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The effect of feeding barley or hay alone or in combination with molassed sugar beet pulp on the metabolic responses in plasma and caecum of horses

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ABSTRACT

Highly fermentable fibre sources like sugar beet pulp (SBP) might be fed as an alternative to starch rich concentrate to horses. However, including soluble fibre from SBP in a meal of concentrate might delay gastric emptying and increase viscosity in the small intestine, altering or impairing glucose absorption, hence affect the metabolic responses measured in plasma and the hindgut. Four diets with different carbohydrate composition were investigated in a 4 × 4 Latin square design experiment in four periods using four caecum cannulated Norwegian coldblooded trotter horses. The diets were hay only (HAY), hay and molassed SBP (HAY + SBP), hay and pelleted barley (BAR), and hay, pelleted barley and molassed SBP (BAR + SBP). The amount of barley (2 g starch/kg body weight (BW)) fed in the test meals was similar for the BAR and BAR + SBP diets. Each diet was fed for 16 days followed by data collection, then each horse changed to a new diet in the next period. Caecum pH and short-chain fatty acid (SCFA) profiles and the metabolic responses measured in plasma at rest were followed for 9 h after the test meal. Caecum pH decreased more ($P < 0.001$) after feeding BAR and BAR + SBP than after HAY and HAY + SBP. Diet also affected the proportions of acetate ($P < 0.001$) and propionate ($P < 0.001$) with less acetate and more propionate measured on the BAR and BAR + SBP diets than on the HAY and HAY + SBP diets, reflecting differences in the substrates fermented by the caecal microbes. Feeding barley resulted in a postprandial increase in plasma glucose ($P = 0.030$) and insulin ($P < 0.001$) whereas these values remained almost stable when the fibre-based diets were fed. The total SCFA concentration in the caecum was greater ($P < 0.001$) on the BAR and BAR + SBP diets than on the HAY and HAY + SBP diets. However, the plasma concentrations of SCFA were differently affected with greater ($P < 0.001$) levels of SCFA (mainly acetate) in horses fed the HAY and HAY + SBP diets than in the BAR and BAR + SBP fed horses, reflecting a shift in the provision of carbohydrate derived nutrients from the small to the large intestine in response to the dietary carbohydrate composition. In conclusion, there was no effect of adding molassed

Abbreviations: BOHB, β-OH-butyrate; BW, body weight; CP, crude protein; DF, dietary fibre; DM, dry matter; DMI, dry matter intake; IGF-1, insulin like growth factor 1; NCP, non-cellulosic polysaccharides; NEFA, Non esterified fatty acids; NSP, non-starch polysaccharides; RIA, radioimmunoassay; SCFA, short-chain fatty acid; SBP, sugar beet pulp.

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SBP to a meal of barley compared to feeding barley alone, and fluctuations in plasma and caecal variables were more stable when feeding hay and molassed SBP than feeding barley.

1. Introduction

Starch is traditionally and commonly fed to performance horses to meet the high energy demands for physical activity, whereas fibre is needed in the ration to maintain gut health and avoid abnormal behaviour (Redbo et al., 1998). Factors like grain type and processing, as well as the intake level of starch affect the digestibility of starch in the small intestine (Meyer et al., 1995; Julliand et al., 2006). Starch escaping digestion in the small intestine is fermented in the hindgut and can potentially decrease pH and alter the fermentation profile (McLean et al., 2000; Julliand et al., 2001). Feeding large amounts of grain reduce the microbial stability in the hindgut (Willing et al., 2009) and increase the risk of diseases like laminitis (Garner et al., 1975), colic (Hudson et al., 2001) and gastric ulcers (Luthersson et al., 2009).

Sugar beet pulp (SBP) has been suggested as an alternative energy source to starch rich grain (Moore-Colyer et al., 2002; Palmgren Karlsson et al., 2002), as SBP has a high content of soluble, highly fermentable fibre (Bach Knudsen, 1997). However, the inclusion of soluble fibre from SBP in the diet might delay gastric emptying and increase viscosity in the small intestine, altering or impairing glucose absorption (Bach Knudsen, 2001), and as a result change both the flow and composition of the digesta reaching the hindgut. One study showed beneficial effects on the fermentation patterns (minimizing pH fluctuations) in the caecum when barley (2 g starch/kg BW) was fed in combination with molassed SBP (~0.5 g/kg BW) compared to feeding barley alone (Brøkner et al., 2010). However, when smaller amounts of soluble (0.1 g/kg BW) or insoluble fibre sources (0.2 g/kg BW) were mixed with cracked corn (2 g starch/kg BW) no effect on the glycaemic and insulinemic response was found in horses (Vervuert et al., 2009). Whether feeding larger amounts of molassed SBP (more than 0.1 g/kg BW) in combination with grain would affect starch digestion in the small intestine and fermentation pattern in caecum requires further studies. Therefore, the aim of this study was to evaluate the metabolic responses in plasma and caecum when horses were fed a hay only diet or a diet including molassed SBP, barley or a combination of molassed SBP and barley in addition to hay.

2. Materials and methods

2.1. Experimental design

The experiment was designed as a 4 × 4 Latin square with four experimental periods of 28 days each consisting of 16 days of adaptation to a diet and 12 days of data collection (Fig. 1). The transition from one diet to another was done over two days after ended data collection on day 28. During data collection the diet effect on caecal fermentation patterns (day 17 or 18) and the metabolic responses in plasma (day 21) were measured. Other measurements were performed on days 19–20 (diet effects on passage rate parameters) and 24–28 (diet effects on the apparent total tract digestibility) and these results are presented elsewhere (Jensen et al., 2014). All horses remained healthy throughout the study, and they were cared for according to the laws and regulations concerning experiments on live animals in Norway (i.e., the Animal Protection Act of December 20, 1974, and the Animal Protection Ordinance concerning Experiments on Animals of January 15, 1996).

2.2. Animals, housing and management

Four 6- to 15-yr-old caecum cannulated Norwegian Cold-blooded trotter horse geldings, with an initial body weight (BW) of 542 (SD: ±17 kg) were used in the experiment. They were housed in an unheated barn in 3 × 3 m individual stalls with wood shavings as bedding material. Throughout the adaptation period the horses were allowed access to a dirt paddock for approximately 6 h after the morning feeding, whereas during data collection they were allowed access to the dirt paddock for a few hours after the daily measurements on d 17–18, 21–23 and 28. Before the start of the experiment all horses had a health inspection by a veterinarian, including floating of the teeth. The horses were exercised 4–5 times a week during the 16 days of adaptation and two times during the 12 days of data collection in an outdoor rotary exerciser (intervals of trotting and walking for 30 min at speeds from 1.8 m/s to 5 m/s). The exercise program started 8 weeks before the experiment.

2.3. Feedstuffs, diets and feeding

Three feedstuffs were used in the study: hay, molassed sugar beet pulp (SBP) and barley (Table 1). The carbohydrate composition of the feedstuffs varied to a large extent, whereas the differences in DM, ash, CP and fat were (relatively) smaller. The hay (mainly mature timothy) was purchased from a local hay producer (To Gode Naboer ANS, Trøgstad, Norway). It was wilted for 2 days and then artificially dried at a drying facility. It was stored loose, but delivered in bales weighing approximately 20 kg. Pelleted barley (Felleskjoebet Agri, Gardermoen, Norway) was produced by grinding barley to pass a 3 mm screen, mixing with molasses (4% of the pellet) and a binding agent (0.7% of the pellet; PellTech 2, Borregaard