Improved bioavailable sugar content in commercial grower finisher diets

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In modern livestock management, feed additives play an important role in animal nutrition. They help improve the utilisation of the nutrients in feed, leading to increased performance and profitability.

Feed prices account for about 70% of total pig production costs. Feed utilisation, however, is not optimal. Pigs cannot digest 15-25% of their feed rations because they lack fibre or non-starch polysaccharide (NSP) degrading enzymes in their intestinal tract (Table 1).

If NSP digestibility could be improved it would significantly increase feed utilisation, both directly and indirectly. Increased fibre digestibility would also increase the availability of other nutrients that are trapped within the fibre matrix. As a result, the energy supply from the fibre itself would also increase, and fewer nutrients will be lost to the environment.

Exogenous enzymes can be used as catalysts to improve feed utilisation, but a more efficient solution is needed. In pigs which cannot produce NSP enzymes, supplementing their feed with probiotic microorganisms, such as BioPlus YC, which can synthesise NSP enzymes, has been shown to improve the nutritional value of individual feed ingredients and to stabilise the gut under commercial farm conditions.

Feed ingredient	Amount of NSP in feed (% of DM)	NSP fraction contained in the feed
Cereals	10-15	Beta-glucans, hemicellulose (barley)
Corn	10-15	Hemicellulose + cellulose
Sorghum	10-15	Not described
DDGS	25-35	Hemicellulose + cellulose
Wheat bran	25-35	Not described
Soybean meal	20-35	Pectins

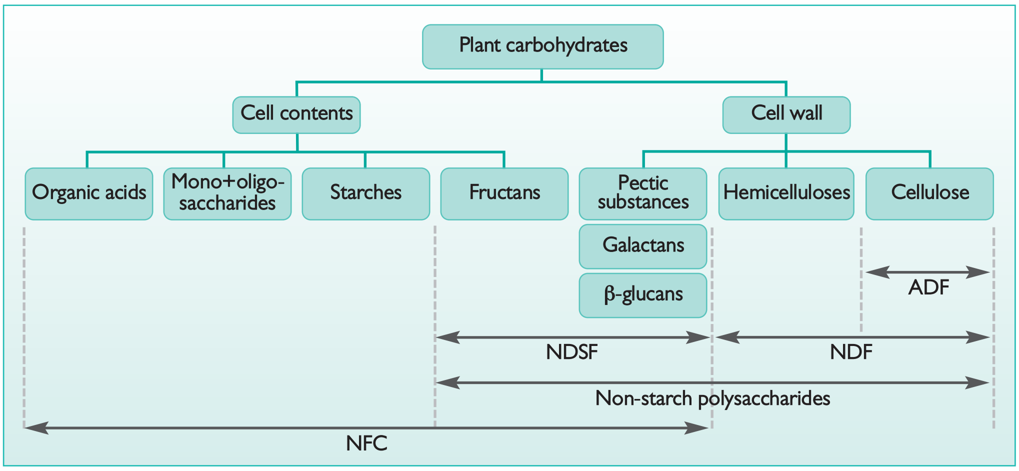
Table 1. Non-starch polysaccharides (NSP) in different feed sources (Modified from Nielsen et al., (Nielsen, 2014).

The bacilli would enable the degradation of the non-starch polysaccharides (NSP) that cannot be digested by monogastrics alone, and would utilise the 15-25% of the feed not being digested by pigs (Fig. 1).

Increased microbial fibre digestibility from Bacilli improves the availability of other nutrients, including vitamins and minerals that are trapped in the fibre matrix.

Increased microbial fibre digestibility also increases the energy supply from the fibre itself, and reduces the loss of nutrients to the environment.

Fig. 1. Illustration of the NSP fraction from plant carbohydrates. Non starch polysaccharides (NSP) = NDSF+NDF. NDF = neutral detergent fibre, NDSF = neutral detergent-soluble fibre (includes all non-starch polysaccharides not present in NDF), NFC = non-NDF carbohydrates (Hall, 2003).



This is illustrated in Fig. 2, which shows the results of a digestibility study on the effect of adding BioPlus YC dual strain bacillus to a commercial grower finisher diet.

The study found that adding BioPlus YC to a grower finisher diet improves digestibility of crude fat, protein, crude fibre, crude ash, dry matter and energy (2.2% units enhancement for protein, 1.1% unit enhancement for energy).

These outcomes serve to improve animal performance and profitability.

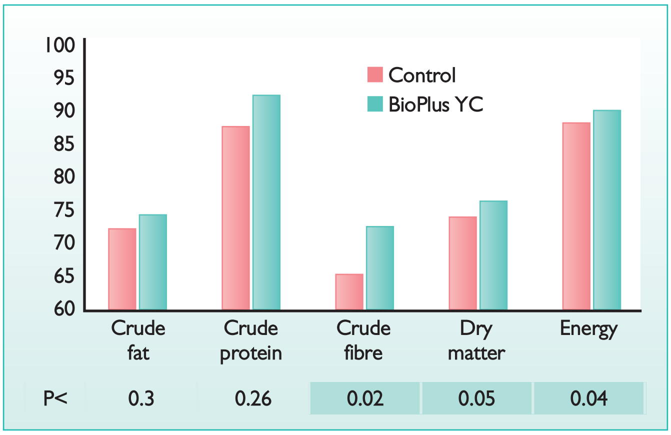


Fig. 2. Digestibility study conducted at a large midwestern US swine production company using BioPlus YC.

The digestibility study provides valuable evidence supporting the benefit of adding BioPlus YC to feed in terms of utilisation of nutrients and energy in the feed. It is not feasible to conduct such a digestibility study on an individual customer-specific basis, as it is both time-consuming and expensive; for that, a high-throughput method is needed.

Analysing the fibre fraction

NSP enzyme activity can be analysed for each single enzyme (for example, endo-cellulase or xylanase) that is produced by the BioPlus YC dual strain bacillus.

The breakdown of the NSP fraction, however, requires the action of multiple enzymes working in a coordinated manner and is dependent on the specific feed source; information regarding the quantity of individual enzymes is of less importance.

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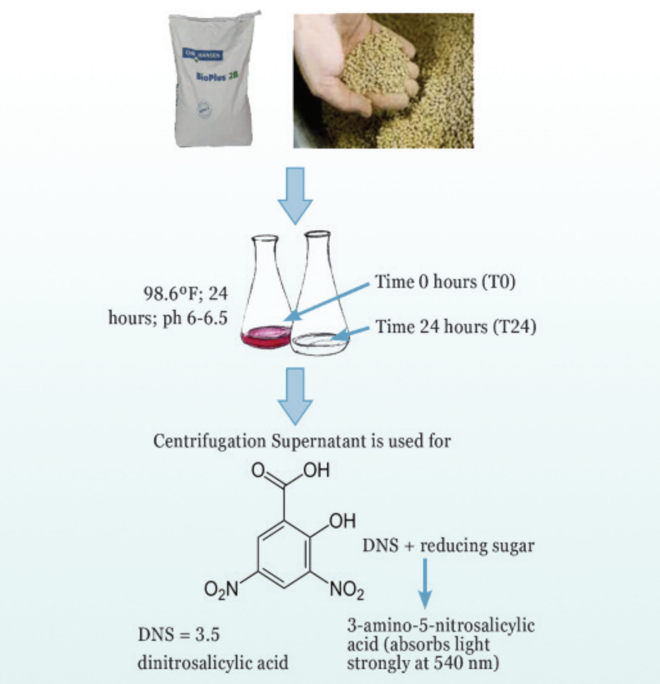

Fig. 3. The Reducing-Sugar Release (RSR) analysis.

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The key is to measure the degradation end-products of digested fibre: reducing-sugars that can be utilised by the pig. A reducing-sugar is any sugar that either has an aldehyde group or is capable of forming one to allow the sugar to act as a reducing agent. Reducing sugars include glucose, glyceraldehyde and galactose as well as disaccharides, like lactose and maltose.

The Bacillus subtilis and Bacillus licheniformis strains used in BioPlus YC have been specifically selected for their ability to produce a wide array of enzymes. The enzymes which are secreted by the bacillus are dependent on the substrate (feed source) that surrounds them. Since Bacilli are most interested in their own survival, and they need to eat to survive, they will produce the enzymes that are most advantageous to them.

This ultimately benefits the pig as well. We can measure this enzymatic activity of the Bacilli by simply measuring the end result of this process: Reducing Sugars. That is why we developed a unique in vitro feed assay to quantify the effect of inoculating feed with BioPlus YC Bacillus strains on reducing sugar content. It is also referred to as the Reducing-Sugar Release analysis.

Advantages of the Reducing-Sugar Release (RSR) analysis:

- The combined effect of all NSP enzymes produces by BioPlus YC can be tested in a high throughput analysis.
- Provides easy comparison with either a control sample without BioPlus YC or to a specific standard curve for quantification of the amount of total reducing sugars released.
- Enables testing of individual feed samples for customers ensuring 'proof of concept'.

As illustrated in Fig. 3, complete feed samples from individual production systems are collected and autoclaved at 121°C for 15 minutes to kill other micro-organisms.

The feed sample(s) are then diluted with sodium phosphate buffer to ensure a pH=6-6.5. The feed sample is then split into two samples: one control sample and one control sample plus BioPlus YC ($1.28*10^6$ CFU /g feed). The samples are incubated at 37°C for 24 hours and CFU count is then re-analysed. The samples are then centrifuged and the supernatant is finally analysed for the content of reducing sugars using 3.5-dinitrosalicylic acid (DNS) as described by Gusakov et al. (2012).

DNS is an aromatic compound that reacts with reducing sugars and other reducing-molecules to form 3-amino-5-nitrosalicylic acid, which absorbs light strongly at 540 nm.

The reducing-sugar release analysis was used to quantify the effect of inoculating a grower finisher diet with BioPlus YC Bacillus strains on the reducing-sugar release from feed. As seen in Fig. 4, the addition of BioPlus YC to the feed sample resulted in a supply of more nutrients to the animals in the form of reducing-sugar as compared with the control sample (Fig. 4, Table 2).

Feed samples with BioPlus YC deliver about 2-3 times more reducing-sugars than the control.

	T0	T24
BioPlus YC	0.37±0.05	3.53±1.43
Control	0.41±0.18	1.29±0.77

Table 2. Effect of adding BioPlus YC on the release of reducing sugar in commercial grower finisher feed (OD, mean ± st.dev) as illustrated in Fig. 4.

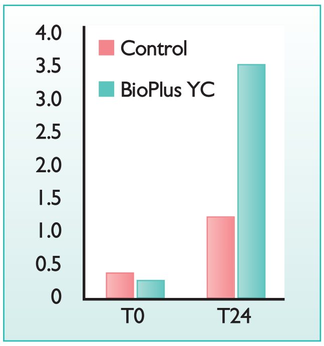

Fig. 4. Reducing sugar units available for utilisation by the pigs in feed samples from a commercial US based grower finisher unit (control is feed without BioPlus YC). Data from Table 2.

Commercial farm trial

To illustrate the benefit of BioPlus YC in commercial settings a farm trial was set up to study the effect of inoculating diets with BioPlus YC Bacillus strains on the performance in growers as a result of improved reducing-sugar release from the feed and improved gut stabilisation as illustrated in Table 3.

Increasing microbial fibre digestibility results in higher bioavailability of reducing-sugars and other nutrients, vitamins and minerals normally fixated by the fibre matrix, and that in turn leads to a 4.8% improvement in FCR, 4.0% in ADG and a 2.4% unit reduction in mortality. We can use the data from Table 3 to calculate the return on investment in a commercial setting for the production of 1000 growers, as illustrated in Table 4. It shows that the difference between adding BioPlus YC to the diet compared to a diet without BioPlus YC (control) would be 1120.1kg less feed in the production as a result of the improved FCR in the BioPlus YC group (assuming the mortality is taking place at the final stage in the production).

The 1120.1kg feed saved could be used to produce 521kg extra pig (FCR = 2.15). In addition, there will be an additional 3373.3kg pig produced for sale as calculated by total gain kg x number of pigs at the end of the period (997 and 969, respectively growers getting a diet with BioPlus YC or a control diet, Table 3 and Table 4). The investment required to add BioPlus to 116,422.5kg of feed equals 46.6kg of BioPlus YC. Thus, the overall return on investment in the commercial farm trial can be stated as follows: 1kg of BioPlus YC will give you a return on investment of:

- 72.4kg more pig on top of saving.
- 24kg feed. ■

References are available from the author on request

Table 3. Data from a commercial farm trial illustrating the return on investment using BioPlus YC grower diets.

Grower results	Control	BioPlus	Index	Diet composition
N in	290	290		NE Mcal (2.29 kg)
Weight in (kg)	16.2	16.2	100	Crude protein (16.9%)
Weight out (kg)	68.21	70.35	103	Lysine (0.86 %)
ADG (g/day)	667	694	104	Methionine (0.57%)
FCR (g/g)	2.26	2.15	95	Met. and Cryst (0.57%)
Mortality (%)	3.1	0.7	23	Phytase (500 IU/kg)

* Commercial farm conditions (farm trial, 80159). Trial period: August-October (78 days). Medium sanitary conditions. 1 feeding phase - Control: standard grower diet and BioPlus: Control + BioPlus YC.

Table 4. Calculated return on investment in a commercial setting for production of 1,000 growers using data from Table 3.

	Control	BioPlus YC	Added value
Weight in (kg)	16200	16200	
Weight out (kg)	68210	70350	
Total gain (kg)	52010	54150	
FCR (g/g)	117542.6	116422.5	-1120.1*
BioPlus YC kg needed		46.569	
Total kg pig produced for sale (total gain kg x live pigs)			
	50397.69		
		53770.95	3373.26
The return on investment from 1kg BioPlus YC			
kg less feed used		24.05	
kg extra pig produced		72.43	

* The 1120.1kg feed saved could be used to produce 521kg extra pig, assuming a FCR at 2.15.