Use of enzymes in pig breeding. A Review

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Abstract

The use of exogenous enzymes gives producers a greater opportunity to use different feed components in pig mixtures. In weaned pigs, amylase, protease and lipase activity is limited and changes in the degree of digestibility of added enzymes can improve productivity and reduce the cases of intestinal disorders caused by undigested nutrients.

The practice of feeding pigs on farms in Europe is to include a more diverse group of feeds in the mix than in North America, where maize-soy mixtures are mainly used. This implies that the addition of mixtures of cellulases, hemicellulases and proteases, can improve the digestibility of complex carbohydrates and proteins from the more diverse cereals included. However, the use of various enzyme complexes is controversial in this respect. The main reason is the activity and type of enzymes, dosage and route of administration, age of the animals and their level of productivity. This requires preliminary testing of some enzyme additives with insufficiently proven results in terms of productivity.

Key words: pigs, nutrition, enzymes

The use of exogenous enzymes in animal husbandry dates back to the mid-1920s. Nowadays, science has developed and uses molecular methods that provide new opportunities for efficient utilization of feed (Salem et al., 2013).

Poultry is currently the largest consumer of feed enzymes. There is also increased interest in pig farming, livestock breeding and aquaculture, especially at critical stages of animal development (Plumstead, 2013).

Due to their immature digestive system, growing pigs have a particular benefit from the use of exogenous enzymes in compound feed. On the other hand, the search for alternatives to protein sources, together with the concept of low digestibility and the presence of anti-nutritional factors in these feeds, leads to increased interest in exogenous enzymes and the application of scientific developments for their optimal use.

The aim of the study was to review the used enzymes and enzyme combinations in pig breeding and their effects on productive traits in animals.

Influence of feed added exogenous enzymes on pig productivity

Feed enzymes mainly help by changing the profile of feed components, to improve the efficiency of meat productivity in pig farming. Enzymes are mainly used when ration components contain relatively high levels of fiber (Bedford, 2000). Certain types of fiber in pig rations are not well digested and as a result large portions of fiber pass intact through the small intestine and digest only those that are subject to fermentation by bacteria in the caecum and large intestine (Asmare, 2014). The effectiveness of exogenous enzymes is variable and depends on different factors such as age of the animals and the type of ration (Bedford, 2000). The application of exogenous enzymes allows producers to use different types of components in pig feeds.

Another area for the use of feed enzymes in formulas for growing pigs is the period when the level of production of endogenous enzymes in young organisms is still limited. In early weaned pigs, amylase, protease and lipase activity is limited and changes in the degree of digestibility of added enzymes can improve productivity and reduce the cases of intestinal disorders caused by undigested nutrients (Asmare, 2014).

Carbohydrate and protease enzymes

Carbohydrases improve the digestibility of carbohydrates in feed, which increases the amount of energy that animals use for muscle development and growth. Types of carbohydrases include amylase, which breaks down starch into fructose, maltose, glucose and other common sugars, and xylanase, which breaks down carbohydrates found in crude fiber.

A number of authors (Choct and Annison, 1992; Grala et al., 1998; Choct et al., 1999; Willamil et al., 2012; Passos and Kim, 2014) have reported that non-starch polysaccharides (NSP) increase intestinal endogenous nitrogen losses, disrupt the intestinal microflora, increase the viscosity of intestinal contents, all of which cause lower nutrient digestibility. In recent years, there has been a growing interest in the use of NSP-degrading enzymes, which improves nutrient digestibility (Choct and Annison, 1992; Choct et al., 2010). The main NSP in maize and maize-soy mixtures are arabinoxylans (Choct and Annison, 1992; Knudsen, 1997; Ward et al., 2008).

Passos and Kim (2014) found that the addition of xylanase at a dose of 1400 LXU/kg altered the digestibility of nitrogen-free extracts NFE in maize-soy rations in fattened pigs.

The studies of Zanotto et al. (2010) reported that the combination of xylanase and amylase improved digestibility and metabolic energy in maize by 2.8 and 2.9%, respectively, while the addition of amylase alone did not affect digestibility.

The addition of xylanase also improves the digestibility of high-wheat rations in growing pigs (Nortey et al., 2007; Woyengo et al., 2008).

Therefore, all of these studies are evidence that xylanase can improve feed digestibility by degrading arabinoxylans in the cell wall (Passos and Kim, 2014).

Cellulase (endo-1,4-b-glucanase) catalyzes the breakdown of cellulose and grain b-D-glucans. Corn and soybean meal have a lower glucan and cellulose content than barley and oats (Knudsen, 1997). Therefore, the scientific interest of scientists in studying the effect of glucanase added to corn-oat rations is fully explained.

Flis et al. (2005) reported that the inclusion of 97% hulled oats and the addition of β-glucanase in formulas for growing pigs improved energy digestibility.

The inclusion of amylase in maize-soy mixtures improved growth by 9% and improved feed utilization by 4% in birds (Gracia et al., 2003), but did not affect nutrient productivity and digestibility in fattened pigs (Jo et al., 2012).

Arabinoxylans are the major NSPs in maize (Knudsen, 1997; Ward et al., 2008) and in maize-soybean mixtures, with a content of about 3%. The negative effect of arabinoxylans on nutrient digestibility has been described even earlier by Choct and Annison (1992).

The results of the studies of the individual authors are difficult to compare due to the large variation of non-starch polysaccharides and the use of different types of enzymes in pig nutrition. The data from the studies are not one-way and do not have a clear determining effect of the addition of carbohydrases in the rations with a higher content of NSP. There have been reports of a positive effect of enzymes added to NSP mixtures in cereals (Cabogan et al., 2003), while other reports have not reported improvements in growth (Mavromichalls et al., 2000; Woyengo et al., 2008). The differences in the results of the individual authors are due to the use of different feeds, the age of the animals, the type and dosage of the enzymes used. In our study (Nedeva and Kanev, 2011) we found that the addition of the enzyme preparation Hostazym suis in compound feed with included 5% alfalfa flour unreliably improves the growth rate and yield of feed by about 7% in adolescent pigs, while in another (Nedeva and Kanev, 2012), with fattened pigs, we found that the addition of the enzyme preparation Hostazym suis in the combined feed with included 5% alfalfa flour did not have a statistically significant effect on the intensity of growth and utilization of feed.

The studies of some authors indicate an omnidirectional, and in some cases even a lack of positive effects from the use of a certain enzyme preparation. Olukosi et al. (2014) reported an improvement in growth intensity in weaned pigs with a live weight of 10 kg, but not in pigs with a live weight of 23 kg, due to added carbohydrates and phytase. While in the studies of Jo et al. (2015), using a complex enzyme preparation (containing α-amylase, b-mannanase and protease) an improvement in the productivity of fattened pigs was observed.

Energy digestibility in pigs mainly decreases with increasing feed intake (Nortey et al., 2008).

Passos and Kim (2014), in a review of the effect of enzymes on pig nutrition, focused on the use of maize and soybean meal as the main feed for pig farming in the United States. Maize contains 9.7% non-starch polysaccharides (Knudsen, 1997) and 0.21% phytate phosphorus (NRC, 2012). Soybean meal contains about 48% crude protein and has an apparent ileal protein digestibility of 82% (NRC, 2012), making it an important component in pig rations. It also contains 21.7% non-starch polysaccharides (Knudsen, 1997) and 0.38% phytate phosphorus (NRC, 2012).

The degradation of indigestible components in pig mixtures in order to provide economic benefits in pig production has been the subject of research by a number of authors (Pettey et al., 2002; Kim et al., 2003; Kim et al., 2006; Ji et al., 2008; Li et al., 2010; Wang et al., 2011 a; Wang et al., 2011 b; Jo et al., 2012; Almeida and Stein, 2012), because pigs did not secrete digestive enzymes that break down non-starch polysaccharides (Lindemann et al., 1986; Huguet et al., 2006). In their studies, Anguita et al. (2006) and Gutierrez et al. (2013) reported that NSPs can be broken down mainly to volatile fatty acids as a source of energy in the colon, and their use is limited to 18% of digestible energy. This necessitates studies using polymeric carbohydrates in pig nutrition (Nortey et al., 2007; Woyengo et al., 2008; Cozanet et al., 2012).

Proteases degrade proteins into peptides and amino acids, and recent studies have shown that the addition of protease can improve the digestibility of protein and amino acids (Guggenbuhl et al., 2012; Mc Alpine et al., 2012 b). These data indicate that there is a possibility to increase the digestibility of the protein by adding exogenous protease and thus, to increase the efficiency of nutrition.

For the first time, the protease enzyme in pig nutrition was studied by Cunningham and Brisson (1957), and the authors found no improvement in productivity.

Petersen et al. (2012) found activity of various protease preparations at pH between 5.5 and 7.0, and Glitso et al. (2012) found that the effectiveness of adding protease to mixtures depends on maintaining a low pH in the stomach and the ability to degrade soybean meal as the main source of protein in pig mixtures.

Some enzymes and their effects on the organism are shown in Table 1.

Finnfeeds et al. (1992) reported the productive results of 25 experiments performed on growing pigs with the added enzyme prepara-

Table 1. Enzymes and their influence

Enzyme type	Decomposes	Effects
Amylase	Starch	Improves gain and feed conversion rate
Xylanase	Crude Fibers	Nutrient digestibility
Cellulose	Cellulose	Energy and fiber digestibility
Protease	Complex carbohydrates and protein	Protein and amino acids digestibility
Phytase	Phytin	Increases the absorption of available phosphorus and improves productivity

tion Porzyme in mixtures with a high content of barley. The results indicate that Porzyme increased live weight and feed utilization by 5–6%. The inclusion of this product also made it possible to replace processed cereals in mixtures with unprocessed ones. And the effect of added Porzyme SP in 128 weaned pigs showed a higher average daily increase of 11.4% and better feed utilization by 7.3%.

The addition of 0.1% Porzyme enzyme preparation to the mixtures (20.0–15.5% protein, 1.0–0.8% lysine and 13.7 MJ/kg digestible energy) 33–41% barley and 33–41% wheat, gave rise to a tendency to improve the growth intensity and utilization of feed by 5–8%, compared to the same mixtures, but without enzyme preparation, in the feeding of growing crossbred pigs (R1) from the two-breed hybrid "Shumen" from 31-days of age (5.5–6.4 kg) to 91–94 days (32–35 kg live weight). Barley-wheat mixtures with the addition of an enzyme preparation are biologically equal to the mixtures with 38–41% maize content, but without enzyme preparation, statistically proven to be inferior in growth by 6–10% and the utilization of feed by 6–12%. The enzyme preparation had a positive effect on the reduction of digestive disorders. The use of Porzyme in maize-free mixtures improves economic results. (Nedeva, 2016).

The studies of Park et al. (2020) indicate that the addition of protease to low-protein mixtures improved growth, nutrient digestibility, and intestinal morphology (villi length) in weaned pigs.

The practice of feeding pigs on farms in Europe is to include a more diverse group of feeds in the mix than in North America, where maize-soy mixes are mainly fed. This implies the addition of mixtures of cellulases, hemicellulases and proteases to improve the digestibility of complex carbohydrates and proteins from the more diverse cereals included. However, the use of various enzyme complexes is controversial in this respect. The main reason is the activity and type of enzymes, dosage and route of administration, age of animals and their level of productivity. In our country, phytase is successfully used in compound feeds for separate pig categories, for the decomposition of phytic phosphorus in the grain components and enzyme combinations for wheat and barley mixtures. The inclusion of additional enzymes and enzyme combinations does not always have good efficiency providing better productivity.

This requires preliminary testing of some enzyme additives with insufficiently proven results in terms of productivity.

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