Insulinaemic and glycaemic responses following changes in the order of feeding oats and chopped alfalfa to horses

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Introduction

In order to offset the problems (gastric ulcers and abnormal behaviour) associated with the rapid consumption and episodic feeding of concentrate (*Vervuert* and *Coenen* 2001, 2004) it is common practice to recommend that chopped roughage is mixed with the concentrate or, that roughage be fed before the concentrate.

High fibre meals have been shown to produce lower blood glucose responses in healthy and diabetic humans by altering the rate of nutrient absorption (*Thorne* et al. 1983), but the results of comparable studies in horses have been equivocal. *Stull* and *Rodiek* (1988) showed a significant increase in the plasma glucose concentration in two-year-old Quarter Horse geldings after feeding maize or, after a combined diet of 50% maize and alfalfa. There was no difference in the postprandial response to glucose between feeding alfalfa alone or, maize or, a combination of 50% maize and 50% alfalfa. Similar results were obtained by *Harris* et al. (2005), who recently reported that the addition of 35% chopped alfalfa did not influence the glycaemic response to a meal of oats. In contrast, *Radicke* et al. (1994) measured a reduced glycaemic response after the addition of roughage to an oats diet. Similarly, *Pagan* and *Harris* (1999) showed that the glycaemic response was significantly reduced by feeding hay either before or with a sweet feed (42% oats, 31% corn, 8% molasses and 19% supplement pellet).

The aim of this study was to investigate the effects of feeding oats alone before or after feeding chopped alfalfa or, in admixture with the alfalfa on the insulinaemic and glycaemic responses of healthy horses.

Material and methods

Four horses (three geldings, one mare; mean body weight 560±36 kg, body condition score: 5) were used in a changeover experiment with two replicates. The animals were individually housed in boxes and bedded on wood shavings with free access to water. The diets consisted of chopped alfalfa (crude fibre: 0.5 g/kg M=1.6 g alfalfa/kg M x meal-1) and unprocessed oats (starch: 2 g starch/kg M = 4.5 g oats/kg M x meal^{-1}). The diets were offered twice in three ways: a) firstly alfalfa and immediately thereafter oats (A / O), b) firstly oats followed by alfalfa (O / A) or, c) a mixture of alfalfa and oats (A - O-mix). Oats without alfalfa was fed as a control. Additionally, the horses received hay (1 kg hay/kg M x day^{-1}) which was subdivided into three equal portions and fed in the morning (0800h), afternoon (1400h) and evening (1930h). Each horse was adapted over a 13 day period to their respective diet before being blood sampled. Horses were fed their respective test diet without any hay. One hour before feeding (0700), an indwelling catheter (1.8 x 2.35 mm/14 G, Braun Melsungen AG, Melsungen, Germany) was inserted into the V. jugularis externa. The catheter was connected to a 50 cm extension set (Vygon GmbH, Aachen, Germany) and sutured in place. The extension set and catheter were flushed with physiological saline after every blood sample.

Blood samples for glucose and insulin determination were collected 30 mins before feeding the test meal and at 30 min intervals thereafter for 5h after the end of the meal, and finally every 60 min until 8h after the meal.

Serum glucose concentrations were determined by glucose oxidase assay (Unimate 7 GLUC GDH®, Roche Diagnostics GmbH, Mannheim, Germany). Serum insulin concentrations were measured by a radioimmunoassay kit (Insulin RIA, Coat-A-Count® (125I), DPC Biermann GmbH, Bad Nauheim, Germany). The data were analysed using an analysis of variance (Statistica®) and the results are presented as mean ± SD. Incremental AUCi (area over the baseline, ignoring area beneath baseline) and AUCbb (area below baseline) was calculated for the different test diets by using the trapezoid model.

Results

The most rapid rate of intake was measured when horses were fed the mixed diet A + O (Table 1); this has been described in greater detail by *Brüssow* et al. (2005).

Table 1 Mean feed intake (g/min) for different diets (mean±SD).

Diet	Feed order	Feed intake (g / min)
O/A	1st oats	104 ± 16.8^{ad}
	2nd alfalfa	59 ± 13.7^{bc}
A/O	1st alfalfa	64 ± 10.2^{bc}
	2nd oats	89 ± 15.8^{ad}
A+O	mixed diet	101 ± 25.7^{a}

Different superscript indicate significant differences, $p<0.05$

Feeding oats alone or before or after alfalfa resulted in a significant increase in serum glucose and insulin (Figure 1 and 2). However, there was a large variation in glycaemic and insulinaemic responses between the two replicates of feeding firstly alfalfa and then oats (A / O); this was mainly attributable to the very high glucose and insulin responses of the individuals during the first trial and that were modified in the second trial. Trial 2 results showed similar glycaemic and insulinaemic responses for the different diets, independent of feeding order or, intake of crude fibre. There were slightly

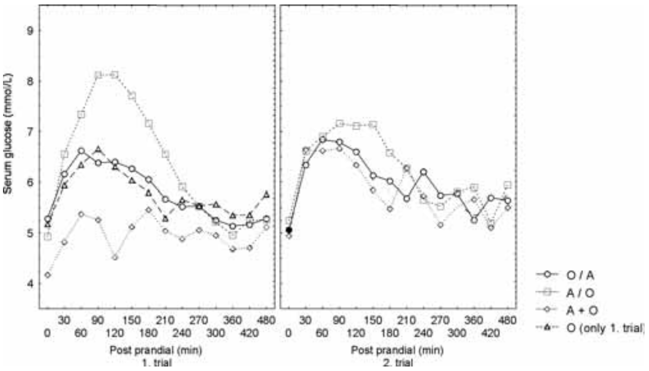

Fig 1 Serum glucose concentrations (mean, mmol/L) for the different diets (time $p<0.05$, diet; $p<0.05$, trial $p=0.053$).

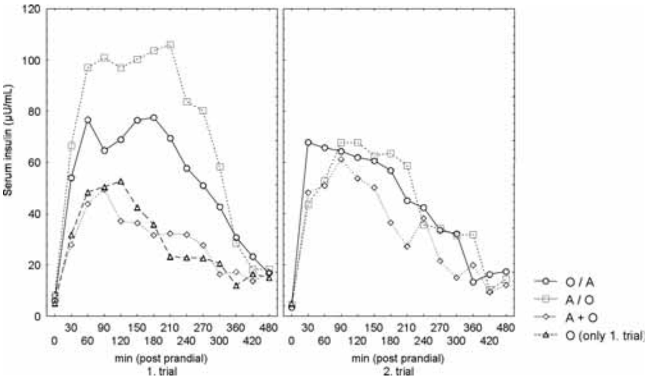

Fig 2 Mean serum insulin concentrations (mean, µU/mL) for the different diets (time, $p<0.05$; diet, $p<0.05$; trial, $p=0.23$).

higher glucose concentrations 120 and 150 min postprandially following the A/O diet when compared to the other diets (treatment $p<0.05$). Individual response showed that the highest variation was measured in A/O, followed by A+O; this is illustrated by the different AUC's for glucose and insulin (Table 2).

Table 2 AUCi and AUCbb for serum glucose (mmol x min/L) and serum insulin (µU x min/mL).

Horse	Replicate 1				Replicate 2			
	Glucose		Insulin		Glucose		Insulin	
	AUC_i	AUC_{bb}	AUC_i	AUC_{bb}	AUC_i	AUC_{bb}	AUC_i	AUC_{bb}
				O / A				
I	0	-348	13725	0	377	0	17147	0
II	520	-1.2	32049	0	444	-0.4	32868	0
III	416	0	16546	0	467	-17.8	5064	-36.9
IV					437	-18.1	13483	0
				A / O				
I	555	0	17729	0	247	0	19343	0
II	555	-4.5	41668	0	237	-6.4	25442	0
III	752	-54.4	22483	0	554	-33.3	16142	0
IV					745	0	6625	-0.1
				A + O				
I	452	0	3608	-44.5	343	-2.1	13939	0
II	373	0	13157	0	419	-3	19431	0
III	280	-0.9	9966	0	366	-0.7	8637	0
IV					502	-1.8	9838	0

Discussion

In humans it is supposed that dietary fibre will lower the blood glucose response to a meal because of the reduced rate of nutrient absorption from the gastrointestinal tract (*Thorne* et al. 1983). However, in horses the addition of fibre to a starchy diet does not significantly lower glycaemic and insulinaemic responses; higher glucose and insulin profiles were measured in the first trial for the different combinations O/A or A/O. Similar results were obtained by other research groups (*Stull* and *Rodiek* 1988, *Harris* et al. 2005). However, perhaps the quantity of crude fibre (35 % in the diets) might have been too low to affect nutrient absorption since 50% crude fibre did not lower the glycaemic and insulinaemic responses to maize starch (*Stull* and *Rodiek* 1988). The nature of the fibre source may be important. Alfalfa provides short chaff which does not slow down feed intake by horses (*Brüssow* et al. 2005) although nothing is known about transit time in the gastrointestinal tract, pancreatic flow and the effectiveness of amylase in the chyme following ingestion of oats and alfalfa. Taking all the results together, it seems that the influence of dietary fibre on the glycaemic and insulinaemic responses is overestimated. The greatest effect on the glucose and insulin profile is dependent upon the starch intake (*Vervuert* and *Coenen* 2005). Generally, an excess of starch should be avoided, especially for those horses with insulin resistance.

There was great variation within and between horses and there was poor repeatability in terms of response to the same diet under the same experimental conditions. Precision could be improved by replicating the test diets and increase the number of animals to eliminate individual variation in terms of response to diet. It would seem that glycaemic and insulinaemic responses are naïve measures since they are considerably influenced by several factors including individuality, speed of gastric emptying, rate of passage through the gastrointestinal tract, enzyme availability, etc.

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