Fiber in Nursery Diets

Diets rich in dietary fiber generally have lower nutritive value for nursery pigs because digestive enzymes are not suited for degrading fiber. However, dietary fiber components seem to have beneficial effects on gut health and development, particularly to ameliorate post-weaning gut disorders. The concepts regarding fiber and the use of dietary fiber in nursery diets are discussed in this fact sheet.

Fiber definition

Carbohydrates are sources of energy in swine diets, but not all types of plant carbohydrates are able to be utilized by the pig. Plant carbohydrates are classified in storage carbohydrates (starch) and structural carbohydrates (non-starch polysaccharides). Starch is the main source of energy in swine diets and digestion in the upper gut produces glucose. Non-starch polysaccharides are the main structural carbohydrates of plant cell walls that resist digestion in the upper gut and are subject to fermentation by gut microflora in the hindgut to produce volatile fatty acids. All carbohydrates that resist digestion in the upper gut of pigs are defined as fiber (Kerr and Shurson, 2013).

Fiber classification and characteristics

Fiber is classified as soluble or insoluble based on fiber solubility in water. The fiber characteristics relevant to swine nutrition include fermentability, viscosity, and hydration. Natural fibrous feed ingredients are usually composed of both soluble and insoluble fiber.

Soluble fibers

Soluble fibers are more rapidly fermented in the hindgut and produce more volatile fatty acids, such as acetate, propionate, and butyrate, which are used as sources of energy to promote gut development (Montagne et al., 2003). Soluble fibers also promote a prebiotic effect by enhancing beneficial bacteria fermentation and production of volatile fatty acids while reducing gut pH to eliminate pathogens. The presence of soluble fibers increases digesta viscosity, which delays digesta passage rate, interferes with nutrient digestion, and predisposes proliferation and colonization of pathogens (McDonald et al., 2001). However, soluble fibers have better solubility, swelling capacity, water-holding capacity, and water-binding capacity that are important for digestion. Soluble fibers include pectins, gums, and β-glucans. Feed ingredients such as sugar beet pulp and citrus pulp have predominantly soluble fiber (Jha and Berrocoso, 2015).

Insoluble fibers

Insoluble fibers are relatively resistant to fermentation in the hindgut and do not contribute much to production of volatile fatty acids (Montagne et al., 2003). The presence of insoluble fibers increases fecal bulkiness and accelerates digesta passage rate, which prevents proliferation and colonization of pathogens (Wellock et al., 2008). Insoluble fibers include cellulose and hemicellulose. Feed ingredients such as wheat middlings, wheat bran, rice hulls, oat hulls, and distillers dried grains with solubles have predominantly insoluble fiber (Jha and Berrocoso, 2015).

Fiber analysis

The most common analytical methods to estimate fiber content in feed ingredients and feeds include crude fiber, acid detergent fiber (ADF), neutral detergent fiber (NDF), soluble and insoluble fractions of total dietary fiber (TDF), and non-starch polysaccharide (Kerr and Shurson, 2013). The fiber analytical methods measure several and sometimes different fractions of fiber. The ADF and NDF methods are widely used and quantify cellulose, hemicellulose, and lignin, which are insoluble fibers. Thus, the detergent methods provide an accurate estimate of insoluble dietary fibers, but soluble dietary fibers are not recovered in the analysis (NRC, 2012). The use of TDF method that categorize dietary fiber in soluble and insoluble fractions seems to provide the most useful analysis to determine the characteristics of fibrous feed ingredients (**Table 1**) for nursery diets (Agyekum and Nyachoti, 2017).

Table 1. Fiber composition of common ingredients used in nursery diets

	Type of fiber, %		Detergent method, %	
Ingredient	Soluble	Insoluble	ADF	NDF
Barley[1,2]	5.4	9.7	5.8	18.3
Canola meal[1,2]	3.2	15.8	15.4	22.6
Corn[1,2]	0.9	6.0	2.9	9.1
Corn DDGS[1,3]	3.0	14.1	12.0	30.5
Oats, whole[1,3]	3.6	9.8	13.7	25.3
Oat hulls[4]	4.9	65.7	32.1	65.9
Rye[1,3]	3.7	8.4	4.6	12.3
Sorghum[1,2]	0.6	5.1	4.9	10.6
Soybean hulls[1,2]	10.0	45.0	41.6	59.4
Soybean meal[1,2]	3.9	12.6	5.3	8.2
Sugar beet pulp[1,3]	25.2	18.0	23.5	44.9
Sunflower meal[1,2]	5.2	29.4	23.0	30.2
Wheat[1]	2.3	6.8	3.6	10.6
Wheat bran[1,3]	2.5	23.8	11.0	32.3
Wheat middlings[1,3]	1.1	20.2	6.0	35.0

Adapted from [1]NRC (2012), [2]Brazilian Tables for Poultry and Swine (2017), [3]Jha and Berrocoso (2015), and [4]Jiménez-Moreno et al. (2016).

Fiber in nursery diets

The use of fiber in nursery diets is mostly related to the purpose of ameliorating post-weaning diarrhea. However, there are no firm recommendations of dietary fiber to confer health benefits on weanling pigs. In general, the use of insoluble fiber is preferred over soluble fiber in the immediate post-weaning period (Agyekum and Nyachoti, 2017) (**Table 2**).

Insoluble fibers accelerate digesta passage rate, which potentially prevents proliferation and colonization of pathogens and ameliorates post-weaning diarrhea. Soluble fibers have the opposite effect and potentially increase the risk of post-weaning diarrhea. The main issue with soluble fiber is the increase in digesta viscosity, which delays digesta passage rate and increases undigested nutrients, predisposing proliferation and colonization of pathogens. Furthermore, weanling pigs would not benefit from the fermentation of soluble fibers in the hindgut because of the very limited capacity to ferment fiber at a young age. However, the use of soluble fiber in later nursery stages might be beneficial to promote gut health and development (Agyekum and Nyachoti, 2017).

The key to effectively utilize dietary fiber in the nursery consist of investigating dietary ingredients that deliver the appropriate fiber characteristics to address the main concern in the nursery, as well as understanding that fiber characteristics that ameliorate post-weaning diarrhea might not be the same as those to maximize growth rate (De Lange et al., 2010).

Table 2. Research evaluating the effects of different fiber sources on performance and gut health of weanling pigs

Type of fiber	Basal diet	Challenge model	Response		Reference
			Performance	Gut health	
Soluble	Rice	*E. coli*	↓Daily gain	↑PWD incidence, ↑*E. coli* colonization, ↑digesta pH, ↑digesta viscosity	Hopwood et al. (2004)
Soluble	Rice	*E. coli*	No effect	↑PWD incidence, ↑*E. coli* colonization, ↔digesta pH	Montagne et al. (2004)
Soluble	Porridge oats, wheat, animal protein	*E. coli*	No effect	↓PWD incidence, ↔*E. coli* colonization, ↓digesta pH, ↑lactobacilli:coliform ratio	Wellock et al. (2008)
Insoluble	Corn, wheat, barley, soybean meal	*E. coli*	No effect	↓PWD incidence, ↓*E. coli* colonization, ↓coliforms, ↑short-chain fatty acids	Molist et al. (2010)
Insoluble	Rice, animal protein	None	No effect	↓ PWD incidence, ↑fecal consistency	Kim et al. (2008)
Insoluble	Corn, barley, soy protein concentrate	None	No effect	↓PWD incidence, ↓*E. coli* colonization, ↑short-chain fatty acids	Molist et al. (2011)

Adapted from Agyekum and Nyachoti (2017). Fiber diets are compared with non-antibiotic control diets.
PWD = post-weaning diarrhea. ↑ increase in response criteria, ↓ decrease in response criteria, ↔ no effect on response criteria.

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