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Testing the safety of genetically modified (GM) feed ingredients in pigs

Key external stakeholders:

EU Commission, farmers, feed compounders, EFSA, FSAI, consumers, policymakers, agricultural advisers

Practical implications for stakeholders:

The main outcomes of this study are:

- Bt MON810 did not have harmful effects on growth, intestinal health or organ function of pigs.
- Bacteria within the digestive systems of pigs are tolerant of the GM maize.
- The *cry1Ab* gene as well as the protein itself did not migrate from the digestive tract and the gene was broken down as it progressed through the digestive tract.
- Feeding GM maize to pigs of different ages and for extended periods of time is as safe as its conventional counterpart with respect to potential effects on animal health.
- In a 30 day feeding study using weaned pigs, GM α-amylase inhibitor (αAI) peas were as safe as their conventional counterpart with respect to potential effects on animal health.
- Multiple conventional comparators should be used during safety assessment of GM ingredients.

Main results:

GM maize did not have harmful effects on growth, intestinal health or organ function of pigs. Bacteria within the digestive systems of pigs are tolerant of the GM maize. In addition, the *cry1Ab* gene, as well as the protein itself, was shown not to migrate from the digestive tract and the gene was broken down as it progressed through the digestive tract. It was concluded that feeding GM maize to pigs of different ages and for extended periods of time is as safe as its conventional counterpart with respect to potential effects on animal health. Furthermore, our results did not reveal any reason for concern regarding the safety of the αAI peas tested. The latter experiment highlights the need to include multiple conventional comparators of the same feed ingredient during safety assessment.

Opportunity / Benefit:

It was concluded that feeding Bt MON810 maize to pigs of different ages and for extended periods of time is as safe as its conventional counterpart with respect to potential effects on animal health. In addition, our results did not reveal any cause for concern regarding the safety of the αAI peas tested. These results can better inform all stakeholders regarding the safety of GM feed ingredients.

Collaborating Institutions:

WIT, UCD, Ireland; MUW, Austria; CSIRO, Australia; NVH, Norway; CFRI, Hungary.

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1. Project background:

Teagasc was a partner in the EU GMSAFOOD project whose principle objective was to determine the safety of GM food/feed ingredients. The consortium focused its work on Bt (MON810) maize and αAI peas, both of which were bred for their insect-resistant properties and grown in Spain. The work conducted by the consortium included:

• The production of αAI peas (CSIRO, Australia)
• Long-, medium- and short-term pig feeding studies (Teagasc, Ireland)
• Salmon feeding studies (NVH, Norway)
• Human immune response to potential allergens in GM peas using human-SCID mice (MUW, Austria)
• Food chain studies in which rats were fed pork and fish that had been raised on Bt maize (NVH, Norway)
• Epitope mapping and antibody determinations (CFRI, Hungary)

2. Questions addressed by the project:

- Is the growth performance and/or health of pigs affected following long-, medium- and short-term consumption of Bt (MON810) maize?
- Is the growth performance and/or health of pigs affected following short-term consumption of αAI peas?
- Is there an inflammatory or allergic-type immune response to the transgenic protein?
- Is the gastrointestinal microflora affected by consumption of the GM feed ingredients?
- What is the fate of the *cry1Ab* gene and the Cry1Ab protein once consumed?
- Will inclusion of multiple comparators (conventional varieties) to the GM ingredient being tested, in animal feeding studies, enable improved interpretation of the data obtained?

3. The experimental studies:

1. Bt (MON810) maize

Weaned pigs were fed diets containing non-GM or GM (Bt MON810) maize for 31 or 110 days. A trans-generational experiment was also conducted, whereby pregnant sows were fed non-GM or GM maize diets with the progeny of both groups being fed non-GM or GM maize diets to commercial slaughter weight. These experiments investigated the effects of GM maize on growth performance, intestinal histology, immune response, intestinal microbiology and organ weight and function. Analyses were also performed to determine if the gene encoding the protein responsible for the genetic modification of the maize, or the protein itself, migrated from the animal's digestive tract.

2. α-amylase (αAI) inhibitor peas

In a 31-day experiment weaned pigs were fed diets containing:

• Non-GM commercial field peas (*Pisum sativum* L.)
• Non-GM parent line peas (*Pisum sativum* L.)
• GM peas (*Pisum sativum* L.) expressing αAI-1 from the common bean (*Phaseolus vulgaris*).

This experiment investigated the effects of the αAI peas on pig growth, blood haematology, organ weight and function.

4. Main results:

1. Bt (MON810) maize

The main results from this work include:

• Feed intake, growth rate and feed conversion efficiency of pigs were not adversely affected when pigs were

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fed GM maize.
• As an indicator of toxicity, the effect of GM maize consumption on the structure and function of the liver, heart, kidneys and spleen of the pigs was determined. Organ pathology and organ function were similar for pigs fed GM or non-GM maize.
• There was no adverse effect of feeding GM maize on small intestinal morphology.
• Comparison of the immune response of pigs fed GM maize or non-GM maize failed to reveal differences of biological importance. Antibodies specific to the GM maize protein (Cry1Ab) were not detected in the pigs' blood, indicating the absence of an allergic-type immune response to the protein.
• In addition to conventional culturing techniques, gene sequencing was used to determine if feeding GM maize influenced the bacterial profile within the digestive tract. Counts of selected culturable bacteria were unaffected by feeding GM maize. High-throughput gene sequencing revealed that GM maize consumption had only minimal impact on microbial community structure in the caeca of pigs, resulting in statistically significant differences in abundance of only 2 of 39 bacterial families and 3 of 54 genera detected. Furthermore, the taxa affected were detected at low abundance and frequency and their role within the intestine is not fully understood. Therefore, the differences observed are not believed to be of major biological importance and in addition, were not associated with any adverse health effects.
• Neither the *cry1Ab* gene nor the Cry1Ab protein was found in the blood, organs or muscle of pigs fed the GM maize. These findings indicate that the gene or protein did not migrate from the digestive system of the animal into other body tissues. Our results also indicate that the cry1Ab gene was broken down as it moved through the digestive system, being found in the stomach contents but not in the colon. As anticipated, fragments of the Cry1Ab protein were found throughout the gastrointestinal tract.

2. α-amylase inhibitor peas
Feed intake, growth rate and feed conversion efficiency of pigs were similar regardless of treatment. Likewise, there was no difference in the weight of the heart, kidneys, liver or spleen between treatments and evidence of pathology was absent from the organs of pigs fed all of the pea treatments. Differences were observed in haemoglobin concentration and hematocrit between treatments; however, the differences were only found between pigs fed the non-GM parent pea diet and pigs fed the other two pea treatments with no difference between the non-GM commercial field pea and the GM pea being found. Differences in mean platelet volume were also found between treatments; however, the GM pea was not different to the non-GM parent counterpart but was different to the non-GM commercial field pea. These results highlight the importance of correctly interpreting data on GM ingredients. Even a comparison between two conventional varieties of any feed ingredient is likely to yield differences in some parameters of interest. Therefore, it is important that feeding trials investigating the safety of GM ingredients should also include a comparison to conventional varieties of the same feed ingredient.

5. Opportunity/Benefit:

The study concluded that feeding Bt MON810 maize to pigs of different ages and for extended periods of time was as safe as its conventional counterpart with respect to potential effects on animal health. In addition, our results did not reveal any cause for concern regarding the safety of the αAI peas tested. These results can better inform all stakeholders regarding the safety of GM feed ingredients. In addition the results indicate that a comparison to a number of conventional varieties of the same feed ingredient should be included in future feeding trials investigating the safety of GM ingredients to enable better interpretation of the data obtained.

6. Dissemination:

Twelve peer reviewed publications resulted from this work. The results of this project were widely disseminated. A final project conference was held in the Medical University of Vienna on March 6-8, 2012 http://www.gmsafoodproject.eu/Sections.aspx?section=463
The talks from this conference and the press conference were videoed and are available at http://www.youtube.com/user/GMSAFOOD Results of the project were presented at the Teagasc pig farmers conferences, European Federation of Animal Science Annual Conference, American Society of Animal Science Annual Meeting, Society for Feed Technologists Pigs Conference, Agricultural Research Forum and Symposium on Digestive Physiology in Pigs.

Main publications:

Buzoianu, S.G., Walsh, M.C., Rea, M.C., Cassidy, J.P., Ryan, T.P., Ross, R.P., Gardiner G.E., and Lawlor P.G. (2013). Trans-generational effects of feeding genetically modified maize to nulliparous sows and offspring on offspring growth and health. Journal of Animal Science 91: 318-330.
Walsh, M.C., Buzoianu, S.G. Gardiner, G.E. Rea, M.C., O'Donovan, O., Ross, R.P., and Lawlor, P.G. (2013).

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Effects of feeding Bt MON810 maize to sows during first gestation and lactation on maternal and offspring health indicators. British Journal of Nutrition 109: 873-881.
Buzoianu, S.G., Walsh, M.C., Rea, M.C., O'Donovan, O., Gelencsér, E., Ujhelyi, G., Szabó, E., Nagy, A., Ross, R.P., Gardiner, G.E., and Lawlor, P.G. (2012). Effects of feeding Bt maize to sows during gestation and lactation on maternal and offspring immunity and fate of transgenic material. PLoS ONE 7(10): e47851.

Popular publications:

Lawlor, P.G. (2008). GM feed ingredients. In: Proceedings Teagasc, Pig Farmers Conferences. October 20th-22nd 2008, Cavan, Kilkenny and Fermoy, p. 10-20.
Lawlor, P. G. and Walsh, M. (2009). The GM debate and the Irish pig meat sector. T-Research 4(4): 26-27.
Lawlor, P.G. (2008). GM feed ingredients. In: Proceedings Teagasc, Pig Farmers Conferences. October 20th-22nd 2008, Cavan, Kilkenny and Fermoy, p. 10-20.
Buzoianu, S.G., Walsh, M.C., Gardiner, G.E., O'Sullivan, L., Rea, M.C., and Lawlor, P.G. (2011). Investigating transfer of genes from genetically modified maize to the pig intestinal microbiota: one of the steps in determining the safety of GM feed. Society for Feed Technologists Pigs Conference, Coventry, UK, November 10th 2011.
Lawlor, P.G., Walsh, M.C., Buzoianu, S.G., Rea, M.C., Ross, R.P. and Gardiner, G.E. (2012). Short, medium and long-term studies of pigs fed GMOs. GMSAFOOD Conference - Genetically Modified Organisms Safety & Post market Monitoring, Medical University of Vienna, Austria, March 6th – 8th 2012.
Lawlor, P.G., Walsh, M.C., Buzoianu, S.G., Rea, M.C., Ross, R.P. and Gardiner, G.E. (2013). Testing the safety of genetically modified (GM) feed ingredients in pigs. T-Research Volume 8(1):36-37.

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