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Ileal and total tract nutrient digestibility in wheat wet distillers solubles and wheat dried distillers grains with solubles when fed to growing pigs

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ABSTRACT

The digestibility of dietary components, amino acids and energy in growing pigs fed with wheat wet distillers solubles (WWDS) and wheat dried distillers grains with solubles (WDDGS) was studied in growing pigs fitted with a post valve T-caecum (PVTC) cannula. Eight PVTC cannulated pigs were used in a cross-over arrangement, with four animals per treatment. The coefficients of apparent ileal (CAID) and apparent total tract digestibility (CATTD) of dry matter, organic matter and energy decreased linearly ($P<0.05$) in diets with increasing dietary inclusion of WWDS and WDDGS. The CAID of crude protein (CP) and fat were unaffected by the dietary inclusion level of WWDS and WDDGS. The CAID of all amino acids were unaffected by increasing dietary inclusion of WWDS and WDDGS. The coefficients of ileal standardized digestibility (CSID) of CP, lysine and histidine were higher ($P<0.05$) in the WWDS product than in the WDDGS product, while the opposite was found for the CSID of methionine, cysteine, isoleucine, leucine and valine. The CSID of CP and phenylalanine in WWDS and WDDGS, and of lysine in WWDS were at the same level as those reported for wheat bran. However, the CSID of CP and essential amino acids were lower in WWDS and WDDGS than in wheat, wheat flour and wheat middlings. The digestibility values presented make it possible to formulate diets for pigs with inclusion of WWDS and WDDGS with better precision, in particular with respect to the supply of essential amino acids.

1. Introduction

Distillers grains are co-products obtained from ethanol production using cereal grains with a high protein content that has the potential to replace other protein-rich feedstuffs in animal production. A major part of the global ethanol production is used as biofuel (Shurson et al., 2000; Crawshaw, 2001), and the bulk of the residue from the grain-based ethanol production (distillers grains) is dried and used as animal feed (Cooper, 2007).

The nutritive value of distillers grains is affected by the grain source used and the ethanol production process (Crawshaw, 2001). Most of the grain starch is fermented to ethanol, and thus protein, fat, dietary fibre and minerals become concentrated in the co-product. Moreover, the proportions of solubles and fibre residue in the final co-product may vary depending on the technical capacity of the factory. As a result, the chemical composition and the nutritive value of the final distillers grain co-products may vary considerably (Newman et al., 1989; Spiehs et al., 2002; Stein et al., 2006).

The use of distillers residues as a feed for livestock has a long tradition (Axelsson, 1936; Newland and Mahan, 1990), but the use in ruminant feeds has been dominating. Earlier published data reported a relatively low nutritive value in distillers grains fed to pigs (Newland and Mahan, 1990), while recent studies indicate a markedly improved nutritive value (Spiehs et al., 2002; Whitney et al., 2006). However, most of the information available on the nutritional properties of

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distillers co-products for pigs is from studies with maize as the cereal grain source. Although limited information is available on wheat distillers co-products, Nyachoti et al. (2005) and Widyaratne and Zijlstra (2007) have reported different digestibility values for wheat DDGS fed to growing pigs fairly recently.

The aim of this study was to determine the digestibility of dietary components, amino acids and energy in growing pigs fed with wheat wet distillers solubles (WWDS) and wheat dried distillers grains with solubles (WDDGS) obtained from the same factory (Agroetanol, Norrköping, Sweden) producing ethanol for use as biofuel.

2. Materials and methods

The study was approved by the Uppsala Local Ethics Committee.

2.1. Animals and housing

Eight castrated specific pathogen-free male pigs (Swedish Landrace × Yorkshire) with an initial body weight (BW) of 31.3 (±1.2) kg and a final BW of 44.4 (±1.1) kg were used in the experiment. The pigs were surgically fitted with post-valve T-caecum (PVTC) cannula (van Leeuwen et al., 1991), approximately three weeks prior to the start of the experiment.

All pigs were housed individually in pens (230 × 145 cm) with rubber mats, urine drainage and no bedding. Between pens, there were narrow, horizontal openings (50 cm height), which allowed snout contact between pigs. The temperature was maintained at 19 (±1) °C and the light regimen was a 12/12 h dark/artificial light cycle from 07.00 to 19.00. They had free access to water from nipple drinkers. Water was available at all times through low-pressure water bowls.

2.2. Experimental design and feeding treatments

The study was conducted as a three-period cross-over design with a total of six diets and eight pigs (Patterson and Lucas, 1962), but in two separate experiments (one for each by-product) with three diets each. Thus, a total of four pigs were subjected to each feeding treatment.

The six diets were composed of an N-free starch mixture (Table 1) and different inclusion levels (333, 444 and 555 g per kg dry matter^{-1}) of wheat wet distillers solubles (WWDS) and wheat dry distillers grain with solubles (WDDGS), respectively (Table 2). The inclusion levels of WWDS and WDDGS were calculated to be 120, 160 and 200 CP per kg dry matter^{-1}. The diets were given as a wet mash (250 g DM kg^{-1} feed) in two equal meals per day (07.30 and 16.30). The daily amount of feed was adjusted to 4% of the average BW of the group of pigs at the beginning of each period.

2.3. Sampling

Each experimental period lasted 14 days, including 7 days of adaptation, 4 days of faecal collection (day 8–11) and 2 separate days (day 12 and 14) of ileal digesta collection with one day of rest (day 13) in between collection days. Faeces were collected twice a day during the 2 h periods after feeding when most pigs defecate, and then frozen (–20 °C). The pens were cleaned and checked between collections. Collection of ileal digesta through the PVTC-cannula was carried out during 1-hour periods, on day 12 from 08:30–9:30, 10:30–11:30, 12:30–13:30 and 14:30–15:30, and on day 14 from 09:30–10:30, 11:30–12:30, 13:30–14:30 and 15:30–16:30. Digesta were collected in polyethylene bags (8 × 30 cm), while the pigs were in their pens; the bags were emptied into a container at 10–15-minute intervals depending on how fast they filled up during the collection and were immediately frozen (–20 °C). At the conclusion of the experiment, digesta and faecal samples were pooled within animal and period.

Table 1
Diet ingredient of starch mixture (g/kg diet), chemical composition (g/kg DM) and essential (EAA) and non-essential (NEAA) amino acid composition of wheat wet distillers solubles (WWDS), wheat dried distillers grain with solubles (WDDGS) and starch mixture.

Item	WWDS	WDDGS	Starch mixture
Wheat starch			764.4
Sugar			179.6
Mineral + vitamin mix [a]			54.1
TiO_2			1.9
Chemical composition			
Dry matter	289	898	900
Ash	89	47	45
CP ($N \times 6.25$)	326	346	<1
Starch	71	34	782
Crude fat	57	66	2
NFE	513	442	951
NDF	23	312	8
Gross energy, MJ/kg DM	19.8	20.6	16.3
Amino acids, g/16 g N			
EAA			
Cysteine [b]	1.7	2.1	
Histidine	2.4	2.2	
Isoleucine	3.2	3.8	
Leucine	5.6	6.7	
Lysine	2.7	2.1	
Methionine	1.2	1.5	
Phenylalanine	4.0	4.5	
Threonine	3.0	3.1	
Tyrosine [b]	3.1	3.2	
Valine	4.0	4.7	
NEAA			
Alanine	3.4	3.5	
Arginine [b]	4.2	4.2	
Aspartic acid	4.8	4.8	
Glutamic acid	28.7	28.2	
Glycine	4.3	3.8	
Proline	10.3	9.9	
Serine	4.9	5.0	

[a] Content per kg mineral and vitamin mix: Ca 189 g; P 98 g; Na 34 g; K 2 g; Se 10 mg; Cu 855 mg; vitamin A 117 500 IU; vitamin D_3 11 750 IU; vitamin E 1420 mg.
[b] Semi-essential amino acid.

2.4. Chemical analyses

Digesta, faecal and feed samples were freeze-dried, ground through a 1-mm mesh screen and then stored frozen until further analysis. The samples were analysed for dry matter (DM) by drying at 103 °C for 16 h and for ash after