Project number: 6671

Funding source: EU FP7 / Teagasc

Date: May 2019

Project dates: **Jan- 2015 to Feb- 2019**

Examination of feed Enzymes as a means of improving feed efficiency in pigs

Key external stakeholders:

Pig producers, animal nutritionists, agricultural advisors, feed mills, agricultural consultants, DAFM, researchers.

Practical implications for stakeholders:

Feed enzyme supplementation to growing pig diets should be considered to help improve feed efficiency and thereby reduce the feed cost per kg weight gain.

1. **Weaned pigs:** Phytase supplementation should be the norm, as it consistently improves piglet growth, phosphorus digestibility and bone mineralization. The growth and nutrient digestibility response to xylanase and β-glucanase is inconsistent. Mannanase and/or protease should be included in multi-enzyme complexes to ensure consistent improvements in growth and nutrient digestibility.
2. **Finisher pigs:** Mannanase and multi-enzyme complexes increase growth and feed efficiency. Xylanase or xylanase + β-glucanase supplementation do not consistently improve feed efficiency. Mannanase should be supplemented to maize-based diets, while a multi-enzyme complex should be supplemented to maize-, wheat-, barley- and co-product-based diets. Protease supplementation to field bean- and barley-based diets improves feed efficiency.
3. **Inconsistency in response to carbohydrases:** Xylanase + β-glucanase supplementation can increase nutrient digestibility but do not always improve pig growth or feed efficiency. It is likely that the lack of consistency between digestibility and growth/feed efficiency data is mediated by changes in feed and intestinal microbial profiles when liquid feeding is practiced.

Main results:

Dietary supplementation with exogenous feed enzymes can reduce feed cost per kg carcass by improving feed efficiency in pigs. However, it is essential that the enzyme selected is correctly matched to the substrate present in the diet. A meta-analysis found that multi-enzyme complexes most consistently improved feed efficiency in pigs. The response to dietary carbohydrase (xylanase and β-glucanase) inclusion in liquid diets was found to be inconsistent and this inconsistency can, at least in part, be explained by the effect of the carbohydrases on feed and intestinal microbiota. The feed efficiency of grow-finisher pigs fed field bean- and barley-based diets was improved when protease was supplemented to the diet. Additionally, our meta-analysis found that mannanase increased feed efficiency with maize-based diets. More work on the latter two enzymes needs to be conducted in an Irish context.

Opportunity / Benefit:

In this project we found that improvements in feed conversion efficiency (FCE) when protease was used ranged from 0.07 to 0.10 of an FCE unit (€1.65 - €2.36/pig), while the response to carbohydrase enzymes ranged from 0 to 0.10 (€0 - €2.36/pig) of an FCE unit. Choosing the correct enzyme for the available substrate in a particular diet will likely improve FCE and is an effective means of significantly reducing feed cost per kg carcass.

Project team: Dr. Peadar G. Lawlor (Project Leader)
Dr. Alberto Torres Pitarch
Dr. Edgar Garcia Manzanilla

Collaborators: Dr. John V. O' Doherty, School Of Agriculture & Food Science,

Contact Dr. Peadar Lawlor Email: peadar.lawlor@teagasc.ie

University College Dublin
Dr. Gillian E. Gardiner, Department of Science, Waterford Institute of Technology

1. Project background:

Feed represents ~70% of the cost of producing a kg of pigmeat and volatility in the ingredients market means that this cost has fluctuated hugely in recent years. To reduce feed costs the pig industry must avail of alternative ingredients and by-products as well as making greater use of conventional ingredients. Pig diets are primarily comprised of ingredients of vegetable origin. Unlike ruminants, pigs lack the enzymes needed to break down fibre and therefore, cannot efficiently digest dietary components that are high in fibre. Dietary supplementation with non-starch polysaccharide-degrading enzymes (e.g. ß-glucanase and xylanase) could potentially improve nutrient availability from fibrous ingredients. Furthermore, supplementing diets with proteases could increase protein digestion as well as providing other benefits such as inactivating anti-nutritional factors. Feed enzymes offer the possibility to make greater use of common ingredients and may allow more widespread use of alternative feed ingredients and by-products (e.g. dried distillers' grains with solubles - DDGS).

2. Questions addressed by the project:

- Determine the effects of exogenous enzyme supplementation to post-weaning and grow-finisher pig diets using a meta-analysis approach
- Determine the effect of phytase, carbohydrase and protease when included in co-product-based diet on in-vitro ileal digestibility, growth and bone mineral density of grower-finisher pigs
- Determine the effect of soaking the cereal component of diets with or without enzyme supplementation on intestinal microbiota and feed efficiency in grow-finisher pigs
- Determine the effect of fermentation of the cereal component of diets with or without enzyme supplementation on intestinal microbiota and feed efficiency in grow-finisher pigs
- Determine the effect of protease and α-galactosidase in barley- and field bean-based diets on growth and feed efficiency in grow-finisher pigs

3. The experimental studies:

The overall objective of this project was to explore feed enzymes as a nutritional strategy to improve feed efficiency in pigs.

Meta-analysis (weaned pigs): The objective of the systematic review and meta-analysis in weaned pigs was to determine which exogenous enzymes are most consistent in improving digestibility and growth in the piglet, when supplemented to post-weaning diets. A secondary objective was to examine enzymes, which have shown an inconsistent effect, and to attempt to determine the reasons for the inconsistency in effect associated with their use.

Meta-analysis (finisher pigs): The objective of the systematic review and meta-analysis in finisher pigs was to determine which exogenous enzymes are most consistent in improving feed efficiency in grower-finisher pigs and with which cereal source. It was hypothesized that the type of enzyme supplemented, and the cereal source used in the diet during supplementation would influence the nutrient digestibility, growth and feed efficiency response to in-feed enzyme supplementation.

Enzyme supplementation to co-product based diets: The objective was to determine the effect of phytase, the complex of xylanase and β-glucanase (XB) and protease when included in a wheat-DDGS and rapeseed meal (RSM)-based diet on the in-vitro ileal digestibility, growth performance and bone mineral density of grower-finisher pigs. We hypothesized that XB, protease, phytase and their combinations would improve the in-vitro ileal digestibility of feed as well as pig growth and feed efficiency. We further hypothesised that protease would reduce the response to phytase and therefore reduce the bone mineral density of pigs fed a diet limiting in phoshphorus and calcium content.

Soaking the cereal component of diets and enzyme supplementation: Cereal soaking and xylanase and β-glucanase (XB) supplementation may release substrates for use by microbes present in liquid feed as well as by those in the gastrointestinal tract of the pig. It was therefore hypothesized that these strategies would favourably modulate the intestinal microbiota and as a consequence improve growth and feed efficiency. The objective was to determine the impact of both strategies on the bacterial composition of the feed, nutrient digestibility, pig growth, feed efficiency, intestinal volatile fatty acid (VFA) production and intestinal microbiota composition. To determine which microbial taxa utilize the substrates released by the cereal soaking and XB most efficiently, correlations between growth

Contact Dr. Peadar Lawlor Email: peadar.lawlor@teagasc.ie

parameters, intestinal VFA concentrations and the relative abundance of microbial taxa were investigated.

Fermenting the cereal component of diets and enzyme supplementation: We hypothesised that feeding fermented cereal, with or without xylanase and β-glucanase (XB) supplementation, to grow-finishing pigs would favourably modulate the intestinal microbiota and consequently improve growth and feed efficiency. The objective was to determine the impact of both strategies on the bacterial composition of the feed, nutrient digestibility, pig growth, feed efficiency, intestinal VFA production and intestinal microbiota composition. To help identify the microbial taxa that utilize the substrates released by cereal fermentation and XB most efficiently, correlations between growth parameters, intestinal VFA concentrations and the relative abundance of microbial taxa were investigated.

Protease and α-galactosidase in barley and field bean-based diets: The objective here was to determine the effect of protease and α-galactosidase supplementation to barley- and field bean-based diets on growth and carcass quality in grow-finisher pigs. The experiment was a 2x2 factorial arrangement. The factors were: 1) Protease supplementation (No, Yes) and 2) α-galactosidase supplementation (No, Yes).

4. Main results:

- **Meta-analysis (weaned pigs)**: The most consistent improvement in piglet growth, phosphorus digestibility and bone mineralisation were found due to exogenous phytase supplementation. Supplementation with xylanase alone or in combination with β-glucanase had inconsistent effects on piglet growth and nutrient digestibility. The most consistent improvements in growth and nutrient digestibility due to supplementation with multi-enzyme complexes were found when mannanase and/or protease were included in the complex of enzymes. There is a need for more experiments to determine the response to protease and mannanase when supplemented alone. Factors such as particle size, nutrient density of the diet and feed form can influence the response to enzyme supplementation in post-weaning diets. In the future it will be important to predict, with greater accuracy, the response to enzyme addition to the diet. In this regard, enzyme specific meta-analyses where the factors listed above are included as explanatory variables in the model will likely be useful.

- **Meta-analysis (Finisher pigs):** Dietary supplementation with mannanase, and multi-enzyme complexes increased growth and feed efficiency in grower-finisher pigs. Despite the improvements found in nutrient digestibility in response to xylanase or xylanase + β-glucanase supplementation, they did not improve feed efficiency in grower-finisher pigs. The response to enzyme supplementation is influenced by the main cereal source used in the diet formulation. Dietary supplementation with mannanase increased feed efficiency with maize-based diets and dietary supplementation with multi-enzyme complexes improved feed efficiency when maize-, wheat-, barley- and co-product-based diets were fed to grower-finisher pigs.

- **Enzyme supplementation to co-product based diets:** Growth and feed efficiency of grower-finisher pigs fed a wheat-DDGS- and RSM-based diet did not improve due to supplementation with phytase, XB and protease, despite improvements in in-vitro ileal digestibility of the diet being observed. Protease addition to a phytase-supplemented diet did not affect bone mineralisation, growth, feed efficiency and carcass quality, indicating that the efficacy of phytase is not reduced when supplemented in combination with protease. Growth and feed efficiency did not improve due to supplementation with phytase, carbohydrases and proteases.

- **Soaking the cereal component of diets and enzyme supplementation:** Evidence of spontaneous fermentation of liquid feed in pen troughs was observed. Despite this, minimal degradation of dietary amino acids resulted. Soaking the cereal fraction of the diet improved pig growth during the early grow-finisher period but not thereafter. Enzyme supplementation increased total tract nutrient digestibility and reduced caecal VFA concentrations but did not improve pig growth or feed efficiency. Cereal soaking and enzyme supplementation modulated the intestinal microbiota composition of liquid-fed pigs; however, our data shows that both strategies promoted the abundance of bacterial taxa negatively correlated with pig growth and reduced the abundance of taxa positively correlated with pig growth and butyrate concentration in the caecum. This may help to explain the lack of consistency observed between nutrient digestibility and pig growth results when feed enzymes are supplemented to liquid-fed pigs.

Contact Dr. Peadar Lawlor Email: peadar.lawlor@teagasc.ie

- **Fermenting the cereal component of diets and enzyme supplementation:** Cereal fermentation increased DM, OM, CP, and GE total tract nutrient digestibility and pig growth, while exogenous enzyme supplementation increased DM, OM, CP and GE ileal, and total tract digestibility resulting in improved feed efficiency. Both strategies appeared to have beneficially modulated the intestinal microbial profile in the ileum and caecum of pigs. Bacterial taxa that were positively correlated with pig growth had higher abundance in pigs fed the enzyme-supplemented diets (i.e. *Lactobacillus kisonensis, Roseburia faecis*), whereas most of the bacterial taxa that were negatively correlated with growth had a lower relative abundance in pigs fed the cereal-fermented diets.

- **Protease and α-galactosidase in barley- and field bean-based diets:** Protease supplementation improved the feed efficiency of grow-finisher pigs fed field bean- and barley-based diets, whereas α-galactosidase supplementation did not improve growth or feed efficiency. Supplementation with these enzymes had no effect on carcass quality of pigs.

5. Opportunity/Benefit:

Improving feed conversion efficiency in finisher pigs by 0.10 between 30 and 110kg liveweight will save 8kg of feed. At a price of €295/tonne this feed saved is worth €2.36/ pig. In this project we found that improvements in FCE when protease was used ranged from 0.07 to 0.10, while the response to carbohydrase enzymes ranged from 0-0.1 of an FCE unit. Choosing the correct enzyme for the available substrate in a particular diet will likely improve FCE and is an effective means of significantly reducing feed cost per kg carcass.

6. Dissemination:

The work conducted in this project has been successfully disseminated to stakeholders, via scientific publications, oral and poster presentations at research dissemination days, ECO-FCE project meetings, Presentations at Eurotier trade fair and national and international conferences as well as one PhD thesis.

- European Federation of Animal Science, (2016, 2017)
- International Pig Veterinary Society (IPVS) & European Pig Health Meeting (ESPHM) (2016), Dublin
- Teagasc Pig Farmers' Research Dissemination Day (2016, 2017, 2018), Horse and Jockey and Cavan.
- American Society of Animal Science, Mid-West Section (2017)
- British Society of Animal Science (2017, 2018)
- Teagasc Walsh Fellowship Seminar (2018)
- Digestive Physiology in Pigs (2018), Brisbane Australia.
- Eurotier (2016), Hannover, Germany
- Teagasc Farmer Discussion Groups (2016,2017,2018)

Only 3 main publications here

1. Torres-Pitarch, A., D. Hermans, E.G. Manzanilla, J. Bindelle, N. Everaert, Y. Beckers, D. Torrallardona, G. Bruggeman, G. E. Gardiner, and P. G. Lawlor (2017). Effect of feed enzymes on digestibility and growth in weaned pigs: A systematic review and meta-analysis. Animal Feed Science and Technology 233: 45-159.
2. Torres-Pitarch A., U.M. McCormack, V.E. Beattie, E. Magowan, G.E. Gardiner, A.M. Pérez-Vendrell, D. Torrallardona, J.V. O'Doherty, P.G. Lawlor (2018). Effect of phytase, carbohydrase, and protease addition to a wheat DDGS and rapeseed-based diet on in-vitro ileal digestibility, growth and bone mineral density of growing-finishing pigs. Livestock Science, 216: 94-99.
3. Torres-Pitarch A. E.G. Manzanilla, G.G. Gardiner, J.V. O'Doherty, P.G. Lawlor (2019). Systematic review and meta-analysis of the effect of feed enzymes on growth and nutrient digestibility in grow-finisher pigs: effect of enzyme type and cereal source. Animal Feed Science and Technology, 251:153-165

Popular publications:

https://www.feednavigator.com/Article/2019/04/01/Enzymes-and-feed-efficiency-in-pigs

7. Compiled by: Dr. Peadar Lawlor

Contact Dr. Peadar Lawlor Email: peadar.lawlor@teagasc.ie