Could you explain how you came to work on the ‘Probiotics improve poultry health and performance’ project?

GT: Hargis and I met when he was a professor at Texas A&M University, USA, and I became his PhD student. While in Texas, we helped develop and commercialise the first US Food and Drug Administration (FDA)-approved probiotic product. It was effective in competitive exclusion and successfully displaced pathogenic bacteria in the gastrointestinal tract of poultry. Unfortunately, the product was expensive and difficult to produce and administer.

After graduation, I returned to my native Mexico, where I continued to work on probiotics. Hargis joined the University of Arkansas in 2000, and I followed in 2001 as a visiting professor during a sabbatical from my institution (National Autonomous University of Mexico). Since then, our focus has been on finding a new approach to identify and produce useful probiotics that are less costly for the poultry industry.

One of your studies looked to identify potential biomarkers for gut barrier failure in broiler chickens. What have been your key findings so far?

GT: Gut barrier failure can be caused by oxidative stress, poorly digestible protein and coccidiosis – among other factors. However, no biomarkers have been described as tools to evaluate gut inflammation in broiler chickens. Barrier function is a critical aspect of gut health. In our study published in *Frontiers in Veterinary Sciences*, we report seven potential biomarkers that can be detected in an experimental model of gut barrier failure in chickens: two in serum and five in the intestinal mucosa.

When switching chickens from a diet based on corn to one high in non-starch polysaccharides (NSPs), how is gut health affected?

GT&JDL: Corn is usually the main energy source in poultry diets, but at times it is cost prohibitive and, therefore, unconventional grains have to be used as feed ingredients. When chickens are fed alternative grains, such as barley, wheat or rye that are high in NSPs, poor performance and detrimental litter conditions caused by sticky droppings are reported. Rye diets evoke mucosal damage in chickens that alter digesta viscosity, increase leakage throughout the intestinal tract and affect the microbiota composition as well as bone mineralisation.

Can you outline your approach to analysing the role of a *Bacillus subtilis* direct-fed microbial (DFM) on digesta viscosity, bacterial translocation and bone mineralisation in turkey poult fed a rye-based diet?

GT&JDL: We have reported that rye-based diets significantly increased both viscosity and *Clostridium perfringens* proliferation when compared with corn-based diets *in vitro* and *in vivo*. Since poultry has little or no intrinsic enzymes capable of hydrolysing these NSPs, exogenous xylanases are used as additives in an attempt to reduce the negative impact of these anti-nutritive factors. We have evaluated the inclusion of selected *Bacillus*-DFM candidates that produce exogenous enzymes in high NSP diets. Turkey poult fed a rye-based diet without DFM showed an increase in bacterial translocation and digesta viscosity, accompanied by reduced bone mineralisation. However, these adverse effects were ameliorated by the inclusion of a selected enzyme producer *Bacillus*-DFM candidate in rye-based diets.

What has been your experience of technology transfer within the poultry industry?

GT&BMH: In 2004, a company was formed to produce our product exclusively for one poultry company. Named Sigrah Zellet LLC (our names spelled backwards), the company was intended to pay royalties to the Division of Agriculture.
The wonderful thing about microbes

At the Poultry Health Laboratory at the University of Arkansas, USA, researchers are rethinking the ways in which to combat bacteria and other microbes. Instead of traditional antibiotic approaches, the team is pitting microbe against microbe in order to improve overall animal health.

ON A TYPICAL trip through the dairy goods aisle in a grocery store, one will encounter a plethora of products, such as fermented dairy drinks and yoghurt, advertising their ability to help regulate gastrointestinal health through live bacterial cultures. The idea of probiotics – live microbial food supplements that benefit the host by improving intestinal microbial balance – began in 1907. At this time, Eli Metchnikoff, a Russian scientist, developed a theory that ageing is caused by toxic bacteria in the gut and lactic acid bacteria could lengthen one’s lifespan. Today, his work has evolved into an entire field of biology. Probiotics have now been found to exclude pathogens, modulate the host’s innate and acquired immune systems and manipulate the host genome through antioxidant and cell integrity properties.

WHY NOW?

Led by Professors Guillermo Tellez and Billy M Hargis, PhD student Juan D Latorre, and a team of researchers at the John Kirkpatrick Skeeles Poultry Health Laboratory (PHL) at the University of Arkansas are working to harness the health benefits of probiotics to decrease the spread of disease and increase general health and wellbeing in poultry. Due to increasing bacterial resistance, antibiotics are becoming less effective – indeed, there is a serious concern that antibiotics will become wholly ineffective if they continue to be used on such a wide scale. The development of novel approaches for keeping livestock healthy without antibiotics is, therefore, becoming increasingly pertinent. Probiotics offer an antibiotic-free alternative to reduce the transmission of pathogenic bacteria such as Salmonella and Escherichia coli, which are of high concern to the livestock industry.

THE GUT OF RESEARCH

When chickens are raised for human consumption (known as broiler chickens), farmers must balance feed cost with nutrition, health and performance benefits. Usually, chickens are primarily fed with corn-soybean based diets, however when circumstances that increase corn demand make it cost prohibitive, farmers often turn to feed ingredients that are high in non-starch polysaccharides (NSPs) such as barley, wheat, rye or biofuel by-products. Notably, chickens cannot properly process NSPs, which is proven by detrimental symptoms such as sticky droppings and intestinal bacterial overgrowth.

In order to better understand the effects of NSPs ingestion on chicken gut health, researchers at PHL compared the bacterial translocation, intestinal viscosity, microbiota composition and bone mineralisation of chickens fed on a rye-based diet with those fed on a corn-based diet. The team found that chickens fed with rye had a lower body weight and an increased intestinal viscosity in comparison to chickens consuming corn-based diets. This viscosity was associated with elevated bacterial translocation to the liver, including E. colii. Rye fed chickens also had an increase in the number of lactic acid bacteria in several parts of the gastrointestinal tract (the duodenum, ileum and caecum), as well as a significant increase in the count of coliforms in the duodenal and ileal sections. Furthermore, chickens offered a rye-based diet had a smaller tibia diameter along with lower breaking strength and phosphorous and calcium percentages, thus indicating that their bone mineralisation was decreased in comparison to broilers fed more common corn-based diets.

DIRECT-FED MICROBIALS

One way to ameliorate the effects of using alternative cereals in poultry diets is to introduce a direct-fed microbial (DFM) previously selected based on enzyme activity profiles. Poultry have little to no inherent enzymes capable of breaking down NSPs; by introducing Bacillus subtilis to their diets,
PROBIOTICS TO IMPROVE POULTRY HEALTH AND PERFORMANCE

OBJECTIVES

- To investigate how probiotics influence the gastrointestinal microbiome to improve poultry health.
- To evaluate the advantages and beneficial effects of probiotics/direct-fed microbial and their interactions with diverse feed ingredients used in poultry diets.

KEY COLLABORATORS

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THE FORGOTTEN ORGAN

Microorganisms make up an enormous part of the planet’s biodiversity. As Tellez stresses: “Collectively, the intestinal microbiome represents a ‘forgotten organ’, functioning as an organ inside another, that can execute many physiological responsibilities”. Prokaryotes, single-celled organisms that lack membrane-bound organelles, such as mitochondria, and a membrane-bound nucleus, have actually shaped the evolution of eukaryotes – organisms whose cells do contain membrane-bound organelles. Indeed, many of the organelles within cells may originally have been prokaryotes that were absorbed by eukaryotes and eventually became a part of the eukaryote; for instance, chloroplasts may have evolved from cyanobacteria.

“From termites and honey bees to ruminants and monogastric animals, the association between prokaryotes and eukaryotes can help to metabolise several nutrients that the host cannot digest, converting them into useful end products,” Tellez explains. Its physiological responsibilities do not end here. Overall, the intestinal microbiome plays numerous roles in the development, health and disease of the host, affecting not only the gastrointestinal tract but other organ systems as well. “When we ponder and contemplate the astonishing and remarkable roles that prokaryotes have on host metabolism, immune function, gene expression, and behaviour, I wonder: who is hosting whom?” he concludes.

Commercial broiler production.

Guillermo Tellez, has a PhD from Texas A&M University, Doctor of Veterinary Medicine (DVM), and MS from the National Autonomous University of Mexico. In 2014, he was awarded the Frank Perdue Live Poultry Food Safety Award for his research in food safety.

Juan Latorre, DVM, has an MS from the Yucatan Autonomous University. Currently, he is pursuing a PhD in Poultry Science at the University of Arkansas.

Billy M Hargis, DVM, has a PhD and BSc from the University of Minnesota and his MS at the University of Georgia. In 2006, he was named the Sustainable Poultry Health Chair.

THE POWER OF PROBIOTICS

When considering the health of livestock, such as poultry, one primary concern is how they will affect human health. Animals have an astounding number of microbes, each within a microbiome. These microorganisms can act as organs, executing many physiological responsibilities; for instance, within the gastrointestinal tract, they can help digest proteins and sugars indigestible by the host animal.

Probiotics can be used to introduce beneficial microbes into the gastrointestinal microbiome in order to improve the overall health of an animal. On the other hand, probiotics – nutrient packages designed to help probiotics growth – help establish successful colonies. One of the many advantages of probiotics is that they can reduce infections such as Salmonella. They can also modulate toll-like receptors – evolutionarily conserved pathogen recognition receptors, which are necessary components in the protection against invading microorganisms.

The team developed a lactic acid-based probiotic culture (FloraMax Brit™) that has helped normal microflora in chickens and turkeys to grow, and increases resistance to Salmonella and other enteric pathogens in poultry. Their primary focus is to use new molecular techniques to assess microfloral composition, thereby determining the mechanism of action that probiotics have to enhance welfare, health and performance in commercial poultry. Advances in the application of probiotics are directed towards producing changes in gut physiology, which will provide higher levels of health and performance parameters in different animals. In humans, it could mean improvements for chronic diarrhoea, inflammatory bowel disease, irritable bowel syndrome and more. Furthermore, other body systems with endogenous microflora or immune system problems may also benefit from probiotic therapy.