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Effect of high canola meal content on growth performance, nutrient digestibility and fecal bacteria in nursery pigs fed either corn or wheat based diets

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ABSTRACT

In North-America, soybean meal (SBM) and canola meal (CM) are the most extensively used protein supplements in the feed industry and corn and wheat are the primary sources of energy in swine diets. Recent studies show that piglets can tolerate relatively high levels of CM inclusion. However, it is unclear whether this ability depends on the cereal ingredient of the basal diet. This study was conducted to examine the effect of including CM in wheat or corn-based diet on growth performance, apparent total tract digestibility (ATTD) and fecal microbial communities compared with wheat- or corn-SBM based diet. Ninety-six pigs (Yorkshire-Landrace x Duroc) with an initial BW of 6.63 ± 0.028 kg (barrows) and 6.78 ± 0.036 kg (gilts) were used in this 28-d feeding study. There were 8 replicates per treatment, each with 3 pigs. Pigs were randomly allotted to one of the four dietary treatments: corn-SBM diet (CSBM), corn-SBM diet + 200 g/kg CM (CCM), wheat-SBM diet (WSBM), and wheat-SBM diet + 200 g/kg of CM (WCM). A two-phase feeding program was used (phase I, 1–14 and phase II, 15–28 d post-weaning). Average daily gain (ADG), average daily feed intake (ADFI) and feed efficiency (G:F) were recorded weekly. Freshly voided fecal samples were collected on d 21 and 27 to determine ATTD of CP, energy, and fecal bacteria community. Data were analyzed as a randomized complete block design using the MIXED procedure of SAS and differences were declared significant at $P < 0.05$. No significant differences were observed in ADFI, ADG, and final-BW among treatments. During phase I, pigs fed the WCM diet had higher G:F compared with those fed the CSBM diet (0.95 vs. 0.79, $P < 0.01$). During phase II, pigs fed CSBM diet had higher ATTD of CP and energy compared with piglets fed the CCM, WSBM and WCM diets (96.6 vs. 89.0, 90.9 and 87.2%; and, 95.3 vs. 89.6, 90.8 and 86.9%, $P < 0.01$). When compared to corn-based diets, wheat-based diets had a significant reduction in the relative abundance of Lactobacillus ($P < 0.05$). Likewise, the relative abundance of Enterococcus was reduced ($P < 0.05$). However, wheat-based diets had a significantly higher relative abundance of Clostridium cluster-IV ($P < 0.05$). In conclusion, the inclusion of CM into either wheat- or corn-SBM based diet influences G:F, protein, and energy digestibility and relative abundance of the measured fecal microbial community without affecting voluntary feed intake and body weight gain.

Abbreviations: SBM, soybean meal; CM, canola meal; CSBM, corn-soybean meal diet; CCM, corn-canola meal diet; WSBM, wheat-soybean meal diet; WCM, wheat-canola meal diet; ATTD, apparent total tract digestibility; ADG, average daily gain; ADFI, average daily feed intake; G:F, gain to feed ratio; BW, body weight; GSL, glucosinolates; RT-PCR, reverse transcription polymerase chain reaction

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1. Introduction

Wheat is widely available in North America and together with corn; they make up the most conventional sources of energy in swine diets (Statistics Canada, 2015; USDA-FAS, 2015; AAFC, 2016). Soybean meal (SBM) and canola meal (CM) are the primary sources of protein and are extensively used in the feed industry. Canola meal is derived from the crushing of canola seed for oil extraction. Canola meal has been used in swine diets for a long time; however, its dietary inclusion levels have been limited due to the presence of anti-nutritional factors (ANF) notably glucosinolates (GSL). However, due to advances in genetic improvements of canola that have led to the production of cultivars with significantly lower ANF content and improved processing procedures, CM with a superior nutritive value for non-ruminant animals is now available (Khajali and Slominski, 2012; Adewole et al., 2016). The maximum GSL level that can be included in swine diets is 2.5 μmol per gram of diet (Bjerg et al., 1987; Bell, 1993). A Recent study indicated that piglets could tolerate relatively high levels of CM without adverse effects on growth performance (Sanjayan et al., 2014). Accordingly, CM as higher as 250 g/kg can be safely included in the wheat-SBM diet without adverse effect on piglet growth performance (Sanjayan et al., 2014). Likewise, increased feed efficiency (G:F) and final body weight (BW) were reported when corn-SBM basal diets were supplemented with 150 g/kg of conventional or dehulled CM compared to corn-SBM alone (Mejicanos, 2015).

Wheat can be substituted by corn in diets for growing-finishing pigs without adverse effects on performance. However, higher G:F has been observed in wheat-based diets compared to corn-based diets (Han et al., 2005). The crude protein (CP) content and content of all essential and non-essential amino acids (AA), except leucine and alanine, are higher in wheat than in corn; but net energy, total dietary fiber, and ether extract are higher in corn (NRC, 2012). Crude protein and standardized ileal digestible (SID) AA concentration are higher in SBM than CM. However, CM has greater methionine and cysteine concentration. Thus, soybean meal and CM can complement each other when used together (Khajali and Slominski, 2012).

Dietary ingredients can affect the composition of the microbial community in the gut and influence the ability of the pig to digest and absorb nutrients (Awati et al., 2005). Gut bacteria benefit from the nutrients in the digesta, but also assist the host with nutrient digestion, vitamin synthesis, pathogen competitive exclusion and immune system development (Berg, 1996; Green et al., 2006; Looft et al., 2014). Furthermore, it has been indicated that short-chain volatile fatty acids (SCVFA) produced during carbohydrate fermentation by gut microbiota are a significant source of energy for the host's epithelial cells (Macfarlane and Macfarlane, 2003; Natarajan and Pluznick, 2014). Butyrate is one of the most important SCFA for colonocytes, and it stimulates growth and development of intestinal cells (Ivarsson et al., 2014). Many factors can affect piglet response to diet composition. However, whether the dietary cereal ingredient of the basal diet influences piglet response to high levels of CM inclusion is not clearly understood, thus, this study was conducted to examine whether the cereal ingredient of the basal diet influences piglet response to high dietary CM addition and the relative abundance of fecal microbial communities.

2. Materials and methods

2.1. Animal care

The animal use protocol utilized in the present study was reviewed and approved by the University of Manitoba Animal Care Committee. Animals were managed according to procedures established by the Canadian Council on Animal Care (CCAC, 2009). The study was conducted at the T. K. Cheung Centre for Animal Science Research.

2.2. Animals and housing

A total of 96 piglets ([Yorkshire-Landrace] × Duroc; Genesus, Oakville, MB, Canada) weaned at 21 ± 1 days of age were obtained from Glenlea Swine Research Unit, University of Manitoba. Pigs were weighed and separated into groups of 3 according to gender and initial body weight (BW) then randomly assigned to pens in 2 rooms with 16 pens each, for a total of 32 pens. Barrows had an initial BW of 6.63 ± 0.028 kg (mean ± SD) whereas gilts weighed 6.78 ± 0.036 kg (mean ± SD). Pens with plastic cover and expanded metal floors were used and the space allowed was 0.6 m^2 per pig. Water and feed were provided ad libitum using nipple bowl drinkers and stainless steel feeding troughs throughout the experiment. Initial room temperature was set at 29 ± 1 °C and was gradually decreased by 1 °C every week. A 16-h light (0600–2200 h) and 8-h dark cycle were provided. Body weight gain and feed disappearance were recorded weekly.

2.3. Diets

The experiment included 4 treatments and 8 replicates per treatment. Two wheat-soybean based diets and two corn-soybean based diets without or with 200 g/kg of CM were formulated to meet or exceed NRC (2012) nutrient requirements for growing pigs. The composition and nutrient content of the experimental diets are presented in Tables 1 and 2. Canola meal of conventional *B. napus* produced using the pre-press solvent extraction method was obtained from the Bunge Altona, MB, Canada processing plant. Wheat used in the experiment was a Hard Canada Western Red Spring (CWRS), corn and all other ingredients were obtained from local market.