Fibre is essential for maintaining intestinal health in piglets

Worldwide, the topic of 'fibre' in diets for monogastric animals in connection with the maintenance of the intestinal health is discussed intensively. For pig feeding 'fibre' and 'fibre effects' are also related to saturation and aspects of animal welfare. So far however, recommendations for quantification are missing, as are those for the qualification of specific fibres that are responsible for the positive effects.

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g/kg in dry matter	Crude fibre	aNDFom	ADFom	TDF	iDF	sDF
Wheat bran	145	585	181	612	579	34
Sugar beet pulp	153	317	196	637	474	163
Soy hulls	301	562	388	654	585	70
Lignocellulose	559	919	757	945	933	13

Table 1. Fibre content in feed materials (Braach et al., 2017). aNDFom: neutral detergent fibre (amylase treated, organic matter balanced). ADFom: acid detergent fibre (organic matter balanced). TDF: total dietary fibre. iDF: insoluble dietary fibre. sDF: soluble dietary fibre.

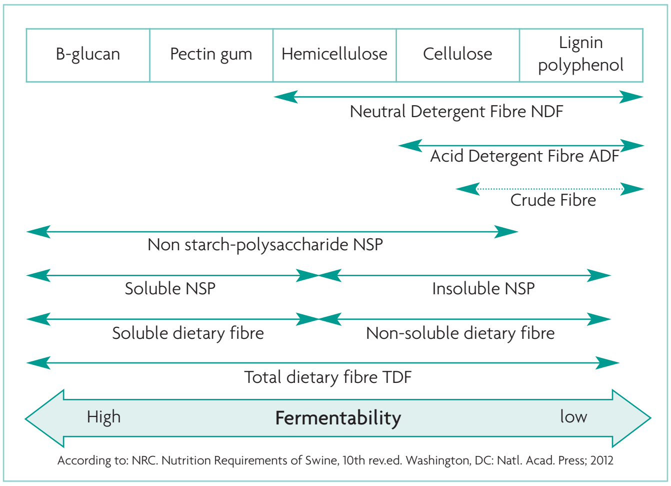
The CODEX Committee on Nutrition and Foods for Special Dietary Uses defines dietary fibre as: 'carbohydrate polymers with 10 or more monomeric units, which are not hydrolysed by the endogenous enzymes in the small intestine of humans'. This definition comprises a variety of components as well as functionalities (Fig. 1).

Neither the 'crude fibre' term of 19th century Weende feed analysis nor the 'Detergent Fibre Analysis' improves the view of feeding fibre sufficiently.

Solubility, viscosity and fermentability of fibre may be important parameters to look at.

Differentiation between feed materials by crude fibre is difficult as there is no clear correlation between the different analytical parameters that characterise fibre (Table 1).

Fig. 1. Cell wall carbohydrates (according to NRC, 2012).



A combined approach by using several parameters should be more promising. Both the non-starch polysaccharides (NSP) or the total dietary fibres (TDF) become chemically 'soluble' or 'insoluble'. Dividing into such fractions does not consider the 'fermentability', which triggers most of the positive effects in the animal.The conceptual differentiation between 'solubility' and 'fermentability' is important.

Soluble dietary fibres are water-soluble and undergo rapid microbial fermentation.

The increase in soluble NSP will increase the viscosity in the intestinal tract and may have negative effects on performance.

Lignocellulose

Lignocellulose is a natural fibre concentrate made from fresh wood. Within the group of LC products there are also variations worth consideration, for example fermentability.

The basic lignocellulose consists of 100% insoluble and non-fermentable fibre, whereas eubiotic lignocellulose (OptiCell, Agromed Austria GmbH) is also insoluble, however, it also contains fermentable fibre. The eubiotic lignocellulose passes an extensive manufacturing process and is ground to a particle size of 50-120 micrometres.

Following pelleting and granulation, this results in an easily transportable and mixable product. The small particles provide a large surface for bacterial fermentation.

In contrast to various co-products used as fibre supplements (for example wheat bran or soybean hulls) the fibre content is constant, it has a high hygiene quality, and is free from mycotoxins, making it a safe fibre source. The added value is the fermentability.

'Digestibility' of fibre

Fibre cannot be digested by endogenous enzymes but may be fermented. Fermentation leads to short chain fatty acids (acetic, propionic, butyric and lactic acid).

Limited data is available on place and extent of fermentation. Recently Navarro et al. (2019) published figures for apparent ileal and total tract digestibility (AID, ATTD) of various fibre sources. Surprisingly about 20 and 40% of TDF in sugar beet pulp and wheat bran are (apparently) digestible in the Ileum (Table 2).

Inulin, a fructo-oligosaccharide, can be fully fermented in the small intestine.

g/kg dry matter	TDF	AID	AHD	Inert
Inulin[1]	1000	980	20	0
Wheat bran[2]	347	139	49	159
Sugar beet pulp[2]	485	84	335	66
eubiotic lignocellulose[3]	945	444		501

Table 2. Digestibility of total dietary fibre (TDF) along the intestinal tract [1]Branner et al., 2004. [2]Navarro et al., 2019. [3]Youssef & Kamphues, 2018. TDF: total dietary fibre. AID: apparent ileal digestible. AHD: apparent hindgut digestible (apparent total tract digestible – AID). Inert: non digestible.

	Control	Cellulose	Citrus pulp
Fibre source	-	1.5	9.0
Crude fibre (%)	3.1	4.4	4.3
NDF (%)	9.2	10.4	10.2
sDF (%)	1.4	1.4	4.1
iDF (%)	18.0	19.3	17.6
TDF (%)	19.5	20.7	21.7
FCR	1.68	1.62	1.74
Diarrhoea (%)	13.9	11.1	22.2

Table 3. Variation of soluble and insoluble dietary fibre: composition of starter diet (day 21-35) and performance data (day 21-63). Starter diet: 21-35 days of age, following diets (days 36-50, 51-63) not shown, only adapted for minerals and protein not for fibre. sDF: soluble dietary fibre. iDF: insoluble dietary fibre. FCR: feed conversion ratio (kg feed/kg gain).

Fibre linked to dysbacteriosis

The effect of soluble or insoluble dietary fibre on performance and health of piglets was evaluated by Pascoal et al. (2012), looking at the effects of supplemented cellulose or citrus pulp in weaner diets (Table 3).

Increased crude fibre or NDF levels had no clear impact on feed conversion ratio or diarrhoea.

Feeding higher amounts of iDF via cellulose resulted in an improved feed conversion ratio (FCR). The sDF exerted clearly negative effects, visible by decreased FCR and higher diarrhoea incidence.

The meta-analysis of Hopwood et al. (2006) confirmed these results with the positive correlation of sDF and ETEC-CFU (enterotoxic E. coli – colony forming units) in the small intestine of piglets.

Hopwood (2006) and Pascoal et al. (2012) focused their research on sDF. Having in mind the negative impact of sDF on the intestinal health of piglets and the high AID of TDF, feed materials need to be reviewed on AID-TDF to balance diets for weaner piglets properly, sDF can trigger dysbacteriosis in weaning piglets.

Using semi-synthetic diets, Jenkins et al. (2015) examined the effects of semi-synthetic diets low or high in soluble non-starch polysaccharides (NSP, 8 and 29g/kg) resp. insoluble NSP (iNSP: 6, 19, 35, 51g/kg) on weaners orally infected with E. coli. Eubiotic lignocellulose was used as a source of insoluble fibre. The combination of 29g/kg sNSP and higher levels of iNSP improved weight gain and feed conversion. For weaner piglets health is often more important than performance.

The shedding of β-haemolytic E. coli could be reduced to zero by increasing the dosage of iNSP (eubiotic lignocellulose; Fig. 2).

Simultaneously, the number of Christensenellaceae was improved in a linear manner. Christensenellaceae are part of the Firmicutes, butyrate producing bacteria, also being involved in various key functions: maintaining gut structure and reducing inflammation processes.

Sun et al. (2019) has tested the effects of eubiotic lignocellulose on performance and immune response in piglets in a challenge trial (Table 4).

In this full factorial trial the piglets (28 days trial period from 34-62 days of life) received a corn/soybean meal diet with 0% or 2% eubiotic lignocellulose.

Lipopolysaccharides were used to induce inflammation (0 or 500g LPS/kg bodyweight).

In the thymus the eubiotic lignocellulose strongly reduced the mRNA levels of various pro-inflammatory cytokines. In the thymus, the pre-T-lymphocytes mature to T-lymphocytes, a process triggered by cytokines.

So, lower levels of cytokine mRNA indicate a reduced need for an energy-intensive immune response. Therefore, more nutrients are available for growth, visible in improved performance.

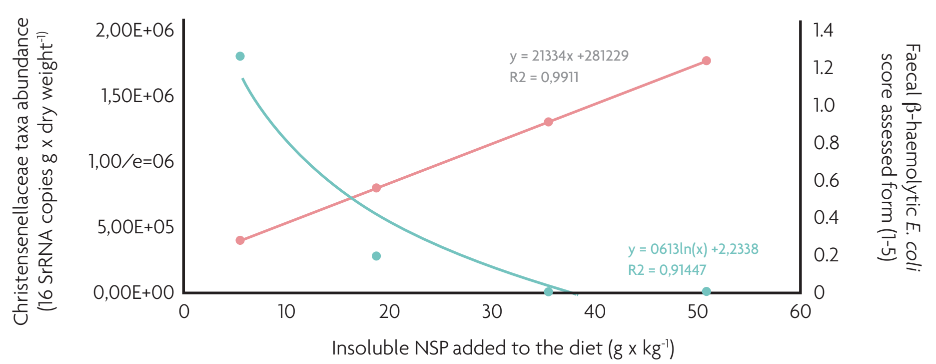
Sun et al. (2019) concluded that the supplementation of eubiotic lignocellulose was able to alleviate the immune response caused by lipopolysaccharides challenge and improved the growth response of piglets.

Finally, this eubiotic lignocellulose not only supports gut health but has an enlarged mode of action to the metabolism and immune system.

Table 4. Effect of eubiotic lignocellulose on piglet performance and thymus cytokine mRNA expression.

LPS, μg/kg bodyweight		0	500
Growth performance	Feed intake, g/day (%)	+41 (+5.7%)	(+5.7%)
	Growth, g/day (%)	+54 (+14.1%)	(+14.1%)
	Feed conversion, g/g (%)	-0.14 (-7.4%)	(-7.4%)
Cytokines mRNA	IL-1β	-82%	-79%
	IL-6	-49%	-69%
	TNF-α	-72%	-44%

Fig. 2. Shedding of bacteria as influenced by insoluble fibre (eubiotic lignocellulose).



Outlook and conclusion

The composition and properties of fibre in fibrous feed materials used for monogastric nutrition differ significantly.

The fermentability in the colon is an essential factor for maintaining intestinal health.

Regarding the physical and physiological effects as well as standardisation and safety, eubiotic lignocellulose is a promising product of the present and future feeding programmes.

- Supply of sufficient amount of fibre for piglets is crucial for animal welfare and performance.
- Dietary fibre for piglets is essential to maintain the health and development of the gastrointestinal tract.
- Excessive supply of soluble fibre may lead to dysbacteriosis.
- Increasing insoluble and fermentable fibre by eubiotic lignocellulose has a positive effect on growth performance in weaners and may be recommended to promote gut development.
- Eubiotic lignocellulose
  - Is the safest fibre source to deliver fermentable and insoluble fibre for piglets.
  - Is the most concentrated fibre to fulfil the requirements of high-nutrient-dense diets. ■

References are available from the author on request