

PLASMA GLUCOSE CONCENTRATIONS AND DIGESTIBILITY OF DRY MATTER, ENERGY AND CRUDE PROTEIN IN MATURE GELDINGS FED WHEAT AND OAT BASED DIETS

D.R. Topliff¹ and D.W. Freeman¹

Story in Brief

Eight mature stock horse geldings were used in two simultaneous 4x4 Latin square experiments to determine the effect of feeding graded levels of wheat and oats on postprandial glucose concentrations and digestibility of dry matter, energy and crude protein. Experimental concentrate diets consisted of 100, 66, 33 and 0 percent wheat with the balance as oats. Concentrate diets were fed in a 60:40 ratio with prairie grass hay at equal dry matter intakes across treatments. The digestibility of dry matter and energy was greatest for the all wheat concentrate as compared to the 33 percent wheat and all oats concentrates. No significant differences were detected in total tract apparent protein digestibility. Plasma glucose concentrations were highest in geldings fed the all wheat concentrate beginning 90 min post feeding and remained elevated out to 4 h indicative of the higher starch content of wheat. No palatability or health problems associated with feeding of wheat were noted. These data indicate that wheat can successfully be included in rations for horses.

(Key Words: Equine, Nutrition, Wheat, Digestibility.)

Introduction

The high cost of oats due to drought conditions over the last two years have forced horse producers to look for alternative sources of concentrates. With the surplus of wheat in storage in the United States, wheat has been a good buy relative to oats and at times has been competitively priced against corn. However, little information on feeding wheat to horses is available. One experiment showed that wheat was less palatable than oats to ponies, but no digestibility data were derived in that study (Hawkes et al., 1985). Because of the lack of information, producers are reluctant to include wheat

¹Associate Professor

in diets for horses at any level. Many fear that the high gluten content will produce an impaction leading to colic and death. The objective of the present study was to determine the digestibility of dry matter (DM), energy (DE) and protein (CP) of wheat fed at graded levels to mature horses, and determine the effect on postprandial blood glucose concentrations.

Materials and Methods

Eight mature geldings were used in simultaneous 4x4 Latin square experiments to study the effects of feeding graded levels of wheat. Concentrate diets (Table 1) were fed in a 60:40 ratio with native prairie grass hay and consisted of 100 (W), 66 (WO), 33 (OW) or 0 (O) percent wheat with the balance as oats. The concentrate portion of each diet was mixed, ground and pelleted into a 3/8 inch pellet. Rations were fed at a constant dry matter intake across treatments (Table 2) in two equal feedings at 7 a.m. and 7 p.m. daily during a two week adjustment period and a one week collection period. Geldings were allowed 12 h to consume their ration at which time any feed refused was collected, weighed and recorded. All geldings were exercised daily on a mechanical walker for 20 min at a rate of approximately 15 miles/h in order to increase DE requirement and allow for feeding a greater amount of total ration. It was felt that if there were health problems associated with feeding wheat, a higher intake would disclose them.

In addition, chromic oxide was added as an indigestible marker to the concentrate portion of the diet at the rate of 5 g/feeding for 7 d prior to the start of collection to determine total fecal output. Fecal grab samples were taken over the last 72 h of each experimental period such that each two hours

Table 1. Composition of experimental diets, DM basis.

Ingredient (%)	Diet			
	W	WO	OW	O
Wheat	59.1	38.6	18.9	----
Oats	----	19.3	37.8	55.5
Salt	.3	.3	.3	.3
DiCal	.36	.33	.30	.27
Limestone	.24	.27	.30	.33
Soybean Meal	----	1.2	2.4	3.6
Prairie Hay	40	40	40	40

Table 2. Least squares mean dry matter and crude protein intake and digestibility of dry matter energy and crude protein.

Item	W	WO	Diet OW	O	SEM
DM Intake, lb	15.2 ^a	15.2 ^a	15.2 ^a	15.3 ^a	.30
CP Intake, lb	1.87 ^a	1.81 ^a	1.81 ^a	1.81 ^a	.09
DM Digestibility, %	69.6 ^a	66.2 ^{ab}	64.1 ^b	65.1 ^b	2.18
Apparent Protein Digestibility, %	71.7 ^a	70.5 ^a	70.5 ^a	72.3 ^a	2.06
Energy Digestibility, %	68.1 ^a	65.1 ^{ab}	63.6 ^b	64.2 ^b	2.08

^{a,b} Means in the same row not sharing the same superscript are significantly different ($p < .05$).

post feeding was represented. All fecal samples were dried for 72 h and composited using equal weights of each sample. The composite was then ground, chromium content of the feces determined colorimetrically using a wet ash procedure (Fenton and Fenton, 1979) and total fecal output calculated assuming quantitative recovery of chromium fed. Energy content of feed and feces was determined by burning pelleted samples under 30 atm of oxygen in a bomb calorimeter (Parr, 1968). Nitrogen content of feed and feces was determined by standard Kjeldahl analysis (AOAC, 1975).

On the last day of each collection period, blood samples were drawn by venipuncture into heparinized vacuum tubes to represent each 30 minutes post feeding out to 4 hours and then hourly until the next feeding. Blood samples were immediately centrifuged and plasma harvested and frozen for subsequent analysis. Plasma glucose concentration was determined on duplicate samples colorimetrically at 430 nm on a Beckman DU spectrophotometer (Sigma, 1988).

Intake and digestibility data were analyzed by analysis of variance using a model that accounted for differences due to horse, period and treatment and least squares means tested using Tukey's W at the $p < .05$ level (SAS, 1985). Plasma glucose data were analyzed by repeated measures analysis of variance, again using horse, period and treatment as main effects and time as the repeated variable (SAS, 1985). Least squares means were calculated and polynomial response curves for plasma glucose concentrations over time compared by constructing orthogonal contrasts. Significance was declared if the F test for a particular contrast had a $p < .05$.

Results and Discussion

Least squares means for DM and CP intake and digestibility of DM, energy and CP are shown in Table 2. No significant differences were found for DM or CP intakes. Therefore, differences in nutrient digestibilities and plasma glucose concentrations observed in this trial were not effected by intake.

Apparent CP digestibility was similar across all treatments ($p > .05$). These values are in the normal range expected, given the ration contained 60 percent concentrate (NRC, 1989). Since crude protein intake was similar for all horses on each treatment, regression analyses to estimate the true protein digestibility of wheat was not possible.

Geldings that received W digested a higher proportion of dietary dry matter ($p < .05$) than geldings consuming either OW or O. Least squares mean dry matter digestibilities were 69.6, 66.2, 64.1 and 65.1 percent for treatments W, WO, OW and O, respectively. Those results were expected since the calculated fiber content of W was 15 percent as compared to 20 percent for O.

Geldings consuming the all wheat concentrate also digested a higher proportion ($p < .05$) of the energy when compared with the other three diets. Least squares mean digestibility coefficients for energy were 68.1, 65.1, 63.6 and 64.2 percent for treatments W, WO, OW and O, respectively. Applying those percentages to the gross energy determined for each diet yields DE concentrations of 1.29, 1.25, 1.21 and 1.25 Mcal/lb DM for the four diets, respectively (Table 3).

Further, in a separate digestion trial the DE content of the hay alone was determined to be .73 Mcal/lb DM (Table 3). Using by difference calculations, the DE (Mcal/lb DM) of the concentrate portion of each diet and wheat and oats can be estimated for comparative purposes. An assumption of no associative effects on energy digestibility between the concentrate and hay must be made. Certainly the potential for a negative associative effect of the concentrate portion of the diet on the neutral detergent fiber (NDF) fraction of the hay and oats exists. It has been shown that as starch intake increases, NDF digestibility decreases, presumably because of a pH depression in the hindgut (Thompson et al., 1981). However, using the calculated values for wheat and oats, a predicted total ration DE can be calculated and compared to the actual values obtained from the digestibility trial to indicate the existence and extent of such an effect.

The DE content of the concentrate portion of each diet was calculated by difference to be 1.66, 1.60, 1.52 and 1.57 Mcal/lb DM for W, WO, OW and O respectively (Table 3). Since wheat is the only energy source in W and

Table 3. Digestible energy of total rations, hay, and concentrates and calculated DE of wheat and oats.

Item	Diet			
	W	WO	OW	O
Total Ration DE ^a	1.29	1.25	1.22	1.25
Hay DE ^b	.72	.72	.72	.72
Concentrate DE ^c	1.66	1.60	1.52	1.57
Wheat DE ^c	1.69	----	----	----
Oats DE ^d	----	----	----	1.47
-Predicted Total Ration DE ^e	----	1.25	1.21	----

a Determined from digestibility data in this trial.

b Determined from digestibility data in a separate trial.

c Calculated by difference.

d Calculated by difference using the DE value for wheat and assuming a DE value of 1.6 Mcal/lb for soybean meal.

e Calculated using a DE value of 1.69 Mcal/lb for wheat, 1.47 Mcal/lb for oats, .72 Mcal/lb for hay, and 1.6 Mcal/lb for soybean meal.

constitutes 98.5 percent of the concentrate, the DE content is calculated to be 1.69 Mcal/lb DM. That compares favorably with published values of 1.74 (NRC, 1978) and 1.75 (NRC, 1989). Applying a value of 1.60 Mcal/lb for soybean meal (NRC, 1989), which constitutes 6 percent of the concentrate, and the above assumptions, the calculated value of DE for oats in diet O is 1.48 Mcal/lb DM. That compares to published values of 1.51 (NRC, 1978) and 1.45 (NRC, 1989) Mcal/lb. Those values are calculated from a regression equation based on the acid detergent fiber (ADF) of the feedstuff as follows: $DE \text{ (Mcal/lb)} = 1.85 - 0.025(\%ADF)$ (Fonnesbeck, 1981).

Using the derived DE values for wheat and oats, the predicted total ration DE for diets WO and OW are 1.25 and 1.21 Mcal/lb DM respectively. The actual values obtained from the digestion trial were 1.25 and 1.22 Mcal/lb for WO and OW respectively. That would suggest that if digestibility of the NDF fraction of oats is depressed by the starch content of wheat, it is a small amount.

Least squares mean plasma glucose concentrations are shown graphically in Figure 1. Plasma glucose response curves were best described by the fifth order polynomial ($p < .05$) and were similar for all treatments.

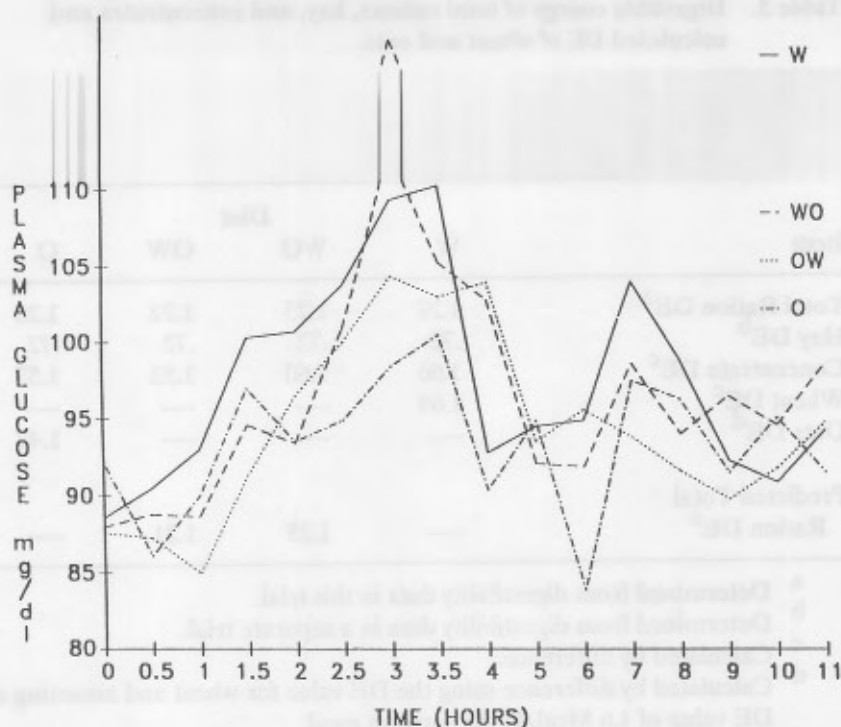


Figure 1. Least square mean plasma glucose concentrations in geldings fed wheat and oat based diets.

The postprandial peak occurred between 3 and 3.5 hr in all treatments, which suggests the insulin response was similar for all treatments, although plasma insulin concentrations were not measured in this experiment. Orthogonal contrasts of treatment response curves were significant for W versus O and the average of W and WO versus the average of OW and O. No difference ($p > .05$) was found between WO and OW. Therefore, plasma glucose concentrations apparently mirror the difference in starch content of the diet, suggesting that at these levels of intake, starch digestion in the small intestine remained at a constant percentage across treatments. That agrees with the findings of other experiments which found no difference in pre-cecal starch digestion with concentrate intakes up to 80 percent of diet (Hintz et al., 1971, Arnold et al., 1981, Hinkle et al., 1983).

Results of this study indicate that energy and DM digestibility of wheat are higher than oats while apparent protein digestibility is similar. The higher starch content of wheat is reflected in plasma glucose concentrations, indicating that a proportional amount of the additional starch was digested and absorbed in the small intestine. Further, the protein in wheat was digested at similar rates as that from oats, suggesting that concerns regarding the gluten being indigestible and a cause of impaction are unwarranted. No

palatability problems with any of the diets were observed, nor were there any short term health problems associated with the feeding of wheat. The authors conclude that wheat can be successfully incorporated into diets for horses, even though NDF digestibility may be slightly depressed when fed in combination with other grains that have a high NDF content such as oats or barley. More research is needed to determine the value of wheat in supporting productive functions such as growth and lactation and the effects of processing on site of digestion and feeding safety.

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