Carbohydrase complex exerts prebiotic effects in broilers

Carbohydrases are added to poultry diets to improve performance. Whilst their main effect is to improve digestibility and nutrient availability there are other ways they influence poultry physiology, which are not yet fully understood. Carbohydrase enzymes degrade the non-starch polysaccharides (NSPs) found in cereals.

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The result of this degradation is the production of short chain arabinoxylans. A recent study showed that these molecules have prebiotic effects in broilers. Beneficial effects on the gut microflora were evidenced, along with improvements in bird performance.

Enzyme effects

NSPs are the main constituents of plant cell walls and play a role in the encapsulation of nutrients, including amino acids, starch and lipids. It is well known that NSPs negatively affect access of endogenously secreted enzymes to their substrates, reducing digestibility (the so-called cage effect). They induce high viscosity of the intestinal content and increase intestinal inflammation.

The ability of an efficient enzyme solution to improve global feed digestibility is known as the feedase effect. By reducing the indigestible fraction of feed, as well as anti-nutritional factors, more nutrients are released.

This is due to the inclusion of a wide range of NSP-degrading enzymes, including xylanases (Xyn), arabinofuranosidases (ABF) and beta-glucanases.

They have the effect of reducing the viscosity of the intestinal content and release oligosaccharides from NSPs in the digestive tract.

Prebiotic action

Prebiotics are described as being selectively fermented and allow specific changes, both in the composition and/or activity of the gastrointestinal microbiota. This in turn confers benefits on host well-being and health.

Table 1. Characterisation of the wheat fractions. By more efficient degradation of NSPs the carbohydrase complex significantly increased the quantity of short-chain arabinoxylans, as demonstrated by the lower molecular weight and degree of polymerisation.

	Positive control	Rovabio
Protein (dry weight %)	14.0[b]	21.0[a]
Sugars (dry weight %)		
Arabinose	19.1	19.3
Xylose	32.2	34.5
Mannose	0.2	0.5
Galactose	3.2	4.4
Glucose	5.2	5.4
Degree of polymerisation (DP)	270[b]	54[a]
Molecular weight (kDa)	178.6	49.6
Intrinsic viscosity (ml/g)	215.7	54.1

Parameters	NC	PC	Rovabio
FI (g/bird)			
0-14 days	547[b]±29	559[b]±33	591[a]±31
BWG (g/bird)			
0-14 days	425[b]±26	430[b]±25	458[a]±26
FCR			
0-14 days	1.29±0.18	1.30±0.19	1.29±0.18

Table 2. Performance of broilers at 14 days of age. Both body weight gain and feed intake were significantly higher in broilers fed the carbohydrase complex treated fraction.

The prebiotic effects of some of the oligosaccharides released by NSPases, including arabinoxylans (AX), arabino-xylo-oligosaccharides and xylo-oligosaccharides; have been studied.

Some of these polysaccharides have also been shown to enhance the production of short chain fatty acids (SCFA), particularly butyrate, by the gut microflora.

These effects are dependent on the efficient degradation of the xylan backbone – to produce short-chain arabinoxylans. ABF are debranching enzymes; they facilitate the enzymatic activity of Xyn on AX, by removing the arabinose on the side chains.

As a result, Xyn have better access to the xylose backbone for hydrolysis. It is this synergistic effect of carbohydrase complex that improves the prebiotic action.

The importance of gut health

In the first two weeks of life broilers are particularly sensitive to NSPs, their digestive systems are not yet physiologically mature and their microflora not fully established.

Their immune system is activated and the gut wall becomes inflamed – reducing nutrient absorption and increasing the risk of infection. The gastrointestinal tract (GIT) of all animals is a key site in the prevention of infection.

SCFAs are known to have a positive impact on broiler digestive health, including stimulation of digestive enzyme production, enhanced development of intestinal villi, reduction of acute inflammatory responses and optimised GIT retention time.

SCFAs, butyrate in particular, is an important energy source for cells of the colon.

It has recently been shown to enhance synthesis of endogenous antimicrobial host defence peptides, which are critical components of the animal's innate immunity.

In vitro experiments

In order to characterise NSP fractions in wheat following treatment, wheat was incubated both with and without a carbohydrase complex (Rovabio, Adisseo).

The water-soluble fractions were then isolated using an extraction procedure. These were further fractionated into ethanol-soluble and ethanol-insoluble fractions.

In terms of chemical composition, both fractions contained mainly xylose and arabinose; with the enzyme treated fraction containing significantly more protein (Table 1). It is thought that a more complete breakdown of NSP results in increased nutrient availability and reduced 'cage effect'.

Importantly, the average degree of polymerisation of the xylan backbone was significantly lower in the enzyme treated wheat; the molecu-

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lar weight and intrinsic viscosity were also reduced. The enzymes thus reduced the size of the polymers present in wheat and produced short-chain arabinoxylans.

In vivo trial

To evaluate the effect of the enzyme treatment on the gut health of broilers, a pen study was carried out.

Day-old broiler chicks were fed one of three diets for 14 days and performance measured. Diets containing the enzyme treated wheat fraction (Rovabio), the untreated fraction (Positive Control) and a non-supplemented diet (Negative Control), were fed.

Feeding the enzyme treated fraction increased both body weight and feed intake, with FCR unaffected by treatment (Table 2).

The mucosa of the ileum and caecum in birds fed the enzyme treated fraction were shown to have less T-cells, than in those fed the negative and positive control diets.

This implies that the effects of the enzyme treatment on the gut microflora and SCFA production resulted in less inflammation of the mucosa.

This effect was echoed in the level of T-cell infiltration, which was significantly lower in birds fed the enzyme treated wheat fraction (Table 3).

This further suggests that these birds had better gut integrity and hence a stronger intestinal barrier.

An assessment of the ileal microbiota revealed that in those birds fed the enzyme treated wheat fraction there were significantly greater numbers of Enterococcaceae and Clostridiaceae species of bacteria (Table 4).

It also showed an increase of Enterococcus durans, which has a probiotic effect as well as antimicrobial and antioxidant activities and Candidatus arthromitus which is a commensal bacterium, helping to develop gut immune functions.

In the caecum more lachnospiraceae and ruminococcaceae bacteria were found. These bacterial species are able to metabolise poly- and oligosaccharides into SCFA.

This effect was confirmed by a significant increase in acetate and butyrate production in the caecum of birds fed the enzyme treated wheat (Table 5).

It was concluded that the enzyme treated wheat fraction provided more substrate for beneficial gut bacteria. They in turn produced more SCFA enhancing the function of the epithelial cells.

The researchers also hypothesised that a butyrate-associated reduction in inflammation, may have contributed to the increase in feed intake – effects that together improved weight gain.

Conclusions

The treatment of wheat grains with a carbohydrase complex resulted in a distinct short-chain arabinoxylan fraction.

	NC (%)	PC (%)	Rovabio (%)
Enterobacteriacea	2	2	1
Erysipelotrichaceae	2	2	1
Ruminococcaceae*	9	8	12
Lachnospiraceae*	43	46	52
Clostridiaceae 1	0	0	0
Lactobacillaceae	40	38	29
Enterococcaceae	1	1	1
Bacteroidaceae	1	1	3
Coriobacteriaceae	1	1	0

Table 4. Caecal microbiota composition. The caecal microbiota of treatment group has significantly higher levels of key beneficial bacteria (* = P<0.01).

Lower molecular weights, a lower degree of polymerisation and a higher protein level, were observed.

Both broiler performance and gut microflora were improved. The greater number of beneficial bacteria in turn produced a higher quantity of SCFA, butyrate, in particular. Both inflammation and T-lymphocyte infiltration were reduced, all adding up to a measurable improvement in gut health.

The effect of better microbial diversity in young broiler chicks will help gut development, optimising future performance.

Good intestinal health is important to the performance and overall health of poultry, particularly with the challenges faced by high performing animals reared without the use of antibiotics. Gut health status is a result of interactions between intestinal integrity and a balanced gut microflora. Therefore, feed additives that can support these areas will have a positive effect on health and performance.

This new research has highlighted further the value of this carbohydrase complex to poultry production. ■

References are available from the author on request

Table 3. T-cell infiltration in ileum and caecum. The significant reduction in T-cell infiltration in the treatment group suggests greater gut integrity.

Parameters		NC	PC	Rovabio
T-cells	Ileum	$16.1^{b}\pm1.1$	$15.9^{b}\pm0.6$	$8.1^{a}\pm0.6$
Labelled area (%)	Caecum	$16.8^{b}\pm0.9$	$15.7^{b}\pm0.7$	$7.0^{a}\pm0.6$

Table 5. Caecal concentration of lactic acid and short chain fatty acids. The carbohydrase complex treated fraction significantly increased acetate and butyrate production in the caecum (* = P<0.01).

	NC	PC	Rovabio
Lactic acid (mM/g)	2.99	2.49	3.65
Butyric acid (mM/g)	6.26	5.26	10.7
Propionic acid* (mM/g)	0.77	1.1	2
Acetic acid* (mM/g)	32.28	30.59	49.74