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## The effect of grain supplementation on the faecal pH of horses maintained on pasture

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### ABSTRACT

The aim of this study was to investigate the effect of grain supplementation on the faecal pH of horses maintained at pasture. Data were obtained from twelve mixed age horses kept at pasture, six controls  $530 \pm 9.4$  kg and six carbohydrate supplemented  $513 \pm 10.2$  kg. The supplemented horses were each fed up to 6.15kg of crushed oats in two feeds (am and pm) per day over a 38 day period. The supplementation was divided into seven treatment periods; a four day period with no grain (block 1), six days with the addition of grain to the diet at a rate of +0.5kg per day (block 2), six days with 3.4kg per day (block 3), four days with the addition of 0.5kg oats per day (block 4), six days fed 6.16kg per day (block 5), six days decreasing grain fed (block 6) followed by a five day observation period with no grain fed (block 7). Faecal material was collected daily for analysis immediately after defecation during the am feeding time. Throughout the supplementation trial there were no significant differences between the supplemented and control groups. There was a significant effect of period on faecal pH ( $P < 0.05$ ). There was no interaction of treatment and period. There was a trend for faecal pH to decrease during the trial. Block 7 was significantly different to all other blocks. Block 5 was significantly different to Block 1 ( $P < 0.01$ ). Within the model horse was a significant effect ( $P < 0.05$ ). There was a strong correlation between the control and treatment groups for faecal pH throughout the trial ( $r^2 = 0.86$ ). There was a trend for increased rainfall in the 2<sup>nd</sup> half of the supplementation trial which was associated with increasing soil temperature ( $P < 0.01$ ).

The lack of significant change in faecal pH with increased grain supplementation indicates that for pasture kept horses factors such as pasture intake and greater activity may have a role in buffering the negative effects of a high grain diet.

**Keywords:** Horse; faecal pH; grain; pasture; acidosis; laminitis.

### INTRODUCTION

The modern competition horse is intensively managed often housed for a large percentage of the day and is fed a few large meals of concentrate feed which are high in soluble carbohydrates and low in bulk to provide the energy required for strenuous work (Frape, 1998; Cuddeford, 1996, Earle *et al.*, 2002). This intensive management is in stark contrast to the continuous intake of high fibre – low digestible energy grasses observed with feral horses (Frape, 1998). The modern intensive management system has been identified as contributing significant risk factors for laminitis (Garner *et al.*, 1977; Slater *et al.*, 1995), colic (Reeves *et al.*, 1989; Cohen *et al.*, 1995, 1999; Hudson *et al.*, 2001), gastric ulcers (Collier 1999), and stereotypical behaviours (McGreevy *et al.*, 1995).

Excessive soluble carbohydrate is a known risk factor for laminitis (Garner *et al.*, 1977; Stashak 1987, Slater *et al.*, 1995). Fermentation of excessive carbohydrate in the hindgut produces a change in composition of the caecal micro flora and an associated decrease in caecal pH from seven to four (Garner *et al.*, 1978). The reduced caecal pH is associated with an increase in the quantities of lactic acid producing bacteria (eg *Lactobacillus*, *Streptococcus*, *Bacillus*) and a decrease in the numbers of lactate utilising bacteria (*Enterobacteriaceae*). The death of *Enterobacteriaceae* results in cell lysis and the subsequent release of

endotoxins, and it is these endotoxins that are believed responsible for the resulting laminitis.

The increase in the lactic acid producing bacteria is associated with an elevation of blood D-lactate levels and a decreased faecal pH (Rowe *et al.*, 1994). Hindgut acidosis can be measured indirectly by monitoring faecal pH (Zeyner *et al.*, 1992 and 1993; Rowe *et al.*, 1994; Johnson *et al.*, 1998; Davie *et al.*, 2002; Channon *et al.*, 2001). Significant decreases in faecal pH have been linked to changes in diet, specifically the increasing ratio of concentrate to roughage in intensively managed horses (Rowe *et al.*, 1994; Johnson *et al.*, 1998). New Zealand has a unique competition-horse management system, with horses often having greater access to pasture than occurs overseas (Mellor *et al.*, 2001, Earle *et al.*, 2002). To date, there has been no study to investigate the implications of the New Zealand management system on the incidence of hindgut acidosis. This paper describes the effect of increasing carbohydrate challenge (in the form of crushed oats feed twice daily) to a group of pasture kept mixed age horses.

### MATERIALS AND METHODS

#### Horses

Twelve mixed age Thoroughbred and Standardbred horses were randomly divided into two treatment groups. The control group (one gelding and five mares, mean bodyweight  $530 \pm 9.4$  kg) were kept at pasture and had

grass available ad lib. The grain supplementation group consisted of 6 horses (one gelding, five mares mean bodyweight  $513 \pm 10.2$  kg) which were provided with an incremental grain challenge of up to 6.16 kg crushed oats/horse/day. Both the experimental and control group were kept under identical pasture based management systems. Weight and condition score (based on the method of Henneke *et al.*, (1985)) were measured every 7 days during the trial.

### Feeding protocol

The basal diet for all horses during the trial was ryegrass/white clover pasture and some supplementation with meadow hay (up to 5 kg DM/ horse/day). The grain fed consisted of crushed white oats (12.43 MJ DE/kg DM), which is commonly used in the New Zealand racing industry. Grain supplementation was based on a 500 kg mature horse consuming approximately 2% bodyweight in DM (forage) per day (NRC, 1989). This was based on the assumption that pasture intake will decrease by 0.7 kg DM per kg DM of concentrate introduced to the diet (Avery 1996). The concentrate to roughage ratio (C:R) with the addition of 3.4 kg and 6.16 kg of grain was 1:2 and 1.1 respectively.

The grain supplementation programme consisted of seven effective treatment blocks (Table 1). The crushed oats were fed as two feeds at 0630h and 1700h. Feed was offered for 45 minutes, after which any uneaten grain was weighed and noted for each individual horse.

**TABLE 1.** Study design and feeding regimen of oats. Control horses were fed pasture only.

Treatment block	Days	Feeding regimen of supplemented horses
Baseline	1 0-4	Basal diet only (no oats)
Increase to level 1	2 5-11	Oats introduced 0.46 kg/d, up to 3.4 kg/d
Level 1	3 11-16	3.4 kg/d oats
Increase to level 2	4 17-22	Oats increased by 0.46 kg/d, up to 6.16 kg/d
Level 2	5 23-27	6.16 kg/d oats
Decrease to baseline	6 28-34	Oats decreased by 0.92 kg/d
Baseline	7 35-38	Basal diet only (no oats)

To identify a potential seasonal effect on faecal pH, climate data was accessed from the Climate Data Centre at the National Institute of Water and Atmospheric Research (NIWA). Pasture samples were collected at the trial site on days 19 and 38, subsequently frozen ( $-20^{\circ}\text{C}$ ) for later analysis.

The DM of pasture was determined by drying at  $60^{\circ}\text{C}$  for 48 hours after which samples were weighed, and ground for chemical analysis. The gross energy, crude protein, soluble carbohydrate, lipid, NDF and ADF of the pasture samples were determined by the methods of Gallenkamp Instruments (1975), Carlo Instruments

(1988), Blakeney and Mutton (1980), and Van Soest *et al.*, (1991).

### Faecal pH

Duplicate faecal samples were collected daily between 0630-0730h, immediately post-defecation. Faecal material was stored in plastic containers in a temperate room until sampling (2-8 hours post-collection). Faecal material (40g) was sampled from the centre most ball of the faecal mass. Equal weight of faeces was mixed with 40ml distilled water and assayed with a laboratory pH meter<sup>1</sup>.

### Statistical analysis

The weight and condition scores of the horses were analysed using a repeated measures General Linear Model. Faecal pH was analysed using a repeated measures General Linear Model, with treatment as a fixed effect. Bonferroni post hoc tests were used to identify significant differences between treatment blocks. All statistical analysis was conducted using SPSS v10.1 (Chicago II) with a significance level set at  $P < 0.05$ . Data is presented as mean  $\pm$  standard error mean.

## RESULTS

The majority of horses ate their full ration of oats within the 45-minute time limit. It proved difficult to ensure that the supplemented horses consumed their full ration when offered 6.16 kg oats per day. Three of the six horses consistently failed to consume more than 5 kg of oats per day. During the six-week observation period there was a trend for a decrease in weight during the trial. The pattern of weight loss was consistent across treatment groups, with no significant difference in weight loss between the supplemented  $513 \pm 10.3$  kg to  $493 \pm 12.2$  kg, and control group  $530 \pm 9.4$  kg to  $490 \pm 4.1$  kg.

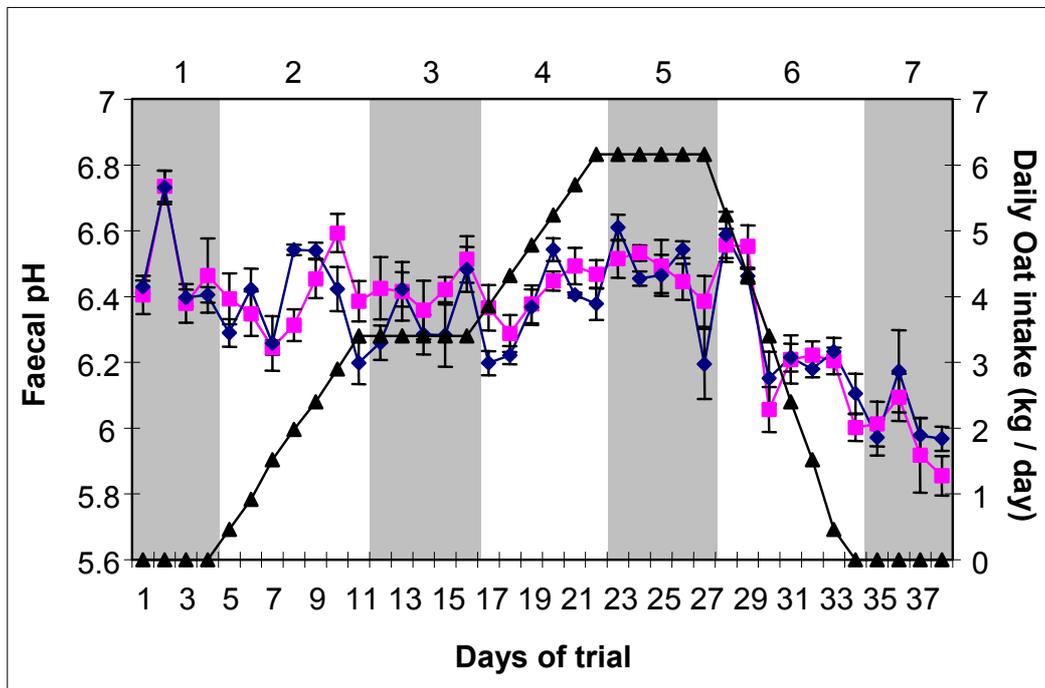
There was no significant effect of supplementation on the condition scores between the two groups at any stage of the trial. During the experimental period the condition score of both the treatment and control groups increased from  $4.8 \pm 0.1$  to  $5.5 \pm 0.3$  ( $P < 0.05$ ).

Throughout the trial the faecal pH of both the control and supplement groups were closely correlated ( $r^2 = 0.86$ ) (Figure 1).

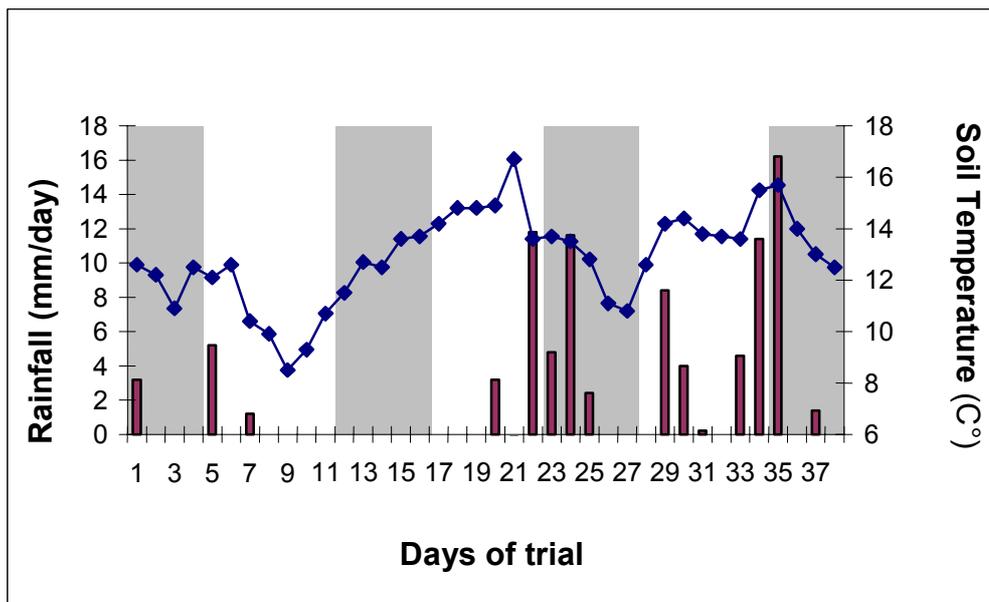
There was no significant effect of oat supplementation on faecal pH. There was large between horse variation for faecal pH and this was reflected by a significant horse effect. Within the model, treatment block was significant, there were no interaction of treatment and treatment block. Faecal pH during the final 5 days (block 7) was significantly different ( $P < 0.001$ ) to all other blocks. Block 5 was significantly different from block 1 and block 5 ( $P < 0.01$ ).

<sup>1</sup> Denver Instrument Company Basic pH Meter, accuracy  $\pm 0.01$  pH

**FIGURE 1:** The mean ( $\pm$  SE) oats ingested ( $\blacktriangle$ ) by the supplement horses and daily faecal pH and the supplement ( $\text{---}\blacksquare\text{---}$ ) and control groups ( $\text{---}\blacklozenge\text{---}$ ) during the trial.



**FIGURE 2:** Rainfall (mm/ day) ( $\text{---}\blacklozenge\text{---}$ ) and soil temperature ( $^{\circ}$  C) ( $\blacksquare$ ) during the trial.



Rainfall and soil temperature (at 10cm) increased after day 19 of the trial (figure 2). There was no significant effect of block on rainfall. However, there was a significant effect of block on soil temperature ( $P < 0.001$ ). Soil temperature was significantly different between block 1 and block 4 ( $P < 0.05$ ), block 2 and block 3 ( $P < 0.05$ ), block 2 and block 4 ( $P < 0.001$ ), block 2 and block 6 ( $P < 0.001$ ), block 2 and block 7 ( $P < 0.01$ ), block 4 and block 5 ( $P < 0.05$ ). There was a trend for a decrease in faecal pH as rainfall and soil temperature increased during the second half of the trial (after day 19).

The composition of the pasture collected at day 19 and day 38 of the trial, are outlined in Table 2. The composition of each sample was very similar, and only carbohydrate (CHO%) increased from 14.5% (day 19) to 16.4% (day 38).

## DISCUSSION

The feeding of high levels of soluble carbohydrate and intensive management systems have been associated with a reduction in faecal pH (Rowe *et al.*, 1994, Johnson *et al.*, 1998, Davies *et al.*, 2000). In our study with horses that had free access to pasture we were unable to demonstrate an association of feeding high levels of soluble carbohydrate (crushed oats) with a reduction in faecal pH.

Previous studies have provided horses with carbohydrate loading at a rate and level greater than would be practised within the equine industries (Rowe *et al.*, 1994, Johnson *et al.*, 1998). Frappe (1998) proposes that horses should be introduced to new carbohydrate feeds at a rate of 200g per day. Within New Zealand it is common practise to introduce or increase the grain feed by 0.5 to 1 kg/day (Johnson pers com). We chose to be conservative and introduce a smaller amount of grain so that the experimental model reflected typical management of New Zealand performance horses.

The availability of pasture, even for a short period of time, is standard practice in most New Zealand performance horse production systems, and it is common for even top class racehorses to have some access to pasture. This is in stark contrast to the management of horses in intensive production systems throughout areas of North America or Europe. It was therefore important to test protocols under the conditions that exist in New Zealand. In the present study crushed oats were used as a carbohydrate source as they are the most common grain fed to horses in New Zealand. Oats have been termed a safe grain because of the lower DE (12.4 MJ DE / kg DM) than grains used by other authors such as maize (16.07 MJ DE / kg DM) (NRC 1989).

The horses of this study were housed at pasture, allowing continuous grazing, which is more reflective of their 'natural' environment compared with intensive management systems. It would appear that pasture moderated the effect of large quantities of soluble carbohydrate on faecal pH. Studies with similar carbohydrate load and C:R ratio (Johnston *et al.*, 1998) demonstrated a decrease in faecal pH, yet in our study

there was no measurable effect of grain introduction of faecal pH.

During feeding, saliva is produced to break down food and aid in its transport to the stomach (Frappé, 1998). Distension of the stomach stimulates release of pancreatic juice and elevates bicarbonate concentration (gastric phase). Arrival of chyme into the duodenum initiates an influx of water and bicarbonate solution into the small intestine (intestinal phase) (Ruckebusch *et al.*, 1991; Frappé, 1998). Horses with constant access to pasture may have an elevated production of saliva, a longer gastric phase, and a longer intestinal phase, buffering the effects of grain in the hindgut.

Surprisingly the faecal pH of the supplemented and control horses was closely correlated ( $r^2 = 0.86$ ). This close association in faecal pH between the supplemented and control horses indicates that even on pasture with limited available dry matter the horse is able to maintain enough throughput of material to neutralise the possible acidosis effects of large feeds of soluble carbohydrate. The change in faecal pH observed in both the supplement and control groups with a change in the pasture composition/cover demonstrates how significant the role of pasture was in maintaining the 'acidity' or homeostasis of the digestive system.

Climate data from NIWA recordings near to the trial site indicated a rise in soil temperature and rainfall over the second half of the trial. It is possible that the humid weather may have had an effect on changes in pasture quality and quantity. The carbohydrate component of the two pasture samples (collected on day 19 and 38) increased from 14.5 to 16.4%, while DM remained relatively stable (21.2 and 21.6%). These findings implied that the non-structural carbohydrate (NSC) content of the pasture might have increased during the later half of the trial.

**TABLE 2.** Composition of pasture grazed by horses.

	DM %	CP %	Lipid %	ASH %	ADF %	NDF %	CHO %
Sample Day 19	21.2	25.9	4.0	11.4	16.0	31.2	14.5
Sample Day 38	21.6	25.0	3.9	11.2	15.2	30.3	16.4

Abbreviations provided in text

Climate data indicated that pasture experienced high soil moisture levels and low minimum temperatures during the first half of the trial, which may have suppressed NSC production in the pasture (Colby *et al.*, 1966; Jung *et al.*, 1974; Fulkerson & Donaghy, 2001). Thom *et al.* (1989) found that total NSC concentration of ryegrass peaked during autumn (April/May), decreasing to a low in late winter (August), and increased again in spring (late October). The increase in NSC concentration in late-October was associated with increasing temperature (Thom *et al.*, 1989), similar to the increase in temperature observed during the present trial.

There was a significant horse effect on faecal pH in our supplementation trial, which was similar to Davies *et al.* (2000). The large between-horse differences were

thought to be a result of different microbial populations (Davies et al., 1989). Differences in hindgut microbial population may result in some horses being more susceptible to acidosis and laminitis than others.

Further studies are needed, as the precise quantification of the effect of pasture on faecal pH is paramount. The results of the present study have demonstrated that good quality pasture has a role in buffering the negative effects of grain on hindgut pH, which has positive implications for the New Zealand horse industry.

### ACKNOWLEDGEMENTS

The authors would like to thank the New Zealand Equine Research Foundation for funding this project.

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