

Institution: Nottingham Trent University
Unit of Assessment: C17 Geography, Environmental Studies and Archaeology
Title of case study: Reduced environmental impact from meat poultry production through improved nutrition.
<p>1. Summary of the impact (indicative maximum 100 words)</p> <p>Three specific projects have addressed issues of resource utilisation and pollution related to poultry production. The novel form of silicon developed by the Poultry Research Unit (PRU) has been taken into the product portfolio of a FTSE100 company, AB Agri [Associated British Agriculture PLC] as a feed supplement to reduce poultry lameness. There are approximately 48 billion meat chickens produced globally every year but high incidence of lameness leads to economic loss and avoidable environmental pollution. In conjunction with AB Agri, PRU also produced evidence-based research resulting in a patent for recovering yeast from bioethanol production. The process is now being implemented by AB Agri to produce high-quality protein for poultry feed alongside bioethanol production to reduce the carbon footprint of both bioethanol and poultry meat production.</p>
<p>2. Underpinning research (indicative maximum 500 words)</p> <p>The NTU Poultry Research Unit established by Burton in 2007 works closely with both small and large stakeholders in the UK poultry industry to reduce the resources required by the poultry sector, and also to reduce the pollution resulting from poultry manure. This is achieved via two main research avenues: firstly improving usage of dietary minerals by poultry and secondly by evaluating plant-based by-products as feed materials.</p> <p>Perry initiated fundamental work¹ at NTU developing a novel form of silicon which Burton subsequently developed into a major body of research. The Silicon Project (2009-present) examined the biological role of silicon in reducing production efficiency losses through lameness in poultry^A and created a bioavailable form of the mineral suitable for feeding poultry^E which was patented by NTU (PCT/GB2009/00768). Burton designed poultry trials^{F,H} to quantify the bioavailability of the novel form of silicon and demonstrated high bioavailability across all dietary inclusion levels (200-1000ppm) and high efficacy in reducing lameness at 1000ppm.</p> <p>The Bioethanol Project (2009-2012) contributed^B to a patent (WIPO no: WO/2010/109203) for a novel process for separating yeast from bioethanol co-product. Globally, 60 billion litres per year of bioethanol are produced by distilling and fermenting wheat and other agricultural feed stocks, which has led to concern the process will compete with food crops for limited farmland. Traditional bioethanol production results in a low value co-product, Dried Distillers Grains and Solubles (DDGS), which is likely to revert to a waste product likely to require incineration as existing markets for DDGS become saturated. The PRU Bioethanol Project has shown that yeast derived from the novel process may be a cost-competitive substitute for imported soya-based protein feed materials currently used in the diets of chickens bred for meat production². This work demonstrated how bio-refining can simultaneously provide fuel and food at a low carbon cost. Furthermore, PRU has also led a project quantifying the potential dietary phosphorus contribution of the novel bioethanol yeast co-product².</p> <p>Poultry production (currently 48 billion birds per annum) negatively affects the environment through draining global resources of inorganic phosphorus and simultaneously polluting through phosphorus in poultry manure. From 2009 to present, the PRU Phosphorus Project led by Burton investigated factors affecting the ability of poultry to utilise dietary minerals. The majority of phosphorus in poultry feed is in a form that cannot be absorbed from the digestive tract and is therefore excreted in manure. Phosphorus is essential for bone development, so approximately 85% of global pig and poultry feed manufacture involves addition of the enzyme phytase to make</p>

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dietary phosphorus available for bone development, and reduce the amount of phosphorus present in poultry manure. Therefore of key interest to the industry has been PRU research^{C,G} demonstrating the negative effects of excess dietary limestone on phytase efficacy³. PRU were commissioned^D to establish precisely the degree of dietary phosphorus utilisation by poultry and Burton showed phosphorus to be currently oversupplied in poultry feed. PRU have founded research in this area by identifying the optimum sampling bone for differing ages of poultry³.

3. References to the research (indicative maximum of six references)

¹Belton, D., Paine, G., Siddharth, P. V., and Perry, C.C. (2004). Towards an understanding of (bio)silicification: the role of amino acids and lysine oligomers in silicification. *J. Mater. Chem.*, 14:2231-2241.

The article has been cited 110 times and was published in a journal with an impact factor of 6.1.

²Burton, E.J., Scholey, D.V. and Williams, P.E.V. (2013). Use of cereal crops for food and fuel - Characterization of a novel bioethanol co-product for use in meat poultry diets. *Food and Energy Security* doi: 10.1002/fes3.30 [Epub ahead of print].

This article (containing data used in patent **WIPO no: WO/2010/109203**) was withheld from publication until 2013 to allow competitive advantage for ABAgri. Articles for this journal are independently peer-reviewed by three scientists representing at least two countries.

³Morgan, N.K., Walk, C., Bedford, M., Perry, C.C. and Burton, E.J. (2012.) Effect of dietary protein source on efficacy of phytase supplements to improve broiler leg health. *Recent advances in animal welfare science III*, 21st June 2012, York

This article was accepted for publication following peer-review. Morgan has been invited to peer-review in this field for Poultry Science (Impact Factor 1.7) based on the quality of this work.

Related funding:

^ABurton – *iNET – innovation Network , an East Midland industry-led funding source: Bioavailable Silicon Project* Aug '09 – Mar '10 East Midlands Development Agency £49,950

^BBurton - *Optimisation of bioethanol co-products* Jan '09 – July '12 EPSRC-KW Trident Case Award £113,000

^CBurton - *Effect of dietary Ca : P ratio on broiler performance* Jan '10 - Jan '11 ABVista £27,600

^DBurton - *Use of phosphorous in poultry diets* Oct '10 – May '11 BOCM Pauls £12,600

^EBurton - *Effect of bioavailable silica on bone strength in poultry* Aug '11 – Dec '11 ABVista £14,972

^FBurton – *Effect of carrier medium on bioavailability of silicon* Sep '11 – Mar '12 ABVista £15,000

^GBurton - *Determining the contribution of reactive phytate to poultry diets* Sept '10-Sept '14 ABVista £120,000

^HBurton - *Use of silicon in conjunction with phytase in poultry diets* Jun'13 to Apr 14 ABVista £26,835

3. Details of the impact (indicative maximum 750 words)

Impact of PRU research on the poultry industry has been:

- **Industry uptake** of a PRU-developed anti-lameness feed supplement (**Silicon Project**)
- Research leading to evidence resulting in a **bioethanol process patent (Bioethanol Project)**
- Industry **change in practice** resulting in improved efficacy of phytase (**Phosphorus Project**)

The **Silicon Project** resulted in the invention of a novel, non-toxic, highly bio-available silicon formulation for global distribution via an agreement in place between the NTU Poultry Research Unit (PRU), a NTU spin out company (Si Active¹) and ABVista, a global leader in the feed supplement sector. The most significant form of loss to the poultry is from leg abnormalities which can cause high rates of mortality and condemnation at processing plants. This leads to heavy

economic losses and also unnecessary environmental pollution through manure production of birds not then entering the food chain. The **Silicon Project** provides evidence of a beneficial role for silicon beyond avoidance of deficiency symptoms that can only be achieved through production of a bioavailable form of silicon feed supplement. Research by PRU resulted in **successful development of an efficacious supplement**. Impact is evidenced by the **formation of the spin out company**, Si Active, in 2009, which holds the patent to the bioavailable silica. As the third largest company in the global feed supplements sector (currently estimated to be worth USD 725 million), AB Vista provide a **pathway** for PRU research to increase efficiency of poultry production in the 50 countries where it currently sells poultry feed supplements. AB Vista have formally agreed an interest² in the project and continued investment in the **Silicon Project** (£56,870), evidencing industry confidence in the PRU-developed supplement.

£49,950 of **Silicon Project** funding contributed to the physical development of the Unit's Poultry Research Unit, thereby increasing the (currently scarce) UK poultry research capacity by supporting the establishment of a facility that can be accessed by industry. Since the construction of the Poultry Research Unit in 2009, it has been used as a contract research facility by both SMEs and multi-national companies working in the poultry mineral supplements sector, leading to changes in practice within the industry and facilitating smaller companies to find new markets, such as Rushcliffe Environmental³: *"The Nottingham Trent University Poultry Research Unit has produced research data that has allowed us to enter a new industry sector. The relationship has also given us expert consultancy, allowing insight into how we can market our new product."* AB Vista also made the following statement²: *"Your group has given up greater understanding of the mode of action behind some of our feed supplements which is essential for our success in the market. This work involved solving a considerable problem with an ELISA assay which had stalled research at several Universities around the world., which is a testament to the quality of the individuals involved."*

The **Bioethanol Project** used the expertise of Burton in developing and evaluating novel feed materials to optimize a co-product from bioethanol production for use in poultry diets. The scale of global bio-ethanol production has saturated the available market (cattle feed production) for the current, low value, co-product. Thus, creating a high nutrient quality product suitable for the larger poultry feed market was essential to prevent the co-product from reverting to a waste material requiring incineration. The research has changed the manufacturing process used by this company. This has resulted in the construction of the manufacturing plant. The addition of the **patented yeast separation technology**⁴ to the newly built Ensus UK Bioethanol Plant will lead to an estimated **40% reduction in energy usage**. The Plant uses 1.1 million tonnes of wheat a year so the new technology allows production of an estimated 180,000 tonnes of yeast protein. **This yeast protein reduces reliance on imported soya**, demonstrating significant impact on change of practice within the poultry industry and benefitting the UK poultry producers through reduced feed costs. This change in practice also reduces the environmental impact poultry production by reducing global proportion of land required for soya bean growth – which often requires destruction of tropical rain forest. Worldwide, bioethanol production will soon reach 100 billion litres giving the technology enormous significance worldwide. Additionally, Burton instigated a project quantifying the potential phosphorus contribution of new bioethanol yeast co-product – an aspect **overlooked by the industry until compelling evidence was provided by PRU**. ABAgri Business Development Manager for Biofuels commented⁴ *"It is has made me realise just how much the biofuel co-product R&D program has relied on the original work that we started with you at the University of Nottingham Trent...."*

The **Phosphorus Project** evolved in response to a poultry industry need for more accurate knowledge on the degree to which minerals supplied in poultry feed are meeting the requirements of the birds – undersupply results in reduced skeletal integrity and oversupply results in environmental pollution via poultry manure. Maintenance of skeletal integrity is a major contributor to poultry health and welfare. The Unit's PRU is recognised for expertise in poultry bone mineralisation and has been approached by several poultry producers and vets for assistance in this area. Therefore PRU initiated a **bone mineralisation investigation service** available to the UK and EU poultry sector, which has **been implemented** on a per sample basis for use by

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commercial companies to determine the mineral content of relevant leg bones at differing stages of bird development. One company⁵ making use of this service said “*The bone mineral investigation service provided by Nottingham Trent University Poultry Research Unit has resulted in an improvement in how our company is able to serve its clients.*” It has also led to an increase in commercial funding in other areas of poultry nutrition such as gut health. The evidence presented by Burton highlighting key factors affecting phytase enzyme efficacy has resulted in **changed industry practice in how a nutritional value for phosphorus is ascribed** to a feed material². This change in practice allows a reduction in the addition of mineral sources of phosphorus (a limited global resource) to poultry diets.

Industry-wide impact from this project is emanating from a small but distinct initial contribution to the regional economy via services to the UK poultry sector, to an increase in the efficiency of global meat production by reducing lameness losses. The secured route to the global market via a UK-based multi-national company evidences early stage impact. The impact of the research outputs of the NTU PRU have been described as follows: “...*I see the emergence of the research capacity in poultry nutrition at NTU as significant for our company and indeed for the state of poultry research in the UK...*”² and “*It is refreshing to have a relatively young team and facilities for poultry research in the UK, this is sorely needed by the poultry industry...*”⁵

4. Sources to corroborate the impact (indicative maximum of 10 references)

¹Si Active spin out company: <http://www.companiesintheuk.co.uk/ltd/si-active>
Link to UK Government website listing registration of Si Active as a company.

²AB Vista – Research and Development Director
Letter provided describing impact of NTU research cited and any comments directly quoted.

³Rushcliffe Environmental – Managing Director
Letter provided describing impact of NTU research cited and any comments directly quoted.

⁴ABAgri – Business Development Manager – Biofuels
Letter provided describing impact of NTU research cited and any comments directly quoted.

⁵Premier Nutrition - Poultry Nutritionist
Letter provided describing impact of NTU research cited and any comments directly quoted.