High Fiber Diets for Swine

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Introduction

Feed cost represents more than 60% of the variable cost of swine production and a major part of the feed cost is to ensure that pigs have adequate energy and protein supply to reach their optimum potential in terms of the production goals. Corn, wheat, barley, and soybean meal have been the most widely used feedstuffs to meet the energy and protein requirements of pigs. However, the prices are variable over time. Therefore, swine producers have to look for feed resources to ensure economic sustainability of their business. Currently, canola meal and cereal grain co-products from the biofuel and milling industry are commonly used for diets in Western Canada because of their availability, low-cost and nutrient content. However, these alternative feed resources are typically fibrous in nature and when fibrous ingredients are incorporated into pig diets; the carbohydrate composition inevitably changes from a high starch diet toward a diet containing less starch and more non-starch polysaccharides, which are the major component of dietary fiber. Starch and dietary fiber, however, differ in several aspects apart from their chemical structures. For instance, starch is mostly digested and absorbed in the small intestine, fiber is not digested in the small intestine of pigs because monogastric do not produce the digestive enzymes that break down fiber. However, some fiber types can be fermented by the microbes in the pig's intestinal tract. Further, dietary fiber has the potential to reduce energy and nutrient digestibility and consequently depress pig growth performance. However, the reports have been rather contradictory and the negative effects of fiber-rich diets on nutrient utilization and pig growth are influenced by the fiber source, type, and inclusion level. On the other hand, dietary fiber has received a lot of attention in swine nutrition in recent years because some fiber components have beneficial effects on pig gut health when fermented in the intestine, and can positively affect gestating sow welfare

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Fiber on pig performance

Replacing conventional feedstuffs with fibrous co-products reduces the DE content of the diet. This can lead to a reduction in the pig's ability to gain body weight with increasing dietary fiber level. For example, increasing the dietary levels of distillers dried grains with solubles (DDGS) up to 20% in nursery diets and up to 30% in grower diets linearly decreased pig body weight (Avelar et al., 2010; Agyekum et al., 2014). However, in some studies, diets containing high fiber co-products had no adverse effect on pig growth performance. The reduction in growth performance reported in some studies can be due to using inaccurate nutrient loading values and/ or not formulating diets containing a substantial amount of fibrous co-products using NE and digestible nutrients values (Wu et al., 2016). Therefore, swine diets containing fibrous co-products should be formulated based on NE, SID AA, and available P to ensure an accurate estimate of the amount of energy and nutrients that will be available for use pigs (Zijlstra and Beltranena, 2013). However, increasing the level of co-products up to 50% in diets for grow-finish pigs may reduce growth rate and feed intake even if such diets are balanced for NE and SID AA (Jha et al., 2013). Nonetheless, high fiber diets depress pig growth rate and feed intake in the nursery and growing phases more than in the finishing phase (review by Agyekum and Nyachoti, 2017). This is because older pigs have a more developed and bigger gastrointestinal tract and can, therefore, increase their daily feed intake to get the energy and nutrients required for their maintenance and growth. Additionally, adult pigs have a greater ability to ferment fiber than younger pigs. However, in weaned pigs, high-fiber diets reduce voluntary feed intake due to limited gut capacity, which reduces DE intake and thus growth rate.

Increasing dietary levels of fibrous co-products have been consistently shown to decrease dressing percentage especially when these co-products are included at 30% or more of the diet. This is because pigs have to increase their feed intake in order to compensate for the low energy value of high fiber diets, which results in adaptive changes in the gastrointestinal tract to accommodate high fiber diets. Therefore, the visceral organs increase in size and weight, which leads to an increase in energy and nutrients for maintenance and thereby decrease energy and nutrient retained for protein deposition. Therefore, no more than 30% of fibrous co-products should be included in finishing diets. Including some amount of fiber in grow-finish diets may also be useful in reducing back fat thickness, if pigs are fed low-crude protein, amino acid supplemented diets.

Fiber on fermentation and intestinal health

Although pigs cannot digest dietary fiber, the microbes in their gastrointestinal tract can ferment some fiber types to produce an array of metabolites that can influence nutrient metabolism and promote intestinal development and gut health in pigs. The level and type of fiber along with their physiological properties like solubility and fermentability affect fiber fermentation in the pig's gut. In this context, fibrous ingredients (e.g. sugar beet pulp, resistant starch, and fructo- oligosaccharides) that are soluble and highly fermentable have been reported to produce greater fermentation products than insoluble fiber ingredients (e.g. wheat bran and DDGS). Soluble and fermentable fibers are fermented in the proximal end of the hindgut, whereas insoluble fibers are fermented gradually and the fermentation can be sustained until the end of the colon. Further, information in the literature suggests that high levels of insoluble fiber in pig diets may hamper or lead to lower microbial fermentation in the hindgut. Nonetheless, fiber fermentation in sows is greater than in growing pigs because sows have a well-developed gut capacity, high microbial activity, while digesta retention time in the sow's gut is longer for fermentation to occur.

Fiber fermentation products include volatile fatty acids (VFA; mainly acetic, propionic and butyric acids), CO_2, H_2, and methane gases. The VFA has been widely reported to be beneficial to intestinal development and gut health in pigs. For example, butyrate is used as an energy source by the colon cells to grow. Propionate and a certain amount of butyrate are used to produce glucose through the process of gluconeogenesis, whereas nearly two-thirds of acetate is metabolized in the muscle cells as fat (Slavin, 2013). Including soluble-fermentable fibrous ingredients like resistant starch and fructooligosaccharides in pig diets can stimulate the growth of beneficial bacteria (e.g. Bifidobacteria and Lactobacilli) and increase VFA production thereby lowering gut pH. The low gut pH has been reported to have a negative effect on the growth of pathogenic bacteria such as E. coli and Clostridium perfringens (Jha and Berrocoso, 2015), which cause enteric infections in pigs. Wheat bran and oat hulls, which are rich sources of insoluble fiber have also been reported to reduce the growth of pathogenic bacteria and the severity of intestinal infections in weaning pigs (Kim et al, 2008; Molist et al., 2011). For example, the addition of 4% wheat bran to a weaner diet, based on corn, wheat, barley, and soybean meal, reduced E. coli population and the incidences of diarrhea in weaned pigs experimentally infected with E. coli K88+ (Molist et al., 2010). However, combining soluble and insoluble fiber in pig diets produces a superior response on intestinal development and health (Pieper et al., 2008; Molist et al., 2009). Therefore, fibrous feed ingredients can be incorporated into nursery and grower pig diets, as a strategy to reduce the incidences of enteric infections and thereby promote gut health. Currently, however, there are no recommended dietary levels of fiber for pigs to confer health benefits because this is difficult to establish and depends on the feed ingredients used for diet formulation. Additionally, it should be noted that a high dietary fiber inclusion rate can hamper nutrient utilization and pig growth performance.

Fiber in gestation diets

Restricting the feed allowance of gestating sows is commonly practiced to prevent excessive body weight gain and the associated negative consequences on locomotion and reproductive functions. Sows still receive sufficient nutrients to meet their maintenance and reproductive needs; however, their daily feed allowance is not enough for the sows to achieve satiety. The lack of satiety due to restricted feeding has been reported to result in aggression and stereotypies (Lawrence et al., 1993), which are of great welfare and production concern in individual or group-housed gestating sows. Incorporating fibrous ingredients into pregnant sows diets have been reported to reduce hunger sensation and to reduce the aggression and behavioral problems associated with restricted feeding (de Leeuw et al., 2008). The beneficial effects of feeding high-fiber diets to gestating sows have been ascribed to their ability to delay gastric emptying and increase swelling of the stomach content and fermentation products (Jorgensen et al., 2010). Further, based on data from 24 studies published between 1975 to 2007, it was observed that sows that were fed high fiber diets during gestation had improved lactation feed intake and weaned more pigs/litter on average than sows fed low fiber diets (Reese et al., 2008). Fibrous ingredients that are soluble and highly fermentable should be used because they have greater effects on satiety and sow lactation performance than insoluble fibrous ingredients. The Nutrition Group at the Prairie Swine Centre are currently running series of experiments utilizing hydrothermal treatment as a processing technique to improve the solubility of straws for group-housed gestating sows. The overriding objective is to evaluate the effect of processed or unprocessed straws on indicators of satiety and lactation performance of sows.

References

Agyekum AK, Nyachoti CM. 2017. Nutritional and metabolic consequences of feeding high-fiber diets to swine: A review. Engineering. doi:10.1016/J.ENG.2017.03.010

Agyekum AK, Woyengo TA, Slominski BA, Yin YL, Nyachoti CM. 2014. Effects of formulating growing pig diet with increasing levels of wheat-corn distillers dried grains with solubles on digestible nutrient basis on growth performance and nutrient digestibility. J. Anim. Physiol. Anim. Nutr. (Berl) 98:651–8.

Avelar E, Jha R, Beltranena E, Cervantes M, Morales A, Zijlstra RT. 2010. The effect of feeding wheat distillers dried grain with solubles on growth performance and nutrient digestibility in weaned pigs. Anim. Feed. Sci. Tech. 160:73–7.

Jha R, Berrocoso JD. Review: Dietary fiber utilization and its effects on physiological functions and gut health of swine. 2015. Animal. 9:1441–52.

Jha R, Htoo JK, Young MG, Beltranena E, Zijlstra RT. 2013. Effects of increasing co-product inclusion and reducing dietary protein on growth performance, carcass characteristics, and jowl fatty acid profile of growing–fi nishing pigs. J. Anim. Sci. 91:2178-2191.