Xylanase: special xylanase by CJ BIO

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INTRODUCTION

Background

Pig and poultry feeds are based primarily on cereal grains such as corn/maize, wheat, sorghum and vegetable protein meals which are required to meet most of the energy and protein requirements. In addition, these grains have also been used in bio-fuel production for many years. Diverting these conventional feedstuffs to ethanol production results in an increase in the price of the raw ingredients internationally. Therefore, it has become important to find ways to use cheaper alternative feedstuffs such as DDGS, corn gluten feed, palm kernel meal, sunflower meal and wheat bran in order to deal with increasing feed costs and to develop sustainable animal production. However, such feed materials contain high amounts of anti-nutritional factors (ANF) which could negatively affect growth performance, feed efficiency, and gut health in poultry and pig. Due to the ANF including non-starch polysaccharides (NSP), the use of these alternative feedstuffs as feed materials is limited (Raza et al., 2019; Teymouri et al., 2018; Al-Harthi, 2017; Waititu et al., 2018).

Understanding of seed grains and their NSP content

A whole grain kernel or seed is composed of three parts: bran, endosperm, and germ. The bran is the outer shell that protects the seed and has a thick cell wall. The endosperm contains a lot of energy sources and the germ plays an important role in providing nourishment to the seed.
The cell wall is the protective and semi-permeable outer layer of a plant cell and is composed of cellulose, hemicellulose (xylan, arabinoxylan, β-glucan, β-mannan, etc.) and pectins (Fig. 1). The composition of NSP may vary depending on the type of plant tissues and grains.

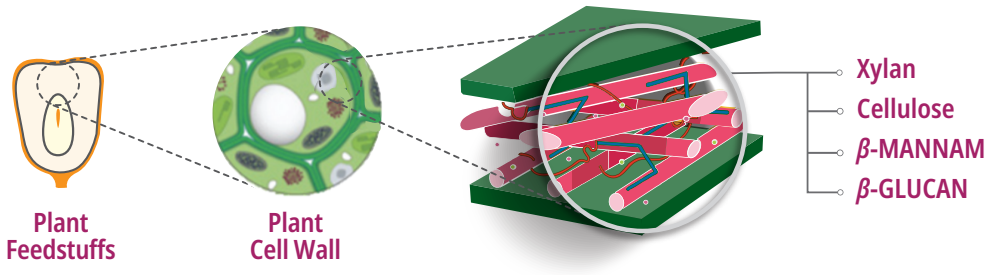

Figure 1. The schematic diagram of plant cell wall and NSP
(Adopted from Merriam-Webster Inc. 2006; Meng et al., 2016; Loix et al., 2017)

Negative effects of arabinoxylan

Arabinoxylan is a polysaccharide composed of β-1,4-linked xylose units with side branches of arabinose. Among the many types of hetero-xylans, arabinoxylan is most abundant in major plant feedstuffs. Its composition accounts for 8-30% (DM basis) of typical feed grains, and is reaching up to 5.9-8.1% and 3.1-4.8% DM basis in wheat and corn, respectively (Jaworski et al., 2015; Pedersen et al., 2014; Englyst, 1989; Knudsen, 1997). Also, arabinoxylan has been found in all major cereal grains including wheat, rye, barley,

sorghum, as well as in DDGS and in other co-products. Arabinoxylan acts as ANFs, causing negative effects on growth performance by giving rise to digesta viscosity, detrimental impacts on gut health, and cage effect in a monogastric digestive system (Bach Knudsen, 2014; Anderson and Simsek, 2018).

1. Increase of digesta viscosity

After ingestion of feeds, NSP including arabinoxylan absorb water, swell and consequently become highly viscous. Therefore, arabinoxylan entraps feed particles in the small intestine. The soluble NSP cause higher viscosity than insoluble NSP and the degree of solubility is directly proportional to the degree of branching of arabinoxylan molecules (Choct and Annison, 1992; Montagne et al., 2003; Annison, 1993; Chen at al., 2020).

2. Detrimental change to gut microflora

Diets abundant in arabinoxylan enable animals to retain their digesta for a long time in stomach and intestine, which causes proliferation of selective microbiota and pathogens such as *Escherichia coli* and *Clostridium perfringens* (Fig. 2). It can be detrimental to growth of animals since the entire community and proportion of bacteria is important in gut health, rather than the presence or absence of a single species (Xiao et al., 2016; Sergeant et al., 2014; Yadav et al., 2019).

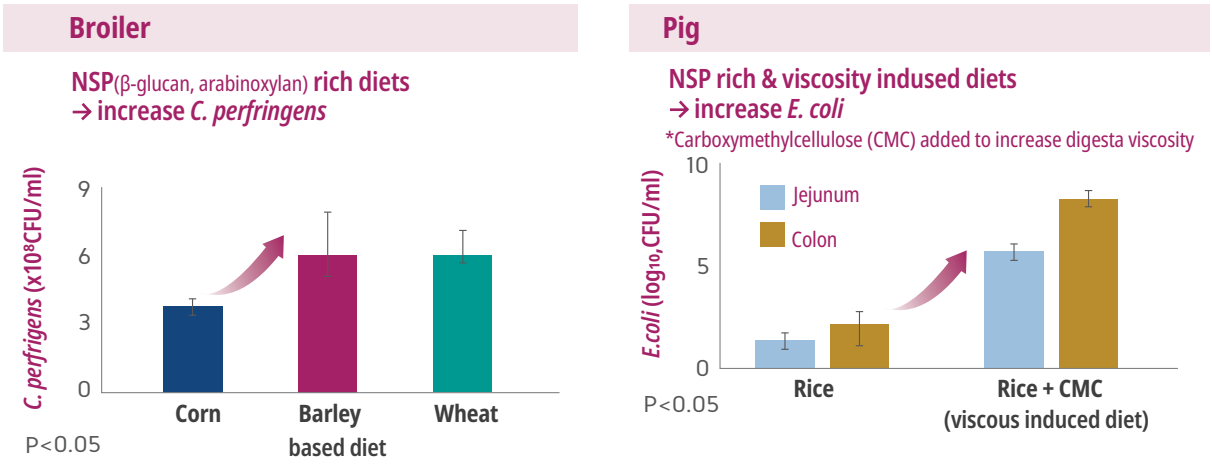

Figure 2. NSP rich diets increase *C. perfringens* and *E. coli* in broiler and pig.
(Adopted from Annett et al., 2002; Hopewood et al., 2002)

3. Cage effect

Arabinoxylan functions as a 'fence' to encapsulate nutrients in the cell lumen, which is frequently called the 'cage effect'. Cell walls protect the cell contents such as protein, phytate, lipid, and starch. Thus, These valuable energy sources cannot be completely utilized (Meng et al., 2005; Grundy et al., 2018).

Xylanase

Xylanase (endo-1, 4-β-xylanase) cleaves the glycosidic bonds in the xylan backbone and produces xylo-oligomers. The cleavage site is selected based on the chain length, the degree of branching, and the presence of substituents.
Xylanase can reduce water-holding capacity and digesta viscosity of arabinoxylan by shortening the transit time of viscous digesta in the intestinal lumen. Therefore, xylanase increases feed intake in monogastrics. Also, xylanase hydrolyzes arabinoxylan to xylooligosaccharides (XOS) and arabinoxylooligosaccharides (AXOS) which act as favorable prebiotics to beneficial microbiota (Fig. 3). Thus, the growth of beneficial bacteria is promoted and the growth of harmful bacteria (pathogens) is reduced. Lastly, xylanase can soften the 'cage effect' and release nutrients, such as protein, phytate, and starch, for utilization by endogenous digestive enzymes results in an improvement in bio-availability of the nutrients (Dotsenko et al., 2017).

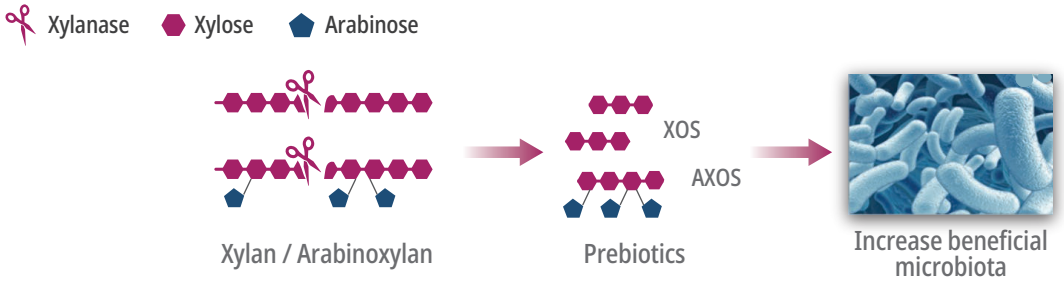

Figure 3. Prebiotics effects of xylanase.

Why 'CJ BIO Xylanase' so special?

Xylanase produced by CJ BIO is a high quality feed enzyme in terms of stability, activity, and resistace to inhibitors.
First of all, feed enzymes need to be thermostable to survive pelleting and pellet conditioning, where temperatures of 75°C to 85°C are reached for 1.5 to 3 min. Xylanase produced by CJ BIO is intrinsically thermostable up to 85°C without coating so that it is not inactivated under pelleting conditions. Thanks to the non-coated form, it begins to act rapidly once being ingested.
Secondly, feed enzymes should be stable and highly active in a physiological pH (pH 2.2 – 7.0). Xylanase produced by CJ BIO is super stable throughout the gastrointestinal tract pH (pH 2.2 - 5.5) and has high efficacy at intestinal pH (pH 5.5 – 7.0) where typically digesta viscosity increases in diets high in NSP.

Lastly, feed xylanase must be resistant to the xylanase inhibitors; TAXI (*Triticum aestivum** xylanase inhibitor), XIP (Wheat xylanase inhibitor protein), TLXI (Thaumatin-like xylanase inhibitor), and TAXI- and XIP-like inhibitors. The presence of xylanase inhibitors in wheat was first found at the end of 1990s and gradually reveals the presence in barley, rye and maize. The xylanase inhibitors can specifically affect microbial xylanase, but have no effect on endogenous xylanases produced by plants. Thus, presence of the inhibitor in cereals is a defensive response of plants to a pathogenic attack by microorganisms. Since most of the commercial exogenous xylanases are derived from fungi and bacteria, the enzymatic activity can be impaired by endogenous xylanase inhibitors in grains (Gusakov, 2010). Xylanase produced by CJ BIO has been developed to be protected against xylanase inhibitors because of an extra loop in its structure. The loop in the xylanase prevents the inhibitors from accessing the active site of CJ BIO xylanase (B) while other xylanases (A) allow the xylanase inhibitor blocking the active site (Fig. 4).

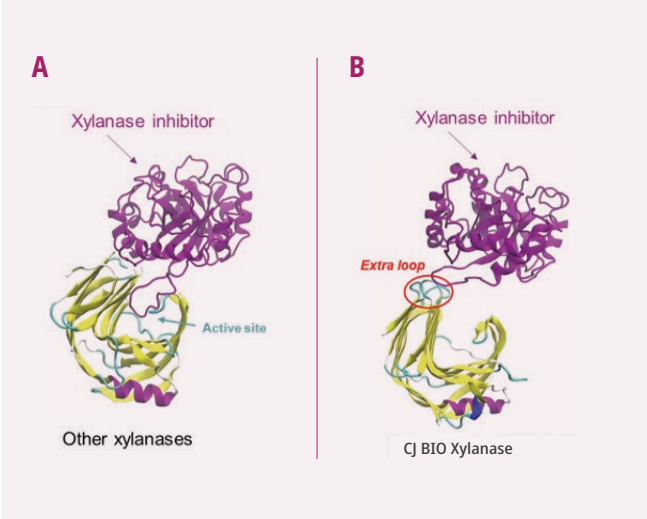

Figure 4. Comparison of inhibition by a xylanase inhibitor.

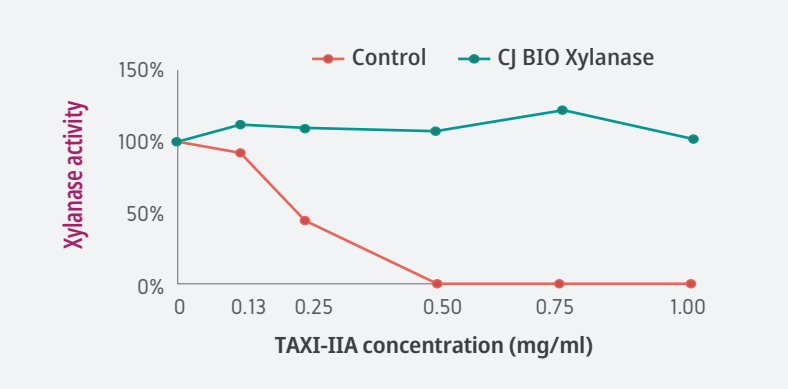

Figure 5. Xylanase activity against xylanase inhibitor.

The figure 5 shows CJ BIO xylanase is not inhibited by TAXI-IIA and retains a high activity despite of the presence of an inhibitor. On the other hand, other xylanases, as control, are markedly inhibited as inhibitor dose increases (Fig. 5).

Conclusion

The negative effects of xylans found in feedstuffs on animal growth have been significantly proven over decades. Therefore, it is essential to select an efficient xylanase.
CJ BIO Xylanase is thermostable and has a high activity under physiological condition. Moreover, CJ BIO xylanase is not inhibited by the xylanase inhibitors which are typically found in the feed cereals. CJ BIO provides a new solution to the industry which does not have the limitation of other xylanases on the market.

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