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Keeping you naturally informed | Issue 55 | Turkeys

The impact of mycotoxins in turkeys

Using beneficial bacteria to improve antibiotic-free turkey performance

Reducing *E. coli* challenges in turkeys despite enrofloxacin resistance

Turkey production gaining momentum


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Turkey production – gaining momentum

EU turkey production in 2016, the most recent data available, surged with a 6.8% growth in production.

This was led by Poland and Spain but with a significant rate of growth in many of the other major turkey-producing countries. Despite this, per capita consumption remains below 4 kg.

A decline in overall EU production is likely for 2017. This is due to the impact of avian influenza in the second half of the year. The AVEC (Association of Poultry Processors and Poultry Trade in the EU) reported bird culling as a result of avian influenza in several countries, including the largest turkey producer in the EU, Germany.

Markets outside the EU are growing with increases in Russia, Ukraine and the North African countries of Morocco, Tunisia and Algeria. However, North America remains the major producing country whilst Brazil continues to increase production. Despite this global growth, turkey consumption remains well below that of chicken.

With a demand for high-density rations, the success of turkey producers is reliant on stable protein commodity prices, which have been present for the past two years. However, with high-density diets there is always a risk of feeding both the birds and some of their less desirable gut inhabitants at the same time. Pathogenic *E. coli* are one of the major concerns in turkey production and can result in losses in performance as well as further economic losses in terms of the veterinary costs required for control. Therefore, maintaining a healthy gut structure and microbial balance is important in order to achieve economic productivity.

In this issue of Science and Solutions, we look at some ways of reducing the incidence of colibacillosis, keeping you naturally ahead with enhanced organic acid products where the addition of a permeabilizing agent enhances antimicrobial activity, resulting in improved efficacy and turkey performance. Similarly, the use of probiotics is gaining acceptance as a way of improving overall gut health through immune stimulation and competitive exclusion of pathogens, thereby reducing the need for antibiotic intervention.

With a long growing cycle, there is a high chance that the birds will be fed mycotoxin-contaminated feed. Mycotoxins have a direct effect on intestinal structure and synergistic effects when combined with some pathogenic challenges. Minimizing their effects can also aid in reducing the need for veterinary interventions.

Enjoy reading this issue of Science and Solutions, keeping you naturally informed.

Andrew Robertson
Technical Manager - Poultry

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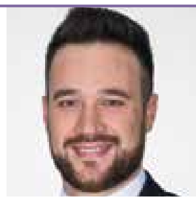
Impact of Mycotoxins in Turkeys



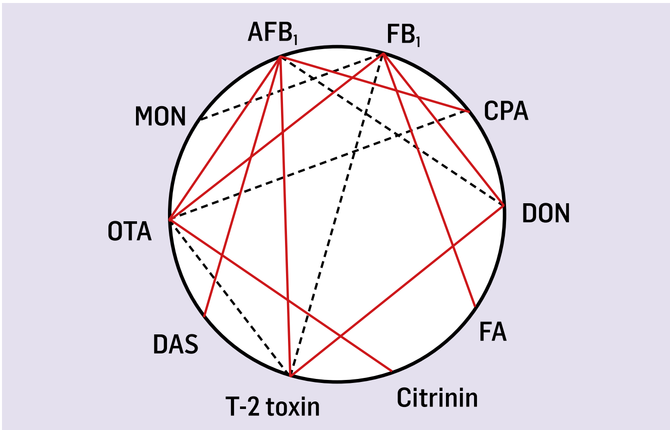
Michele Muccio MSc
Product Manager

Mycotoxins are present in nearly all raw materials used to make turkey feed. They have a huge impact on the production performance of the flock, but using a mycotoxin deactivation product in the diet can mitigate these negative effects.

Turkey and poultry species in general are sensitive to a broad array of mycotoxins. Aflatoxins, type A trichothecenes (T-2 and HT-2 toxin), type B trichothecenes (deoxynivalenol (DON), nivalenol (NIV), or diacetoxyscirpenol (DAS)), fumonisins (FUM) and ochratoxins are among the groups that can impair production the most. Aflatoxins are potent liver carcinogens; they can influence animal production by triggering severe immunosuppression, cancer of the liver and spleen, feed refusal and carry-over into tissues and eggs. Contamination of feed with subclinical doses of aflatoxins can negatively influence intestinal histology and reduce the adsorption of crude proteins from the feed. Trichothecenes are protein synthesis inhibitors; hence, they are highly toxic to cells. Type A trichothecenes such as T-2 and HT-2 produce visible lesions on the beak and in the gut, leading to feed refusal. The most detrimental effects of trichothecenes are observed in the gastrointestinal tract, where they can compromise the integrity of the gut by disrupting the tight junctions – thus favoring the passage of pathogens and other toxic entities into the bloodstream. Trichothecenes such as DON have repercussions on villi histology as well: villi atrophy, decreased villi height and crypt depth have been observed in birds fed subclinical doses (below EU regulation guidelines) of DON. The effects of DON are enhanced by the presence of FUM. These mycotoxins act synergistically, rendering the immunosuppressive and cytotoxic effects of DON and other trichothecenes more severe. Moreover, DON and FUM are predisposing factors for the development of necrotic enteritis and coccidiosis.

When it comes to mycotoxin exposure, it is important to bear in mind the synergistic effects. Synergism is when the toxicity of one mycotoxin is greatly increased by the presence of others. The most relevant synergistic interactions in poultry are reported in *Figure 1*. The toxicity of mycotoxins depends on the dosage and the exposure time. Consequences

Figure 1.
Synergistic effects of mycotoxins in poultry

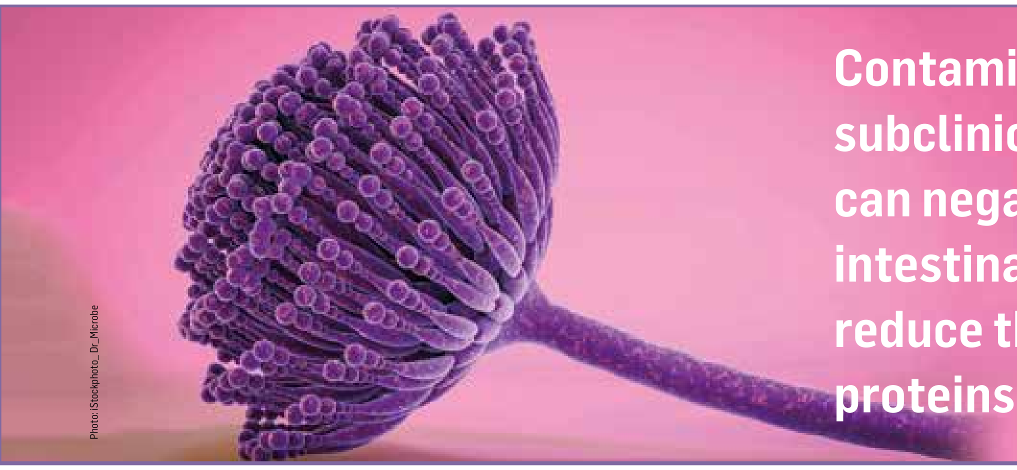


FB$_1$ = Fumonisin B$_1$, CPA = Cyclopiazonic acid, DON = Deoxynivalenol, FA = Fusaric acid
DAS = Diacetoxyscirpenol, OTA = Ochratoxin A, MON = Moniliformin, AFB$_1$ = Aflatoxin B$_1$

Source: BIOMIN

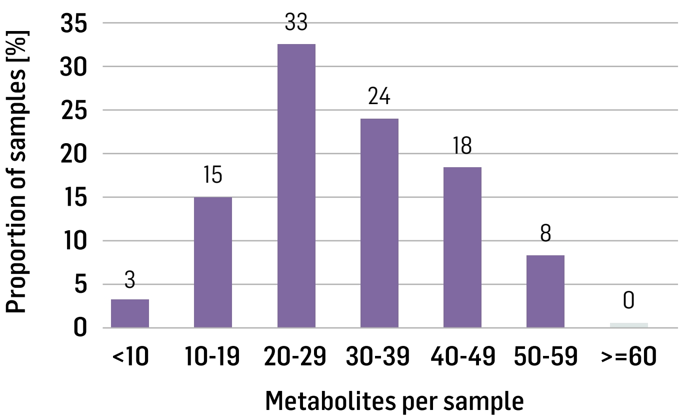
IN BRIEF

- Mycotoxin contamination in feed can cause a myriad of performance and health problems
- Most raw materials are naturally contaminated with more than one mycotoxin
- To mitigate negative effects, a mycotoxin deactivation product with several modes of action should be included in the diet



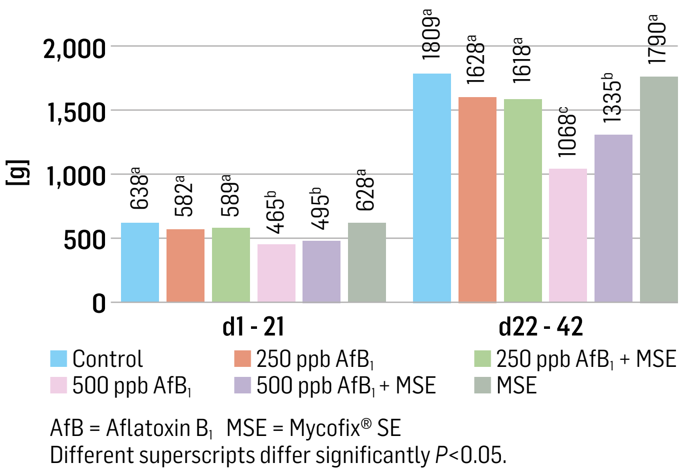
Contamination of feed with subclinical doses of aflatoxins can negatively influence intestinal histology and reduce the adsorption of crude proteins from the feed.

Figure 2.
Co-occurrence of mycotoxins in samples worldwide, Jan. - Nov. 2017



Source: BIOMIN

Figure 3.
Body weight at day 21 and at the end of the experiment



AfB = Aflatoxin B_1 MSE = Mycofix® SE
Different superscripts differ significantly $P<0.05$.

Source: BIOMIN

to production can be detrimental whether the animals are exposed to subclinical doses over a prolonged time, or short-term high-level exposure.

As reported by the BIOMIN mycotoxin survey, animals are always exposed to cocktails of mycotoxins – the 2017 survey data reported an average of 31 metabolites per sample (*Figure 2*). As mycotoxins can greatly differ in their physiochemical proprieties, an efficacious mycotoxin deactivation product needs to work in several different ways to counteract them all. Adsorption can only help against a small number of mycotoxins (mostly aflatoxins, ergots and ochratoxins).

One of the major challenges for mycotoxin deactivation is to prove the effectiveness *in vivo*. According to the official EU registration protocol, this has to be accomplished with biomarkers, as they are the proof of mycotoxin deactivation at a molecular level. In fact, to register a product in the EU, *in vitro* results are not enough. Mycofix® is the only EU registered multi-strategy product available on the market and its state-of-the-art mode of action, based on adsorption and biotransformation, has been tested in turkeys against aflatoxins, trichothecenes and fumonisins in three different trials.

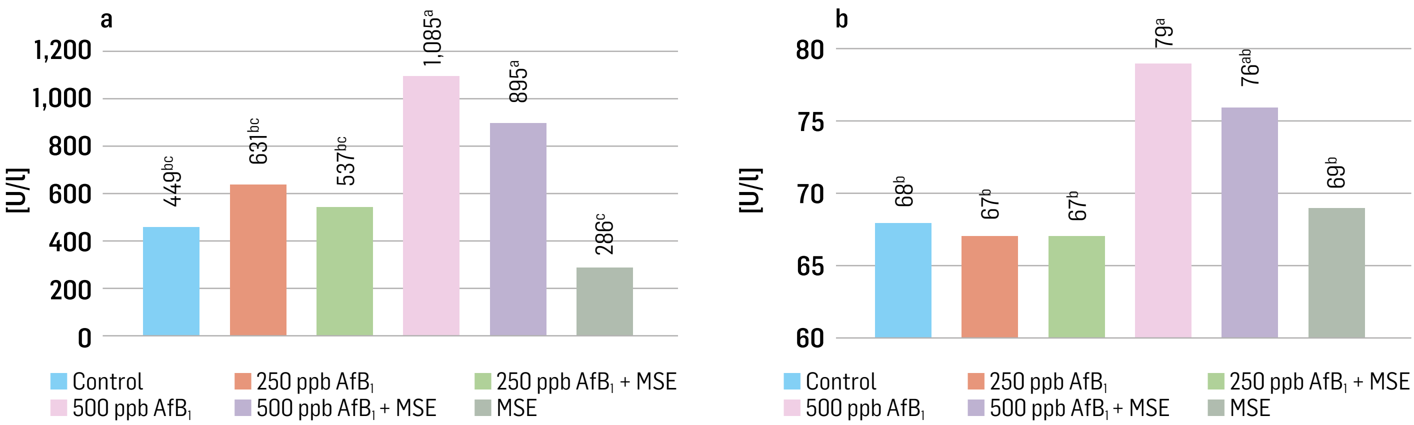
Mycofix® is able to counteract high concentrations of aflatoxin

The efficacy of Mycofix® to counteract aflatoxins (Afla) was tested on 210 one-day-old turkey poults exposed to relatively high amounts of Afla for 42 days. Different parameters were measured during the experiment including performance parameters (individual weight, feed intake, feed conversion ratio (FCR)), organ health measurements (relative organ weights, liver enzymes (AST and LDH), and strength of the immune response. The results showed that Mycofix® counteracted the adverse effects on turkey performance and on selected toxicopathological parameters, and completely overcame the negative effects of mycotoxins, including mortality, which has important economic implications for the poultry producer. The results are shown in *Figures 3* and *4*.

FUMzyme®, the breakthrough in FUM deactivation

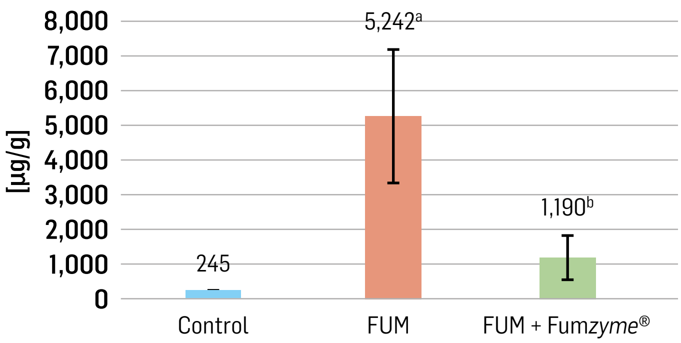
The ability of FUMzyme® to detoxify FUM in the gastrointestinal tract of turkeys was assessed in a field trial.

Figure 4.
LDH (a) and AST (b) levels at day 35



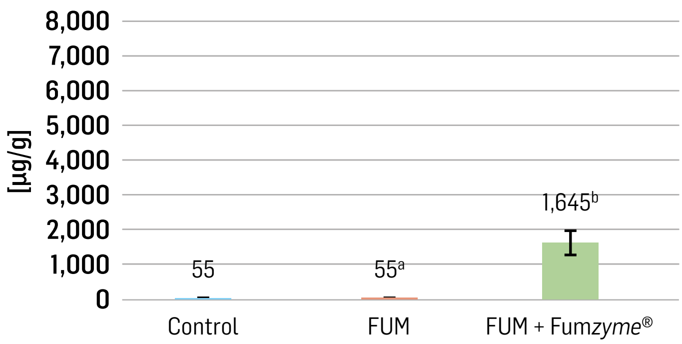
Different superscripts differ significantly *P*<0.05.
Source: BIOMIN

Figure 5a.
FB_1 in turkey feces day 14 (µg/g)



Different superscripts differ significantly *P*<0.05.
Source: BIOMIN

Figure 5b.
HFB_1 in turkey feces day 14 (µg/g)



Different superscripts differ significantly *P*<0.05.
Source: BIOMIN

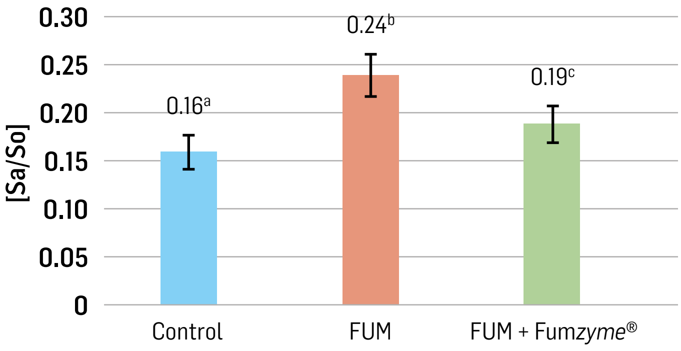
Fifteen hybrid turkeys at ten weeks of age were fed 15 ppm of FUM (specifically FB_1 was used in the trial). FUM*zyme*® converts FB_1 into the hydrolyzed non-toxic metabolite HFB_1. A way to assess the activity of the enzyme is to measure the gradual disappearance of FB_1 and appearance of HFB_1. To do so, fecal samples were collected after 14 days. As shown in *Figure 5a* (green bar), FUM*zyme*® significantly lowered the FB_1 content in the feces compared to the FB_1 contaminated group without additive (red bar). The metabolite HFB_1 was significantly elevated in the FUM + FUM*zyme*® treatment (*Figure 5b*, green bar), showing effective biotransformation of FB_1 to HFB_1.

Another biomarker assay that is commonly used to assess FUM deactivation is the sphinganine (Sa): sphingosine (So) ratio. The mode of action of FUM is the inhibition of the enzyme ceramide synthase that coverts free Sa and So (molecules that are precursors of sphingolipids) into complex sphingolipids, important structural components of cell membranes. Once the enzyme is inhibited, the free Sa and So molecules start accumulating in the cell with Sa being the predominant metabolite. This accumulation is measurable; specifically the ratio between free Sa and So. The higher the ratio, the more severe the FUM intoxication. In one trial, the Sa:So ratio (*Figure 6*) in serum at day 14 was significantly elevated in the FUM contaminated group compared to the control group without FUM and FUM*zyme*®. The addition of FUM*zyme*® significantly lowered the ratio, indicating FUM inactivation *in vivo*.

Trichothecenes detoxification by BIOMIN BBSH 797

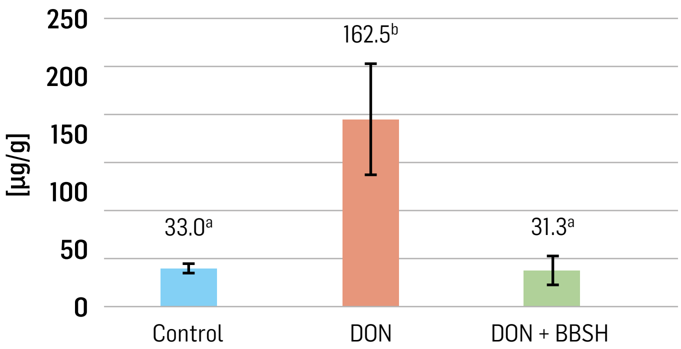
BIOMIN BBSH 797 catalyzes the cleavage of the epoxy group of trichothecenes by producing a specific enzyme called de-epoxidase during its metabolic activity in the gastrointestinal tract, which results in metabolites of no toxicological concern. The main metabolite of DON, the most prominent and prevalent mycotoxin among the group of trichothecenes, is DOM-1 (de-epoxy-deoxynivalenol). As reported in the literature (Wan *et al.*, 2014), DON-3-sulfate is the major metabolite of

Figure 6.
Sa:So ratio



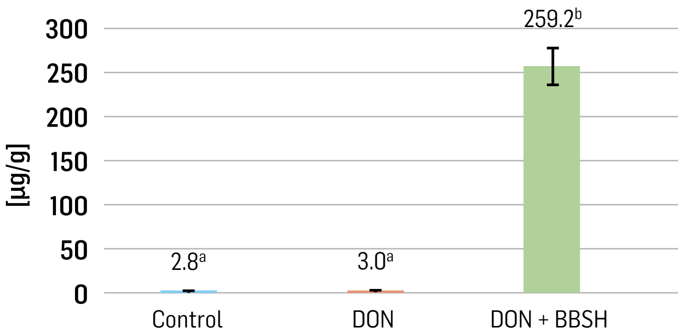
Different superscripts differ significantly *P*<0.05.
Source: BIOMIN

Figure 7a.
DON-3-sulfate in turkey feces (µg/g)



Different superscripts differ significantly *P*<0.05.
Source: BIOMIN

Figure 7b.
DOM-3-sulfate in turkey feces (µg/g)



Different superscripts differ significantly *P*<0.05.
Source: BIOMIN

DON in poultry. The resulting de-epoxy metabolite of BIOMIN BBSH 797 activity is DOM-3-sulfate. DON, DOM-1, DON-3-sulfate and DOM-3-sulfate were used as biomarkers in the feces.

In this trial, 15 female ten-week-old turkeys (Hybrid Converter) were randomly allocated to three experimental groups using three double pens with five birds per double pen of the poultry trial facility. Birds were kept for six days in floor pens on wood shavings with free access to feed and water. After the first six days of accustomization, the trial period started for two consecutive days. The diets were artificially contaminated with 1.5 ppm DON, and BIOMIN BBSH 797 was administered via the feed as well. Fecal samples were taken five times per day from each pen. A pooled fecal sample per day and pen was analyzed for toxin residues and metabolites at the Christian Doppler laboratory at IFA-Tulln, Austria. The recorded parameters were the concentration of DON, DOM-1, DON-3-sulfate and DOM-3-sulfate in feces (µg/day). DON was only present in small amounts below the limit of quantification and only in the group receiving the toxin without the additive (results not shown). BIOMIN BBSH 797 significantly lowered the load of DON-3-sulfate (*Figure 7a*; green bar) and significantly raised the amount of DOM-3-sulfate detected (*Figure 7b*; green bar). It was clearly demonstrated that the de-epoxidation reaction only took place in the BIOMIN BBSH 797-treated group.

To conclude, the enzymes contained in Mycofix® are an effective, state-of-the-art strategy for the deactivation of non-adsorbable mycotoxins. The fact that biomarker studies have been carried out on turkeys as well is a warranty that the product works efficiently in different animal classes. Purchasing registered products with a proven mode of action *in vivo* is a way to ensure robust production and to make sure that capital is properly invested in a product designed to get the job done!

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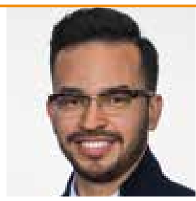
Using Beneficial Bacteria to Improve Antibiotic-Free Turkey Performance



Luis Valenzuela MSc
Product Manager

Turkey production comes with its own challenges including enhancing growth rates, increasing nutrient absorption and decreasing enteric bacterial diseases. Reduced antibiotic usage amplifies these challenges, but the addition of PoultryStar® to the diet can deliver beneficial bacteria to restore performance levels.

The poultry industry has gone through some tremendous changes recently, including genetic improvements, preventive disease control, increased biosecurity measures and the introduction of modern intensive production methods. The changes have been implemented due to increased demand for animal protein. From 1990 to 2005, the consumption of poultry meat increased by 35 million tons in developing countries (Narrod *et al.*, 2007). In some countries where the production of red meat is not suitable, turkey meat has been a well-accepted replacement. However, its production, as with any other livestock sector, comes with complex challenges such as the need to enhance growth performance, nutrient absorption and to reduce enteric bacterial diseases.

IN BRIEF

- Pressure from consumers is fueling the reduction of antibiotic use in turkey production
- Without antibiotics, a performance gap opens up
- Supplementing the diet with feed additives can help to close the performance gap
- Feed intake and final body weight increased when PoultryStar® was added to the diet

Doing more with less antibiotics

Enhanced growth and feed efficiency are relevant topics for any turkey grower. In many places, reliance on non-medically important poultry antibiotics has been essential to keep up with rising demand for safe and affordable animal protein. However, increasing pressure from consumers, food retailers and regulators has spurred the reduction of antibiotic usage in farm animals. Furthermore, the development of resistant pathogenic bacterial strains to certain antibiotics may jeopardize the effectiveness of antibiotics when treatment is needed. Already, an increase in susceptibility to some infections through immunosuppression or through the alteration of the gut microbiota has been observed (National Research Council, 1980).

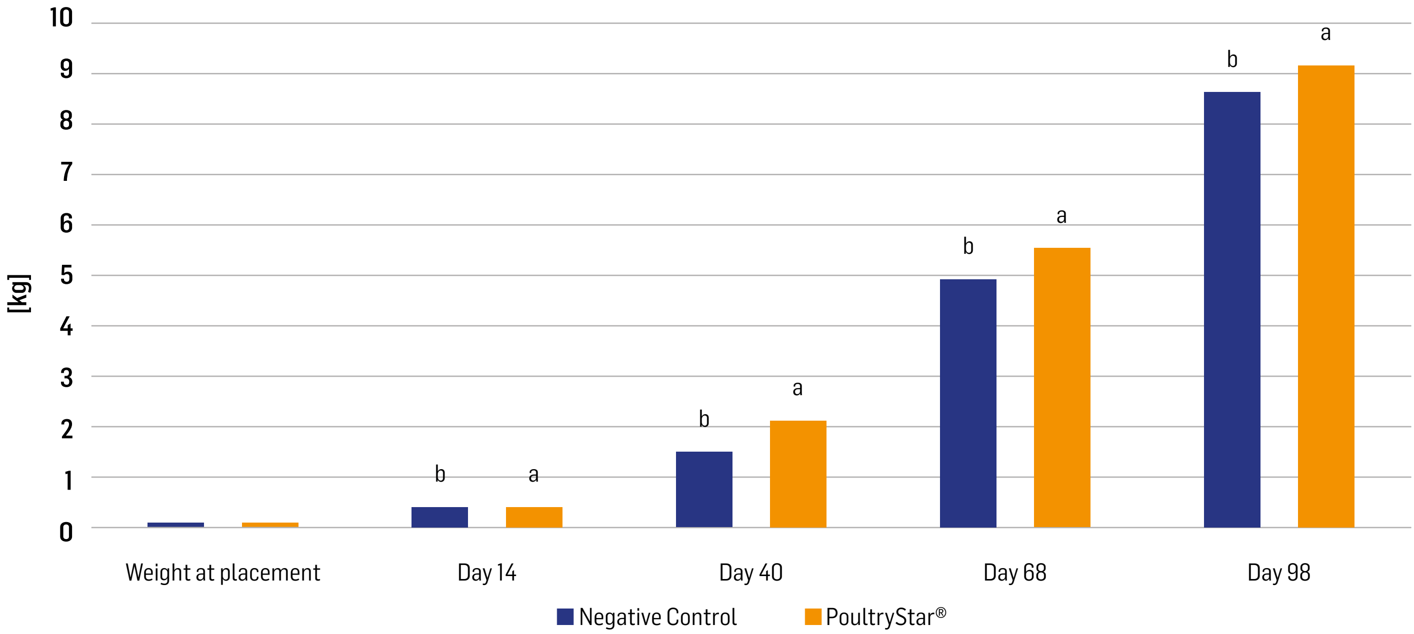
A boost from beneficial bacteria

To counteract the undesired effects of antibiotic growth promoters (AGPs) and to reduce the use of antibiotics overall, novel feed additives and preventive drugs have been developed, such as phytogenics, organic acids, probiotics,

Increasing pressure from consumers, food retailers and regulators has spurred the reduction of antibiotic usage in farm animals.

Photo: iStockphoto_aetb

Figure 1.
Body weight per hen



Different superscripts at the same time point differ significantly (P< 0.05)

Source: BIOMIN

prebiotics, synbiotics (combined probiotic plus prebiotic), and vaccines, that offer alternatives to promote animal performance and prevent health issues.

PoultryStar® is a well-defined, multi-species synbiotic product that promotes a beneficial gut microflora through the combined action of carefully selected species-specific probiotic microorganisms and prebiotic fructooligosaccharides derived from inulin. It was designed to improve gut health and make chicks more resistant to pathogenic infections, while also achieving enhanced performance.

Antibiotic-free turkey trial in the US

In a scientific experiment in the United States with 540 poults (Koch's turkey hybrid) conducted over 98 days, the synbiotic PoultryStar® sol from BIOMIN was used in drinking water at a dose of 20g/1000 birds/day in combination with the commercial antibiotic-free (ABF) diet. The additive was applied in days 1-3, 7, 13-15, 21, 28, 35, 41-43, 49, 56, 63, 69-71, 77, 84 and 91 (first three days, every three days, around feed change and once a week). The control flock was administered only the commercial ABF diet, devised to support the marketing of "naturally fed" turkeys whose organic diets were free from animal protein products and antibiotics.

Trial results

The results of the trial show that PoultryStar® sol improved turkey performance. Final live weight was significantly higher (P<0.05) in the PoultryStar® group compared with the negative control (*Figure 1*). At 98 days of age, the supplemented birds achieved 9.120kg compared to 8.604kg in non-supplemented birds, a significant difference of 516g.

Feed intake was 8% greater in the supplemented group, which may partly explain the achieved weight at the end of the trial (*Figure 2*). The feed conversion ratio (FCR) was not statistically different between the two groups.

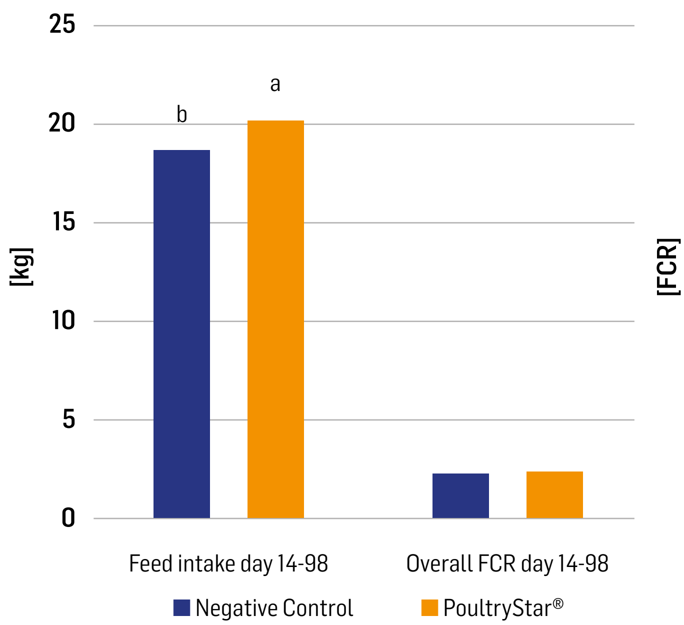
Related findings in chicken

These findings have also been confirmed in multiple scientific, commercial and field trials in broilers. A recent study found that the synbiotic PoultryStar® was able to improve intestinal histomorphology (Palamidi *et al.*, 2016), which in turn improves digestibility due to an improved digestive function. Probiotics may induce enhancements in intestinal architecture forming an increased surface area, which may contribute to a greater absorption of nutrients (Awad *et al.*, 2009). However, this must be confirmed specifically for turkeys with further studies.

Furthermore, trials in chickens have shown that the early prophylactic supplementation of PoultryStar® improves immune response of the birds, evidenced in peer reviews. PoultryStar® considerably reduced the incidence of pathogenic diseases, such as *Salmonella* Enteritidis in cecal content (Sterzo *et al.*, 2007), decreased lameness attributable to bacterial chondronecrosis (Wideman *et al.*, 2012) and enhanced performance and provided an additional protective effect against a mixed *Eimeria* challenge (Ritzi *et al.*, 2016).

Figure 2.

Compilation of overall feed intake and FCR



Different superscripts differ significantly ($P< 0.05$)

Source: BIOMIN

Novel feed additives and preventive drugs have been developed, such as phytogenics, organic acids, probiotics, prebiotics, synbiotics (combined probiotic plus prebiotic) and vaccines, that offer alternatives to promote animal performance and prevent health issues.

Conclusion

Scientific studies and trials have highlighted the benefits of using natural growth promoters, such as a synbiotic that includes a mix of probiotic strains and a prebiotic. This makes them an interesting tool in antibiotic-free feeding programs or in conventional operations as feed supplements to improve gut health and achieve better overall flock performance.

Note: At time of writing, PoultryStar® has EU authorization for use in feed or water for chickens for fattening, chickens reared for laying and minor avian species to the point of lay. PoultryStar® is under evaluation for EU authorization for use in turkeys.

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Reducing *E. coli* Challenges in Turkeys Despite Enrofloxacin Resistance

The majority of the bacteria found in the gastro-intestinal tract can inhabit the host without causing any harm. But there are certain strains that cause diseases, resulting in significant economic losses for producers. Managing these bacterial diseases, while also reducing the use of antibiotics in turkey production, requires a considered, strategic approach.

Antonia Tacconi PhD
Global Product Line Manager – Acids

The gastrointestinal tract of birds is intensively populated by many different microorganisms. Recent analytical technologies, such as next-generation sequencing, have made it possible to characterize this microbiome thoroughly. In general, the microbiota is a very important component for the host as it can influence the development and function of the digestive and immune systems. While there are lot of studies available on the chicken microbiome, not many have been published regarding the microbiome of turkeys.

The importance of species-specific studies was highlighted by Pan and Yu (2014) who showed that chickens and turkeys have only 16% similarity in their intestinal microbiome. Wilkinson *et al.* (2017) showed that Firmicutes, Bacteroidetes, Actinobacteria, and Proteobacteria were the dominant phyla in the microbiota of turkeys across age and location. *Escherichia coli* belong to the Proteobacteria phylum and are common inhabitants of the gastrointestinal tract of turkeys, but they can also be found in other birds and also in mammals. *E. coli* predominantly inhabit their host without causing any harm.

However, there are certain *E. coli* strains that possess specific virulent genes which are able to cause diseases in birds (avian pathogenic *E. coli* – APEC). Avian colibacillosis is one of the most common diseases in poultry. Colibacillosis can occur in many different clinical forms, causing considerable economic losses to producers worldwide. To counteract colibacillosis, antimicrobials need to be used. However, the misuse or incorrect application of antibiotics can contribute to the spread of antimicrobial resistance, which poses a threat both for animals and humans. In relation to the latest trends and pressure coming from the market, the need for alternatives to be used as preventive tools to avoid colibacillosis has become crucial.


Photo: iStockphoto_Anna Usova

IN BRIEF

- The gastrointestinal tract of turkeys contains a complex microbiome of bacteria, most causing no harm to the host
- Some bacterial strains cause diseases leading to economic losses
- The downward trend in antibiotic use has driven the rise of alternative disease management strategies
- Biotronic® Top liquid can reduce the *E. coli* count in turkeys when used as part of a holistic approach to turkey production

Organic acids: an alternative solution

Organic acids or single chain fatty acids (SCFA) have been proven to be toxic for many microorganisms. This toxicity is primarily associated with the ability of the undissociated acids to freely diffuse across the membranes of bacteria. Once inside the cell, the acids will dissociate into anions and protons and the resulting anions can affect cell growth in many different ways. In order to support and facilitate the passage of the acids across the bacterial membrane, the use of SCFA can be combined with the use of permeabilizers that destabilize the outer membrane of Gram-negative bacteria (like *E. coli* and *Salmonella* spp.) and hence ease the passage of the acids into the cells. Such a formulation has been considered for the development of the enhanced acidifier Biotronic® Top liquid: a combination of substances able to permeate the outer membrane of Gram-negative bacteria (Permeabilizing Complex™) with a well-studied blend of organic acids. Such a product can be added to the water supply as a preventive tool to reduce the replication of pathogenic *E. coli* in birds.

Biotronic® Top liquid: prevention against *E. coli* replication

In a trial performed in cooperation with the Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia-Romagna "Bruno Ubertini", 80 one-day-old female turkeys (Big 6 Aviagen®) where fed three different diets (*Table 1*).

Feed and water administered to the birds was tested for the absence of *E. coli*, Enterobacteriaceae, *Clostridium* spp. and *Salmonella* spp. before it was offered. The diets were administered from day 4 onwards after the birds were preventively treated with colistin at the dose recommended by the manufacturer. On day 11 of the trial, all the birds were challenged with 1.38x10^8 CFU of *E. coli* O78 serotype, an APEC which was isolated during an incidence of colisepticemia in a turkey flock in Italy, 2014. The strain was found to be resistant to enrofloxacin. On day 4 of the trial, one animal per group was sacrificed by cervical dislocation in order to confirm the absence of the *E. coli* O78 as well as any other *E. coli* strain. All other animals were left in the pens to grow. On day 20 and 30 of the trial, ten birds from each group were sacrificed by cervical dislocation and examined by bacteriological analysis and lesion score assessment.

"A holistic approach that includes proper management, proper vaccination measures and the right nutritional design are needed in order to prevent the spread of *E. coli*."

Table 1.
Experimental diets

Negative control (NC)	Standard diet
Positive control (PC)	Standard diet + enrofloxacin supplemented in the water at 0.50 mL/L (from day 11 to day 20 of the trial)
Biotronic® Top liquid (BTR)	Standard diet + Biotronic® Top liquid supplemented in the water at 1.25 mL/L (during the whole period)

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Table 2.
Lesion scores and their descriptions

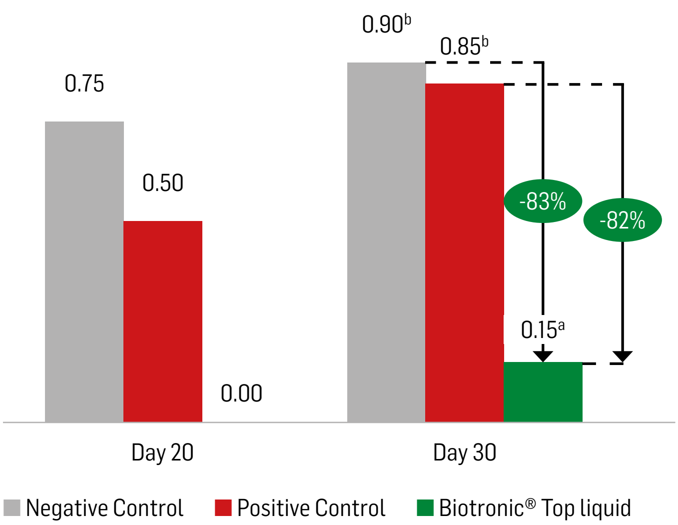
Lesion Score	Description
0	No lesions
0.5	One yellow or brown pin-head sized inflammatory spot
1	Two or more pin-head sized inflammatory spots
2	Thin layer of fibrinous exudate in various locations
3	Thick and extensive fibrinous exudation

Adapted from Van Eck and Goren, 1991.

Lesion scores

Liver lesions of the sacrificed animals were scored using a slightly modified version of that described by Van Eck and Goren (1991) (*Table 2*). The mean lesion score was calculated for each group. There were no signs of lesions on day 20 in the Biotronic® Top liquid (BTR) group. However, results

Figure 1.
Average lesion score of the liver content



(Different superscripts differ significantly (P<0.05))

Source: BIOMIN

were not found to be significantly different from the negative control (NC) or positive control (PC). On day 30, the lesion score for the BTR group was significantly different ($p<0.05$) from both the PC and NC (*Figure 1*).

E. coli count

E. coli were isolated from both the intestinal tract and the liver, and were further enumerated using appropriate buffers and agar. Biotronic® Top liquid supplemented to the water reduced *E. coli* counts in the intestinal tract and liver of turkeys. On day 20 and day 30, *E. coli* counts in the intestinal tract of turkeys in the BTR group were significantly reduced ($p<0.05$) compared to NC and PC as shown in *Figure 2*. On day 20 and day 30, no *E. coli* counts were found in the liver samples of the BTR group, whereas the NC and the PC groups were both found to be positive for *E. coli*. On day 30, the *E. coli* count in the liver was significantly lower ($p<0.05$) in the BTR group compared to NC and PC (*Figure 3*).

Biotronic® Top liquid: a profitable solution

The treatment of colibacillosis in poultry should take into consideration the costs of treating flocks with the correct dosage for a sufficiently long period, and the rising percentage of isolated *E. coli* that are resistant to bacterial drugs. The diagnosis of colibacillosis is mainly based on the clinical features and the typical macroscopic lesions. But in order to confirm infection, *E. coli* need to be isolated and identified. Further, bacterial resistances need to be excluded. All these steps take time, leading to losses in production when the analysis needs to be outsourced. They can also lead to wrong decisions being made when it comes to selecting the right therapy to be adopted. In this case, treatment with a commonly used antibiotic (enrofloxacin) would not have been effective, as highlighted by the results, because the bacteria used for the challenge was resistant to this specific drug. This is why it is important to work on a prevention strategy against colibacillosis rather than relying on therapy alone.

Conclusion

A holistic approach that includes proper management, proper vaccination measures and the right nutritional design are needed in order to prevent the spread of *E. coli* and hence colibacillosis in turkeys but also in poultry. The use of feed additives like the enhanced acidifier Biotronic® Top liquid can support the replication reduction of pathogenic bacteria in the animal, and the product can play a crucial role in reducing environmental *E. coli* contamination.

Reference

Pan, D. and Yu, Z. (2014). Intestinal microbiome of poultry and its interaction with host and diet. Gut Microbes 5(1): 108 – 119.

Van Eck, J.H. and Goren, E. (1991). An Ulster 2C strain-derived Newcastle disease vaccine: vaccinal reaction in comparison with other lentogenic Newcastle disease vaccines. *Avian Pathology* **20**(3) pp. 497-507.

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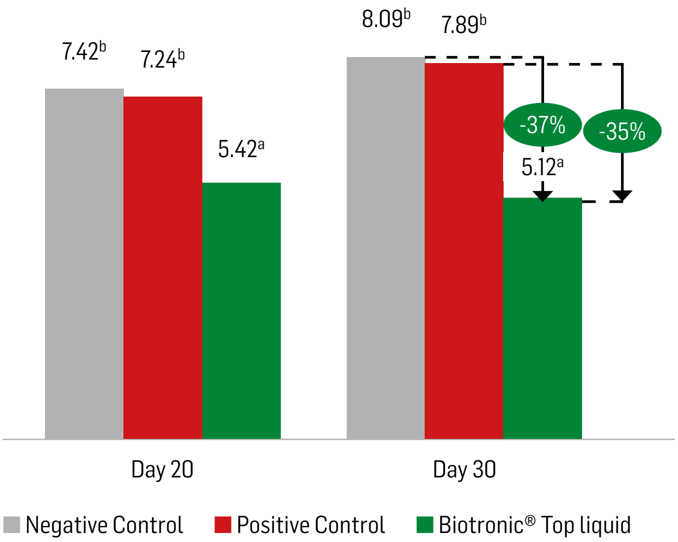
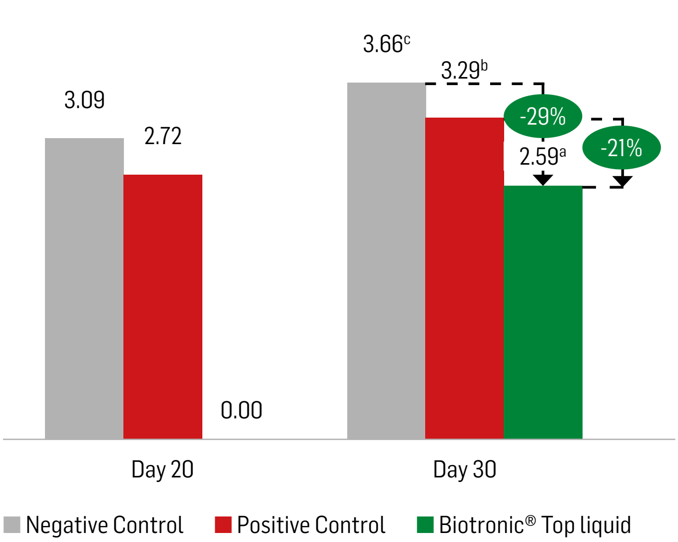
Figure 2.
Average *E. coli* count of the intestinal content



(Different superscripts differ significantly ($P<0.05$))

Source: BIOMIN

Figure 3.
Average *E. coli* count of the liver



(Different superscripts differ significantly ($P<0.05$))

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