Looking for a HERO in the fight against foodborne bacteria

Chicken and eggs are a great source of nutrition and are at the heart of many tasty dishes, including Sunday roast, Yorkshire pudding, chicken curry and omelettes.

Chicken and eggs can serve as a protein source in a diverse number of meals. However, if the right precautions are not taken when handling and storing these items, they can lead to foodborne illnesses.

by Dr Harriet Walker, Poultry Technical Specialist, Alltech Gut Health Team. www.alltech.com

Foodborne infections from bacteria like salmonella, campylobacter and E. coli are a major food safety issue and public health concern in both industrialised and developing countries.

They can also incur a large economic burden. For instance, in the UK, known cases of campylobacter cost an estimated £712.6 million, while salmonella incurred costs of £2.120 billion and E. coli O157 cost £3.9 million.

Globally, its estimated that nearly 600 million people fall ill each year as a result of eating contaminated foods, with campylobacter being the most frequently reported bacterial pathogen leading to illness. In the EU, there are over 246,000 human cases of campylobacter contamination-related illness every year; however, as not all cases are reported, the actual number is believed to be closer to nine million annually.

Studies on the source of campylobacter infection in humans have predominantly shown it to be associated with poultry products. In 2018-19, the UK Food Standards Agency (FSA) reported that 55.8% of chicken skin samples tested were contaminated with Campylobacter spp, 10.8% of which had levels of over 1,000 colony-forming units (CFUs) of the bacteria per gram of chicken skin.

The main route of transmission of campylobacter is commonly thought to be foodborne, via eating raw or undercooked meat and meat products, with chicken liver pate/parfait being the most frequently reported source of contamination-related illness.

After campylobacteriosis, salmonellosis is the second-most commonly reported foodborne disease in humans, with about 88,000 reported cases in 2019 – which, again, was thought to be only a small portion of the actual number of cases due to many other cases not being reported.

Eggs and poultry meat products are most commonly implicated in salmonella outbreaks in the UK and the EU. Poultry species – including broilers, layers and turkeys – are a main known source of all of the top five salmonella strains responsible for human infections.

Salmonella and campylobacter account for approximately 90% of all reported foodborne illness cases. Both strains caused diarrhoea, fever and stomach cramps and bringing with them a large economic burden.

Controlling infections

Therefore, it is critical that salmonella and campylobacter are controlled in poultry to stop the spread of the bacteria to the human population. Effective control of salmonella and campylobacter infections in poultry include improved on-farm biosecurity and the use of vaccinations and competitive exclusion products, along with educating the public about best practices for handling raw meat and the importance of cooking meat thoroughly, as well as improving slaughter hygiene and technologies in processing plants to reduce the likelihood of contamination.

To get maximal control over these bacteria, a complete approach is needed to reduce the levels of campylobacter and salmonella in poultry, part of which should include the concept of 'HERO':

- Helping to establish a healthy gastrointestinal microbiome.
- Excluding pathogenic bacteria from the gastrointestinal tract.
- Reducing the issue of antibiotic resistance.
- Optimising health and performance.

Mannan-rich fractions (also known as MRF, which can be provided as Actigen) can be used as a tool to improve the food safety of poultry via the HERO programme.

Helping to establish a healthy microbiome

The gut of a chicken contains a diverse and complex microbiota that plays a vital role in digestion and the absorption of nutrients, as well as immune system functioning and pathogen control.

The relationship and interactions between the bird and the bacteria, fungi, archaea, protozoa and viruses that make up its microbiota are essential for bird production, health and welfare, as the microbiota affects nutrition, physiology and gut development. The diversity of the gut microbiota is affected by many factors, including the bird's diet, its environment, its age and any stressors being placed on the bird.

A diverse and balanced gut microbiota can reduce the attachment of pathogenic bacteria to the gut cell wall by forming a protective barrier, thereby fostering competitive exclusion and increasing the microbiome diversity of the bird's gastrointestinal tract to enhance its resistance to colonisation by pathogenic bacteria.

Prebiotics containing MRF are one of the most promising feed supplements in terms of their ability to alter the diversity and composition of the microbiome. MRF has a consistent impact on caecal microflora diversity, with phylum Bacteroidetes appearing to replace phylum Firmicutes during supplementation.

These mannan-rich fractions are particularly effective in binding to type-1 fimbriae in Gram-negative bacterial pathogens, allowing commensal microbiota like lactobacillus to flourish.

Increases in the complexity of the microbiome have been associated with improved health, and similarly, increases in the phylum Bacteroidetes have been associated with favourable outcomes.

These beneficial bacteria in the microbiome also produce compounds that can be used by the gut, like short-chain fatty acids (SCFAs), vitamins and antimicrobial compounds. MRF stimulates the production of the short-chain fatty acid butyrate by influencing the microbiome. SCFAs can be used as an energy source, can decrease the gut pH and have bacteriostatic properties that can reduce the presence of foodborne pathogens, such as Salmonella spp.

Excluding pathogenic bacteria from the GI tract

Poultry producers play a major role in reducing the level of pathogens contaminating poultry products.

A decreased number of pathogens can be achieved by reducing the load of the pathogen in the bird through vaccinations, improved biosecurity and the competitive exclusion of pathogenic bacteria with commensal non-pathogenic bacteria.

A number of pathogenic bacteria colonise and infect the gut by binding to mannose receptors on the gut cell wall using type-1 fimbriae, including E. coli and salmonella. MRF can adhere to these type-1 fimbriated bacteria, blocking the pathogen from attaching to the gastrointestinal cell wall and preventing pathogen colonisation, thereby leading to reduced inflammation, tissue damage and the overall pathogen load.

Girgis et al. (2020) reported that MRF supplementation in layer diets significantly reduced both the prevalence of salmonella in the ovary tissue and the concentration of it in the caeca, making MRF supplementation a useful strategy for reducing the risk of eggshell contamination.

MRF has been shown by Corrigan et al. (2017) to significantly reduce campylobacter colonisation levels in the broiler caecum and to lead to increased weight gain. The mode of action of MRF is thought to be through competitive exclusion.

Reducing the issue of antibiotic resistance

Antibiotic resistance is one of the biggest threats to global heath, as it can occur naturally — but the misuse of antibiotics in animal production has accelerated an increase in antibiotic resistance. With increased antibiotic resistance, infections become harder to treat, which can result in longer hospital stays and increased rates of mortality.

In 2020, the overall resistance of Salmonella spp. found on broiler and turkey carcases to ampicillin, sulfamethoxazole and tetracycline was moderate to very high, reaching over 50% in some cases.

This makes antibiotic resistance a huge food safety issue. An increasing awareness of and pressure to reduce antimicrobial resistance, as well as the effects of using antibiotics in animal feed, have led many countries to ban the use of antibiotic growth promoters in animal feeds.

However, these bans are not enough to stop the increased emergence of antimicrobial resistance.

This is a persistent issue, and rates of resistance are still high despite restrictions on antibiotic use. Because pathogens harbour resistant genes, it is critical to find ways to reduce resistance and increase bacterial sensitivity to antibiotics.

The World Health Organization (WHO) has outlined various ways that the agriculture sector can prevent and control the spread of antibiotic resistance, including:

- Only providing antibiotics under veterinary supervision.
- Avoiding the use antibiotics for growth promotion or prevention in heathy animals.
- Improved biosecurity.
- Vaccinating animals and using alternatives to antibiotics.

MRF can be used as an alternative to antibiotics, as they have the ability to modulate the microbiome, bind pathogenic bacteria and impact bacteria's susceptibility to antibiotics.

Smith et al. (2022) showed the effects of MRF and antibiotic treatment on the growth of antibiotic-resistant E. coli relevant to a control culture.

They found that MRF significantly reduced the growth of antibiotic-resistant E. coli relevant to a control culture and that, when MRF was used in combination with ampicillin, there was a larger reduction in the growth of antibiotic-resistant E. coli relevant to the control culture. Smith et al. (2017) also reported that resistant organisms became more sensitive to antibiotics in the presence of MRF.

Smith et al. (2017) observed that salmonella-carrying plasmids that conferred antibiotic resistance had decreased growth when MRF was present. It was reported that the metabolism and growth of resistant E. coli changed when grown in the presence of MRF, resulting in an increased sensitivity to antibiotics.

This increased effectiveness of antibiotics when provided in conjunction with MRF could result in a reduction in the level of antibiotic-resistant organisms in the bird and the environment, as well as the development of a diverse and balanced microbiome.

Optimising health and performance

When the bird is in optimal health, their natural defences against pathogenic colonisation are also optimal. A large proportion of the bird's immune system lives within the gut, meaning that if the bird has a healthy gut, it will likely also have a strong immune system, allowing the bird to defend itself against pathogens.

There are three lines of defence for the immune system. The first line of defence includes the gut cell wall, the mucus layer and the microbiota. This first line of defence works to block pathogens and foreign materials from entering the body.

The second line of defence against pathogens is a non-specific response of the innate immune system that involves white blood cells and other immune system components, such as antimicrobial chemicals.

The third line of defence involves B cells that produce an antibody response and T cells that produce a cell-mediated immune response. If the bird is in optimal health, these elements will work together to defend the bird against pathogens, reducing bacterial colonisation and the load of the pathogenic bacteria in the bird, thereby improving the food safety of the end poultry product going to the consumer.

In addition, birds that are in optimal health will, by definition, have a healthy gut, allowing them to

digest and absorb nutrients from their diet efficiently and thereby increasing the likelihood that they will perform well. If a bird performs well and has a strong immune system, there is less of a need for antibiotics, which will help in the fight against antibiotic resistance.

Conclusion

Chicken and eggs are eaten in large amounts worldwide every year, as they serve as a great source of nutrition in many dishes.

The food safety of the meat and eggs produced by poultry is extremely important, as proper food safety can help reduce foodborne infections, such as salmonella, campylobacter and E. coli, and, as a result, can also reduce the mortalities and the economic burden cause by these infections.

Therefore, developing a robust, holistic approach to increasing food safety in poultry production is vital. To get maximal control of these bacteria, implementing the HERO approach and using MRF should be part of a complete food safety plan. ■

References are available from the author on request