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Rethink carbohydrases, product development effect in monogastrics

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DEVELOPMENTAL progress in science depends on the construction and deconstruction of hypotheses and applies to all scientific fields, including animal science.

One hypothesis recently called into question is what is responsible for the performance effect of carbohydrases in monogastric animals. This has always been explained by three hypotheses:

1. Reduction of viscosity in the gastrointestinal (GI) tract;
2. Provision of prebiotics, and
3. Reduction of the cell wall effect.

Although broadly accepted in the scientific community, these hypotheses have scarcely been proved in research. The most controversial is that carbohydrases open the cell wall of ingredients and allow endogenous enzymes to hydrolyze the nutrients inside, which are otherwise trapped and excreted through the feces.

The two major pieces of evidence to support this are reports showing the greater degree of cell wall opening in the small intestine of broilers (Bedford and Audio, 1996) and pigs (Torrallardona, 2000) and *in vitro* tests showing that when cereal samples are incubated with carbohydrases, there is a hydrolysis process of the cell wall (Parkkonen, 1997; Le, 2013; Ravn, 2017).

Besides that, there is only, to our knowledge, one report evaluating the cell wall effect *in vivo* (Khadem, 2016).

Results showing the destruction of the cell wall obtained *in vitro* with the inclusion of carbohydrases have been achieved by including between 10 and 50 times higher than commercial doses used by the feed industry (Parkkonen, 1997; Le, 2013; Ravn, 2017) and with the assay performed in an optimal environment for the enzyme activity.

What is not replicated is the GI tract of animals, where factors such as the presence of other nutrients and minerals, pH variation, microbiota and temperature fluctuation affect enzyme activity.

Even so, the time to observe any effect on the destruction of the cell wall *in vitro* is around two to three hours, while *in vivo* results report cell wall destruction as early as the jejunum using a relative pure mono-component xylanase (Bedford, 2018).

Possibly the most comprehensive trial evaluating the cell wall effect *in vivo* was conducted by Khadem (2016). Broilers were offered diets produced with regular corn or previously frozen corn in which the cell wall had been physically opened by the freezing process, with or without the inclusion of a xylanase product.

Xylanase showed effects related to a prebiotic-like product, such as a change in the microbiota profile in cecal contents, an increase in jejunum villus height and increases in the glycemia and triglyceride concentration at 34 days, while frozen corn showed higher glycemia.

Animal performance was only reported by phase and showed an improvement in feed conversion between 27 and 39 days; the feed conversion ratio was lower in frozen corn without xylanase than normal corn without xylanase.

When overall performance was calculated based on intake and gain (Figure), animals fed frozen corn and without xylanase had a heavier weight and lower feed conversion, while animals fed regu-

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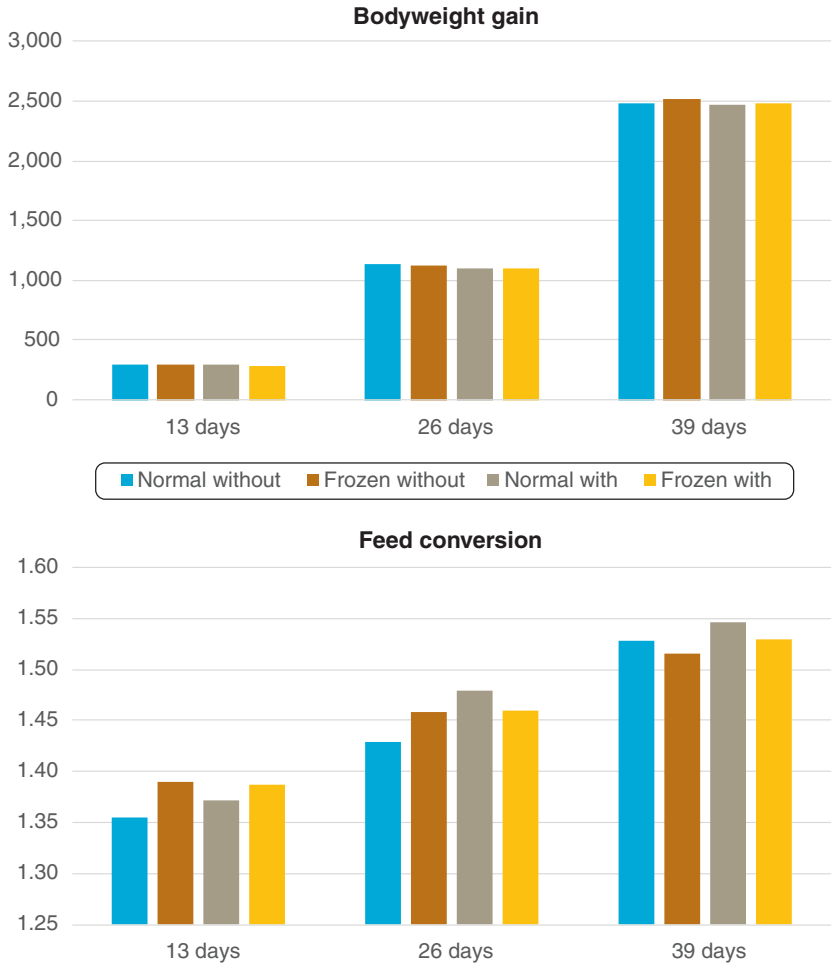
Bodyweight gain (top) and feed conversion (bottom) of broilers fed regular or frozen corn with or without inclusion of a xylanase product



Source: Adapted from Khadem (2016).

lar corn with xylanase were at a lower weight and the worst feed conversion, although a statistical analysis was not possible.

Results of this *in vivo* trial would reinforce the effect of xylanases as prebiotic-like, with the lack of response when corn is frozen bringing into question whether or not xylanases act directly on the cell wall and if opening the cell wall and reducing the cage effect is at all an important process to improve animal performance. For instance:

- If carbohydrases have an effect on opening cell walls as reported *in vitro*, this means the cell wall would be open — making nutrients available to be digested and absorbed — only in two to three hours, when the digesta is already at the end of the digestive tract and where nutrient absorption is already reduced.
- Ingredients commonly used in monogastric feed formulation with intact cells to be disrupted are cereals (corn and wheat). High-protein ingredients such as soybean meal already have the cell walls disrupted during oil extraction or biodiesel production, and animal byproducts do not have such structure.

If the cell wall effect was real, the effect of improvement in nutrients would be associated with the composition of cereals. Cereal intracellular content is composed of high concentrations of starch, which is already highly digestible, and the improvement in nutrient absorption when carbohydrases are added in diets is correlated to the nutrient concentration of the diet as a whole (Cowieson and Bedford, 2009), supporting the idea that the cell wall effect is not a primary effect of the carbohydrase activity.

- If the effect of carbohydrase comes from the cell wall opening and an improvement in digestibility, one would expect to see the effects of its use more prominently in animals where the GI tract is less developed, with the effect decreasing over time as the animal naturally improves its ability to digest nutrients.

This is not what is usually seen in carbohydrase research, however, except where viscosity is playing a big role in the response. The effect of the use of carbohydrase becomes more pronounced as the animal ages and naturally increases its ability to digest nutrients (Rosen, 2002).

The lack of supporting data that carbohydrases act by opening cell walls present in the digesta does not represent that this effect is not observed *in vivo*, only that carbohydrases do not directly hydrolyze and open the cell wall, reducing the cage effect.

Researchers have shown that the improvement of fiber fermentation in the lower GI tract affects the production of gut hormones that modulate the transit of the digesta in the GI tract (Singh, 2012; Lee, 2017).

The increase in the opening of cell walls observed in trials may not be the consequence of the direct action of carbohydrases on the cell wall but more so the enzymes stimulating fermentation in the lower gut (Cowieson and Masey O'Neill, 2013). This stimulates the retention of digesta in the upper gut, therefore increasing the cell wall opening and the overall digestibility of the whole diet (Masey O'Neill, 2014).

It supports the idea that the effects found *in vivo* relate to not only the number of open cells found in the lower gut but also to the improvement of digestibility being more in line with the digestibility of the whole diet (not only of the nutrient concentration inside the cell wall) and the latter effect as the development of the fiber fermentation in the lower gut is associated with the maturation of the microbiome in the lower gut.

The understanding that carbohydrases do not directly open cell walls in the GI tract has an impact on how these products are used. This calls into a question the logic that a carbohydrase product needs to have a plethora of different enzyme activities to completely hydrolyze the complex matrix of the cell wall and reduce the "cage effect."

Instead, this highlights the need for a product to steer the capacity of the hindgut to ferment the fiber present in the diet, simultaneously calling into question the need to monitor and evaluate the effect of carbohydrases through the improvement of fiber digestibility, which is routinely done at the end of the small intestine.

The effect of carbohydrases in diets for monogastrics would be more related to the stimulation of a microbiome in the lower gut (Tapingkae, 2008) that could use and ferment fiber as a source of energy, bringing positive benefits to gut health and animal performance.

References

The list of references may be obtained by contacting nam@abvista.com. ■