding 1,206.67 g of starch/d did not yield an advantage in recovery time over a MDS or LS diet.

Key words: exercise, glycogen, horse, starch

INTRODUCTION

The prevalence of multiday competitive events throughout the performance horse industry brings forth the necessity to understand recovery from exercise, especially with bouts of intense, anaerobic exercise. These events take place in a period of 24 to 72 h where horses may become fatigued, resulting in a suboptimal performance during the event finals. Recently, an industry trend of high fat, high fiber diets has gained popularity and is promoted as a safe way to increase the energy density of a diet. This complicates the issue of fatigue and recovery because anecdotal evidence has shown that horses on these diets may fatigue early. This premature fatigue is likely due to less resting skeletal muscle glycogen stores in horses fed low starch diets as well as an increased recovery rate before glycogen is replenished for the next exercise period (Kline and Albert, 1981; Waller and Lindinger, 2010).

Muscle glycogen is an important fuel for energy during anaerobic metabolism, especially during maximal, exhaustive exercise (Harris et al., 1987; Pagan, 1998). Whereas humans and rats can replenish their muscle glycogen stores in as little as 4 to 6 h, replenishment in the horse is 3 to 4 times slower (Jentjens and Jeukendrup, 2003; Waller and Lindinger, 2010). Horses can require between 48 and 72 h to fully replenish skeletal muscle glycogen (Hodgson et al., 1983; Snow and Harris, 1991; Lacombe et al., 2004). Although researchers have successfully increased skeletal muscle glycogen repletion via nutritional intervention in the human, improvements in the horse have been limited (Bergström and Hultman, 1967; Waller and Lindinger, 2010).

Consequently, it is of importance to further explore methods of nutritionally manipulating equine glycogen replenishment to prevent fatigue and subsequent loss of athletic performance. However, the methods of nutritional intervention must be practical outside of a research setting. In the present study, use of commercially available feedstuffs were of importance for consumer application. The objectives of this study were to compare glycogen concentration in skeletal muscle before and after exercise and determine subsequent repletion of muscle glycogen in horses fed a high starch (**HS**), medium starch (**MDS**), or low starch (**LS**) diet.

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MATERIALS AND METHODS

Animal Management

American Quarter Horse mares (n = 5) and geldings (n = 4) owned by the Texas A&M University Department of Animal Science were used in a 3 × 3 Latin square with replication study lasting 105 d. Horses were from 2 to 7 yr of age (average age 4.5 yr) with an average BW of 463 kg and were selected based on temperament, health, and soundness. The horses were vaccinated and dewormed before the study according to a regular schedule maintained by the Texas A&M Horse Center. Horses were dewormed halfway through the project as per the regular farm schedule. Horse hooves were trimmed before the study and were trimmed 7 d before each standardized exercise test (**SET**). Horses were individually housed at the Texas A&M Horse Center in pens measuring 14.17 m by 11.88 m and were managed in accordance with the guidelines established by the Institutional Animal Care and Use Committee.

The study consisted of three 14-d experimental periods during which the horses were fed 1 of 3 concentrates, one 7-d washout period where horses were fed MDS, and three 7-d transition periods during which horses were gradually acclimated to their treatment diet. Horses were fed comparable Coastal bermudagrass (*Cynodon dactylon*) (hay A) for 7 d during the beginning of the study and were then switched to a batch of Coastal bermudagrass (hay B) for the remaining 98 d of the experiment. Diets were formulated in an isocaloric manner with the only significant difference being the starch concentration of the diet. Horses were weighed weekly to maintain a consistent feeding protocol.

Dietary Treatment

Horses were fed 1 of 3 diets of either HS with 56% commercial pelleted ration A and 44% steam-flaked corn; MDS with only commercial pelleted ration A; or LS with 70% commercial pelleted ration B, 30% alfalfa pellets, and added corn oil to meet remaining energy requirements (average 60 g; Table 1). Horses received Coastal bermudagrass hay at 1% of BW (as fed) daily. Horses were fed to light working horse requirements based on the *Nutrient Requirements of Horses* sixth revised edition (NRC, 2007). Daily calories not met through Coastal bermudagrass hay were met with a concentrate treatment that averaged 3.293 kg/d. Daily rations were divided equally into 2 meals, fed at 0700 and 1900 h. Hay and concentrate were offered to each horse in an individual elevated feeder. Horses had individual water troughs or buckets to monitor intake and had ad libitum access to water throughout the study.

Prior to each 14-d experimental diet period, horses were gradually acclimated to the new diet over a transition period of 7 d. Horses were randomly placed into 3 groups with n = 3 per group and were assigned 1 of the 3 experimental diets. The MDS feed was used as a washout feed for 7 d before the first transition period. The MDS diet was selected because horses were on a comparatively similar diet before the start of the study. Horses were transitioned from HS to LS to MDS throughout the course of the project to prevent any adverse reactions to starch amount.

Exercise Protocol

Horses were exercised throughout the trial at a walk and trot in a 6-slot panel exerciser (Freestyle Equine Equipment, Unadilla, GA). Horses were exercised 3 d/wk for 30 min at 40% walk and 60% trot to properly simulate light exercise to maintain fitness (NRC, 2007). One horse per exercise group would wear a heart rate (**HR**) monitor (Polar Electro, Lake Success, NY) to ensure that the average target heart rate of 80 beats per minute was reached. Horses traveled an average of 5.8 km per exercise session at an average speed of 4.1 m/s.

Horses were placed into 2 exercise groups (n = 5; n = 4) based on their housing order to prevent fighting during exercise. Horses were exercised at 0900 and 1000 h on exercise days. Horses were exercised on a forward (clockwise) panel cycle for the 0900-h exercise bout and on the reverse (counterclockwise) panel cycle for the 1000-h exercise bout. Exercise groups alternated the first or second exercise bout every exercise day to negate any differences between ambient temperature and direction of the panel cycle. When horses were not being worked, they were turned out in their individual pen.

Table 1. Total analysis of dietary treatments (100% DM)

	Treatment[1]		
Component	HS	MDS	LS
Moisture (%)	10.6	9.5	5.7
CP (%)	14.2	16.2	15.7
ADF (%)	9.5	14.4	25.9
NDF (%)	21.8	31.7	42.8
Starch (%)	39.3	24.8	6.2
Crude fat (acid hydrolysis; %)	6.9	9.0	13.6
TDN (%)	80	77	74
Calcium (%)	1.02	1.47	1.31
Phosphorus (%)	0.56	0.75	0.41
Magnesium (%)	0.23	0.31	0.22
Potassium (%)	0.79	1.10	1.74
Sodium (%)	0.18	0.25	0.25
DE (Mcal/kg)	3.37	3.08	2.75

[1]HS = Commercial Strategy GX (Purina Animal Nutrition LLC, Shoreview, MN) and steam-flaked corn (Producers Cooperative Association, Bryan, TX); MDS = Commercial Strategy GX (Purina Animal Nutrition LLC); LS = Commercial Strategy Healthy Edge (Purina Animal Nutrition LLC), alfalfa pellets (Producers Cooperative Association), and corn oil (ACH Food Companies Inc., Cordova, TN).