Canadian Alternatives for Dietary Antibiotics as Growth Promotants

Martin Nyachoti and Hossain Manik

Department of Animal Science, University of Manitoba, Winnipeg, Manitoba, R3T 2N2
Email: martin_nyachoti@umanitoba.ca

Introduction

Feeding and management programs relying on the use of in-feed antibiotics have played a major role in the growth and development of the livestock industry in general and the swine industry in particular for many years. However, for various reasons including increased risks to human health, there is a concerted effort by industry and government to reduce and/or eliminate the use of antibiotics as growth promoters in pork production. Consequently, there has been an increased global interest in identifying alternatives to in-feed antibiotics that can allow the swine industry to maintain the same level of production efficiency. There is a plethora of products that are marketed as alternatives to antibiotics in many countries, including Canada, with varying degree of efficaciousness. In this presentation, the focus is on those that have been developed in Canada or that have been extensively tested in Canada. Nutritional strategies that are geared towards supporting a healthy gut in piglets fed antibiotic-free diets are also discussed.

Canadian alternatives to AGP in swine production

As indicated above there are many products registered in Canada that claim to modulate gut health in swine. Within the context of this review, products that have been developed in Canada or extensively studied in Canada are covered. The following is a list of Canadian alternatives to AGP that are discussed:

- Egg yolk antibodies
- Raw potato starch
- Pre- and probiotics
- Organic acids
- Feed enzymes
- Lysozyme
- Plant extracts (Phytogenics)
- Use of low crude protein diets

Egg yolk antibodies: generally referred to as IgY

Egg yolk antibodies (EYA) have been available to the swine industry in Canada as a means of controlling post-weaning diarrhea in weaned pigs for almost two decades. As EYA are produced in response to a specific antigen, they tend to be very specific in terms of the pathogen they act against. Available products have been shown to be quite effective against *Escherichia coli* K88, the pathogen responsible for much of the diarrhea disease in piglets (Fairbrother et al., 2005). For example, in a study with 10-day old piglets, EYA supplementation was shown to support similar performance, reduce incidences of diarrhea and mortality to the same extent as did an antibiotic. Supplementing piglet diets with anti-*E. coli* EYA may prevent the pathogen from attaching itself to and damaging the gut mucosa,

thus ensuring normal gut barrier functions (Kiarie et al., 2008), or may act by agglutinating bacteria thus preventing them from causing a disease. In addition to the EYA against *E. coli*, products against other pathogens such as Salmonella and Rotavirus have been developed but effectiveness in studies with pigs has not been well established (Marquardt et al., 1999; Mathew et al., 2009).

Some of the variability seen in the effectiveness of EYA may be related to such factors as 1) low gut pH, which has been shown to inactivate EYA, and 2) breakdown due to pepsin digestion. However, it is possible that these challenges can be overcome by such protective techniques as microencapsulation.

Prebiotics and probiotics

Prebiotics are defined as a non-digestible food ingredient and /or carbohydrates that beneficially affect the host by selectively stimulating the growth and/or activity of one or a limited number of bacteria in the colon. Probiotics on the other hand are single or mixed cultures of live nonpathogenic microbial feed supplements which beneficially affect the host animal by improving its microbial balance. Lactic acid bacteria and bifidobacteria are the best candidates for use as probiotic cultures. These additives have been shown to have beneficial effects on growth performance, nutrient digestibility, immunity, intestinal, fecal microbiota and diarrhea score in pigs (Heo et al., 2013). Based on results of 20 recent trials, including those carried out in different Canada institutes, prebiotic and probiotic supplementation increased average daily gain and feed efficiency of pigs by 7.46 and 2.80 and 5.46 and 4.86%, respectively.

Raw potato starch

Resistant starch, a category to which raw potato starch (RPS) belongs, refers to starch plus its digestion products that are not absorbed in the small intestine and pass to the large bowel and beneficially modify gut microbial populations. A study by Bhandari et al. (2009) demonstrated that that dietary inclusion of raw potato starch at 7% was as effective in controlling diarrhea in weaned piglets as a control diet with an antibiotic. Similarly, piglets fed a control diet with antibiotic or 7% RPS had improved feed efficiency to the same extent. In a follow up study, supplementing piglet diet with RPS at 0.5 and/or 1.0% delivered in capsules reduced toxic microbial metabolites in the piglet intestines and the incidence of diarrhea. Taken together, these studies support the potential utility of RPS as an alternative to antibiotics in piglet diets to control post-weaning diarrhea.

Feed Enzymes

Enzymes are biologically active proteins that break specific chemical bonds to release nutrients for further digestion, absorption and metabolism. The use of feed enzymes in swine diets is extensive, primarily to increase nutrient and energy utilization. However, recent studies have provided evidence to support the idea that feed enzymes may play a role as part of the overall nutritional strategy for raising pigs without the use of in-feed antibiotics. This evidence relates to the fact that carbohydrate-digesting enzymes may break down complex fibre components in the diet into small fibre components that could function as prebiotics. Indeed, a series of experiments done at the University of Manitoba showed that these enzyme breakdown products are able to maintain gut barrier

function in the presence of an *E. coli* infection (Kiarie et al., 2008). Furthermore, feed enzymes may eliminate dietary compounds with antinutritional factors thus eliminating their potential to interfere with nutrient utilization and/or cause damage to the gut mucosa. These effects contribute to robust piglets that are able to grow fast and efficiently.

Lysozyme: A naturally occurring enzyme

Lysozyme is an enzyme that is naturally present in bodily secretions, such as saliva and milk, and is known to act as an antimicrobial agent by destroying bacterial cell walls, leading to cell death. In a study by Nyachoti et al. (2012) dietary supplementation with lysozyme was shown for prevent *E. coli* infection in piglets and to stimulate the immune system. Others have since reported beneficial effects of dietary lysozyme supplementation in piglet diets in promoting indicators of gut health and suppressing populations of pathogenic bacteria in the gut (Wells et al., 2015). Based on these findings, and if cost-effective, it seems that lysozyme is an effective alternative to antibiotics for maintaining a healthy gut and therefore production efficiency in an antibiotic-free feeding regimen.

Phytogenics

Phytogenic feed additives are commonly defined as plant-derived compounds incorporated into farm animal feeds, such as herbs and/or herb extracts, plant extracts, spices and essential oils (Windisch et al., 2008). They have beneficial effects on farm animals, including improvement of growth parameters, immunity and gut microbial balance in swine primarily due to the high contents of

antioxidants (Windisch et al., 2008). In Canada, the use of plant extracts to control diarrhea has not been extensive. Nonetheless, there are plants with medicinal properties that might play a role in the development of the overall nutritional strategy that does not include in-feed antibiotics. Limited studies have evaluated fenugreek seed extracts and red osier dogwood, both of which are grown in Canada, with promising results (Isaak et al., 2013; Hossain et al., 2015).

Organic acids

Organic acids are considered to be any weak acids with at least one carboxylic group and a carbon chain with one to seven carbon atoms. The most common organic acids that are used in farm animal feed are formic, acetic, propionic, butyric, lactic, sorbic, fumaric, tartaric, citric, benzoic and malic. Organic acids, used individually or in combination, are well accepted as an alternatives to antibiotics as growth promoters in swine as they have been repeatedly shown to inhibit gut infections while improving the population of beneficial bacteria, nutrient digestibility and growth performance (Heo et al., 2013).

Yeast-based nucleotides

Dietary nucleotides supplementation may be beneficial during periods of rapid growth, stress, or limited nutritional supply, such as at weaning. Nucleotides have been associated with beneficial effects such as minimizing morphological changes in intestinal tissues, growth promotion of beneficial gut microflora, reducing incidence of post-weaning diarrhea, immune system modulation, and improving growth performance (Superchi et al., 2012). Nucleotide rich yeast

extracts are available in Canada as a source of nucleotides and available data generally support their utility in mitigating gut health and nutrient utilization in pigs (Waititu et al., 2016).

Conclusions

There are many products available in Canada with potential to modulate gut health and function in pigs. Many of these products, including egg yolk antibodies, organic acids, pre- and probiotics, and raw potato starch are commonly used as alternatives to antibiotics in Canada and elsewhere in the world. Other products with potential to be used as part of the solution to the withdrawal of in-feed antibiotics include feed enzymes, nucleotides, lysozyme, and plant extracts with medicinal benefits. Use of these products individually and/or in combination coupled with dietary formulation strategies will offer producers useful tools to improve gut health and animal performance without reliance on in-feed antibiotics.

References

Bhandari, S. K., C. M. Nyachoti, and D. O. Krause. 2009. Raw potato starch in weaned pig diets and its influence on postweaning scours and the molecular microbial ecology of the digestive tract. J. Anim. Sci. 87:984–993.

Fairbrother, J. M., E. Nadeau, C. L. Gyles. 2005: *Escherichia coli* in postweaning diarrhea in pigs: an update on bacterial types, pathogenesis, and prevention strategies. Anim. Health Res. Rev. 6: 17–39.

Hossain, M. M., M. Begum, C. M. Nyachoti, J. D. Hancock, and I. H. Kim. 2015. Dietary fenugreek seed extract improves performance, and reduces fecal *E. coli* counts, and fecal gas emission in lactating sows and suckling piglets. Can. J. Anim. Sci. 95:561-568.

Isaak, C. K., J. C. O. K. Petkau, K. Ominski, J. C. Rodriguez-Lecompte, and Y. L. Siow. 2013. Seasonal variations in phenolic compounds and antioxidant capacity of Cornus stolonifera plant material: applications in agriculture. Can. J. Anim. Sci. 93:725-734.

Kiarie, E., D. O. Krause, and C. M. Nyachoti. 2008. Net fluid and electrolyte losses in enterotoxigenic Escherichia coli infected piglet small intestine upon perfusion with fumaric acid, zinc oxide, egg yolk antibodies or carbadox. Can. J. Anim. Sci. 88:485-488.

Marquardt, R. R., L. Z. Jin, J. W. Kim, L. Fang, A. A. Frohlich, and S. K. Baidoo. 1999. Passive protective effect of egg-yolk antibodies against enterotoxigenic *Esherichia coli* K88+ infection in neonatal and early-weaned piglets. FEMS Immunol. Med. Microbiol. 23:283–288.

Nyachoti,C. M., E. Kiarie, S. K. Bhandari, G. Zhang, and D. O. Krause. 2012. Weaned pig responses to *Escherichia coli* K88 oral challenge when receiving a lysozyme supplement. J. Anim. Sci. 90:252–260.

Owusu-Asiedu, A., S. K. Baidoo, C. M. Nyachoti, and R. R. Marquardt. 2002. Response of early-weaned pigs to spray-dried porcine or animal plasma-based diets supplemented with egg-yolk antibodies against enterotoxigenic *Escherichia coli.* J. Anim. Sci. 80:2895–2903.

Superchi, P., R. Saleri, P. Borghetti, E. De Angelis, L. Ferrari, V. Cavalli, P. Amicucci, M. C. Ossiprandi, and A. Sabbioni. 2012. Effects of dietary nucleotide supplementation on growth performance and hormonal and immune responses of piglets. Animal. 6: 902–908.

Waititu, S. M., J. M. Heo, R. Patterson, and C. M. Nyachoti. 2016. Dietary yeast-based nucleotides as an alternative to in-feed antibiotics in promoting growth performance and nutrient utilization in weaned pigs. Can. J. Anim. Sci. 96:289-293.

Wells, J. E., E. D. Berry, N. Kalchayanand, L. A. Rempel, M. Kim, and W. T. Oliver. 2015. Effect of lysozyme or antibiotics on faecal zoonotic pathogens in nursery pigs. J. Appl. Microbiol. 118:1489–97.

Windisch, W., K. Schedle, C. Plitzner, and A. Kroismayr. 2008. Use of phytogenic products as feed additives for swine and poultry. J. Anim. Sci. 86:140-148.