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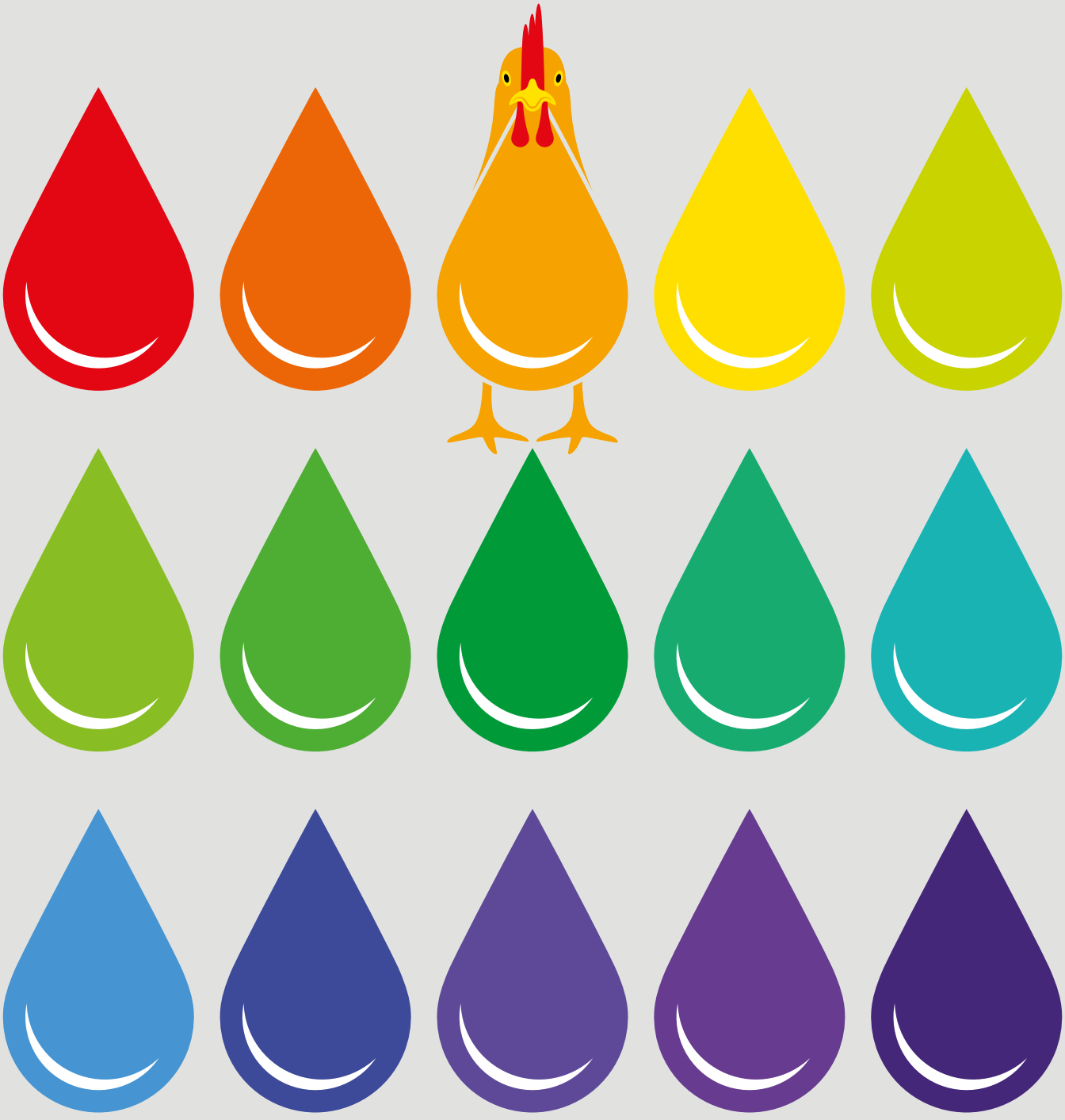
How to improve poultry drinking water quality with acidification

10 tips to control Campylobacter

Proving the efficacy of Biotronic® Top liquid in water sanitation



Water management and acidification

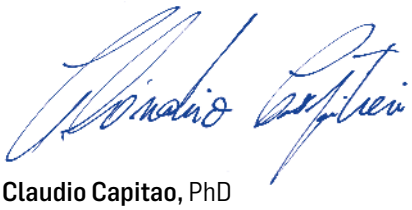
Water Management and Acidification

Poultry production is very complex, with many factors under constant scrutiny by managers and owners during each production cycle. The key to keeping naturally ahead is to pay special attention to all inputs, applying suitable management techniques and strategies to adjust conditions to optimize performance outputs. One farm input that is frequently overlooked in both layer and broiler units is the water supply.

In this issue of Science & Solutions, the BIOMIN team explains how important water is for poultry production, not only in terms of quantity, but also quality. Many farms simply connect to the local or town water supply without checking its quality or cleanliness. The use of organic acids can dramatically improve the quality of water by decreasing bacterial counts. Additionally, lowering the pH of the water in the crop can indirectly improve the digestibility of the feed, leading to further performance benefits.

Campylobacter is one of the biggest concerns on any poultry farm. Although research is ongoing, there is no vaccine against *Campylobacter* currently available. Birds are able to carry *Campylobacter* without showing any signs, which makes control of these bacteria particularly difficult. As Mark Karimi and Richard Markus explain in the second article, prevention is the best way to tackle *Campylobacter*, and they offer ten tips on doing so.

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



Claudio Capitao, PhD
Product Manager

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How to Improve Poultry Drinking Water Quality with Acidification

Andrew Robertson
Poultry Technical Manager

Without enough water, chickens are unable to reach their performance potential. However, ensuring an adequate water supply is not enough. Careful and thorough water management is necessary on a daily basis to prevent any of a number of health issues that will result from poor water hygiene. Adding an acidifier to the water can help maintain water quality and promote bird performance.

Water has often been called "the forgotten nutrient" and not without reason. In many cases, it is assumed that water will be available for the chickens to drink, and that it requires little or no maintenance to keep an adequate supply. Often, little thought goes into whether or not the water is suitable for the birds to drink.

A chicken will drink anywhere between 1.8 to 3 times the amount of food it eats, dependent on the strain, housing conditions and temperature. An inadequate quantity of water will therefore directly reduce feed intake, negatively affecting performance. The removal of water from a flock in lay will halt egg production very rapidly, and when combined with the removal of feed as well, will induce moulting.

IN BRIEF

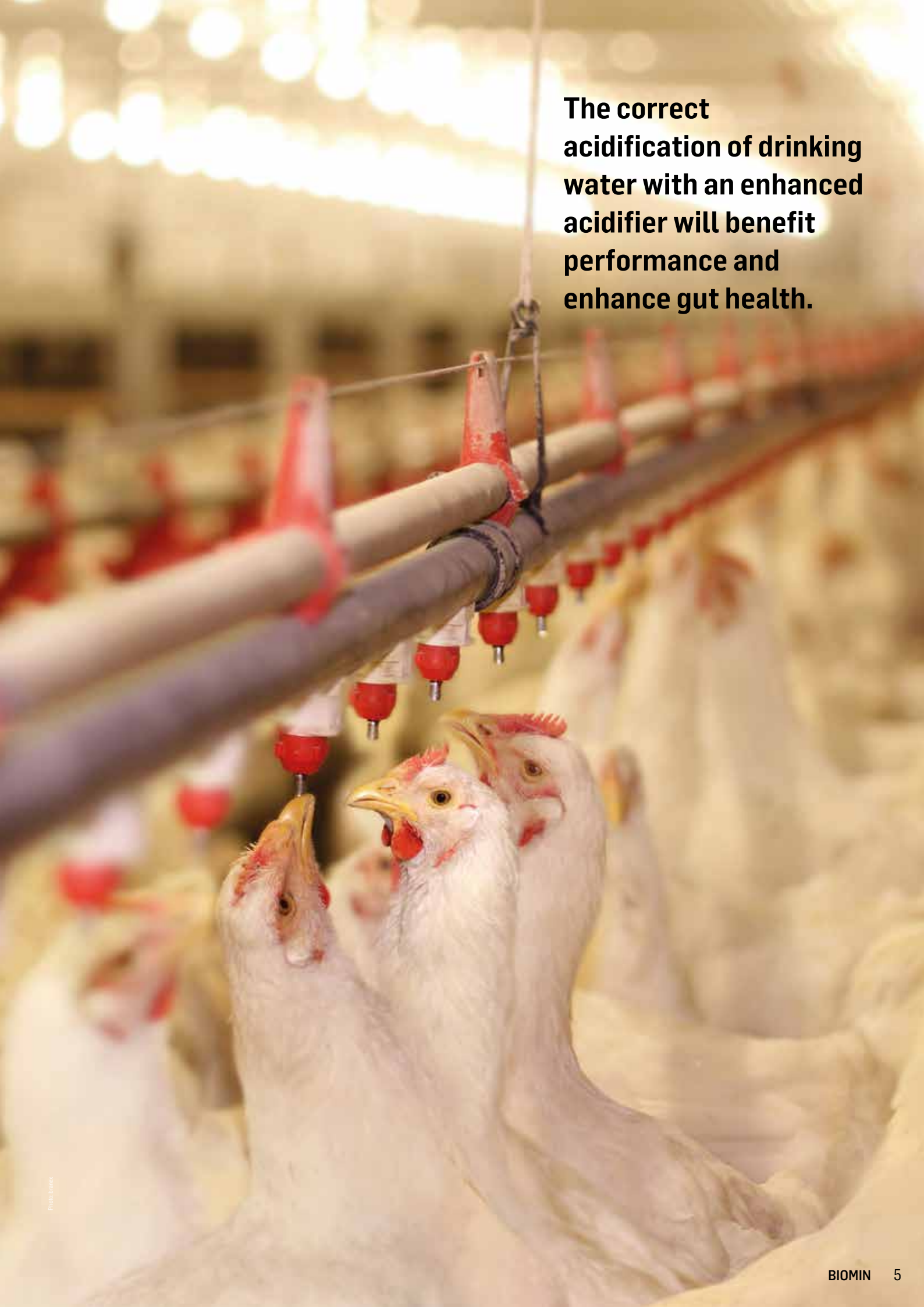
- Water should be supplied at the highest possible quality and in abundant quantities to maximize flock performance.
- All pipes and drinking equipment should be kept as clean as possible during the production cycle, and chemical cleaning of the water system should be carried out between flocks.
- An enhanced organic acid product, such as Biotronic® Top liquid, should be added to the water supply to reduce bacteria and increase the digestibility of the feed.

Water vaccination

Water is also the medium of choice for administering live vaccines to chickens. This method is applied whenever possible as it has a markedly reduced stress factor for the chickens, as well as a lower cost of administration. Vaccination is always best carried out in the morning when the birds have had a natural period of water deprivation overnight, and will be less stressed compared to inducing thirst through a physical deprivation later in the day. The early morning is also the natural time for the birds to eat after the night, so they will eat and drink more readily at this time.

Water quality

Water is one of many vectors that can transport pathogens such as bacteria, viruses or protozoa into the poultry house. Some diseases, such as infectious coryza and *Haemophilus paragallinarum* can also spread through the drinker system, especially if it is a non-nipple system.



The correct acidification of drinking water with an enhanced acidifier will benefit performance and enhance gut health.

Photo: Biomin

Therefore, water hygiene must be considered an integral part of any biosecurity programme. Part of this will include regular water quality checks, including measuring both dissolved salts and, more importantly, bacterial contamination. To be considered acceptable, water should contain less than 100 CFU/ml of coliforms and less than 100,000 CFU/ml of total bacteria (*Table 1*). There should be no *Salmonella* contamination in the drinking water. Where water does not comply with this standard, steps should be taken as quickly as possible to rectify the areas that are failing.

Five tips for ensuring good water quality

Tip 1
Apply water sanitization

In order to maintain water quality, it is advisable to use some form of water sanitization. The most common method uses chlorine, dosed either into a holding tank or directly through a dosing machine into the water in the house. Town water is usually chlorinated to a level of 3 ppm at the point of entry into the house. However, by the time water reaches the last drinker in the house, this may have reduced significantly depending on cleanliness and any organic matter in the pipes. It may be advisable to increase the level of chlorination on farms to offset this possible loss in efficacy.

Tip 2
Test water quality regularly

Water should be tested frequently in order to ensure that its quality is stable, and that dosing equipment is functioning correctly. To do this, water should be collected from the farthest point of entry into the house, the last drinker. The degree of water sanitation, or lack of it, varies considerably across the globe, from sophisticated systems in some developed countries to no sanitation at all in several developing countries.

Tip 3
Check for biofilm

In many parts of the world the levels of hardness, dissolved solids in the water, are quite high, which increases the pH to the upper end of acceptable levels. These salts, especially calcium or magnesium salts, can form deposits in the water pipes that can ultimately reduce water flow. Additionally, they can also encourage the build-up of biofilm in the pipes by providing attachment sites for bacteria to lodge. Biofilm is a living colony of microorganisms comprising bacteria, algae, fungi and even protozoa. This living colony is protected by an accumulation of filamentous proteins excreted by some of the bacteria, which over time can further reduce the flow of water through the pipes. The different types of pathogens found in biofilms are quite extensive as shown in *Table 2*.

Table 1.
Parameters of acceptable water quality

Parameter	Drinking water for poultry	
	Good quality	Do not use
pH	5-8.5	<4 and >9
Ammonium* (mg/l)	<2.0	> 10
Nitrite (mg/l)	<0.1	>1.0
Nitrate (mg/l)	<100	> 200
Chloride (mg/l)	<250	> 2,000
Sodium (mg/l)	<800	> 1,500
Sulfate (mg/l)	<150	> 250
Iron (mg/l)	<0.5	> 2.5
Manganese (mg/l)	<1.0	> 2.0
lime/chalk content (°dH)	<20	> 25
oxidizable organic matter (mg/l)	<50	> 200
H_2S (mg/l)	non detectable	non detectable
Coliform bacteria (CFU/ml)	<100	> 100
Total germ count (CFU/ml)	<100,000	> 100,000

*If the pH becomes alkaline, ammonium (NH_4+) turns into ammonia (NH_3), the toxic form

Source: ISA Management guide, 2014

Table 2.
Some of the pathogens isolated from biofilms

E. coli spp.	*Staphylococcus aureus*
Salmonella spp.	*Listeria monocytogenes*
Pseudomonas spp.	*Mycobacteria* spp.
Helicobacter spp.	*Cryptosporidium parvum*
Legionella spp.	*Giardia lamblia*
Vibrio cholera	Amoeba
Klebsiella spp.	Enteroviruses (and other viruses)

Source: BIOMIN

Tip 4
Thoroughly clean the water system between flocks

Thorough cleaning of the water system between flocks is strongly recommended, using products that can remove both the biofilm and any limescale present. This often requires a two-strategy approach with a product such as hydrogen peroxide to remove the biofilm, and an acid product to remove the limescale in hard water areas.

The build-up of biofilm can be reduced during production by regularly flushing out water lines. This should be done under water pressure of between 1.5 and 3.0 bars (20 – 40 PSI). Flushing of water lines should be carried out at least once per week, and more often in hot climates to ensure good results.

This will reduce the risk of parts of the biofilm breaking loose in the water pipes and causing an obstruction in the drinker valves, or releasing undesired pathogens into the water supply. Any remaining residues of water treatment should be removed immediately after the treatment by flushing the system.

Hard water increases the pH of the water. Today, there is some debate over the recommended acidity/alkalinity of water, with current views tending towards reducing the pH to the lower levels, between pH 4 and pH 5. This is in order to create a pathogen-static environment, thereby limiting their development in the water lines.

Tip 5
Aim for the optimal pH level

When chicks hatch, they have an immature gut, and the production of acids in the proventriculus and gizzard is reduced in the first seven to fourteen days. Experimental work showed that the pH level of the proventriculus ranged from 5.2 at day one to 3.5 at day 15, with a linear reduction between hatching and day ten of age. Similarly, the pH in the gizzard dropped from 3.5 to 3.3 between day one and day ten, then stabilizing at a pH of 3.3 at day 15 (Rynsburger, 2009).

Care needs to be taken when acidifying water to ensure that the correct amount of acids are applied to reach the desired pH of 4.5 of the drinking water. Failure to do this can result in either over-acidification of the water, which can hinder water intake and damage the equipment, or an under-acidification, which can then provide an energy source to the bacteria residing in the water line.

Four benefits of water acidification

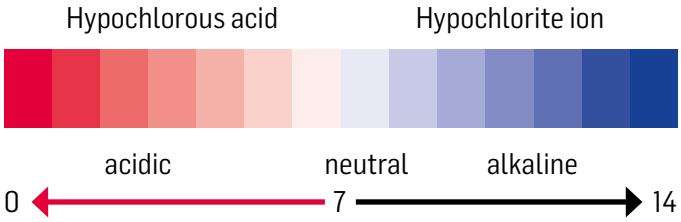
Many companies are employing chlorination as a way to sanitize water, either by having access to town water or adding chlorine to water on the farm. However, the efficacy of chlorination depends on the formation of hypochlorous acid, which has stronger antimicrobial activities than the hypochloride ion. The level of hypochlorous acid produced will be dependent on the pH of the incoming water (*Figure 1*).

Benefit 1
Acidification prevents bacteria from reproducing

Most pathogenic bacteria are Gram-negative and as such are sensitive to acidic environments, which have a bacteriostatic effect. When a chicken is drinking twice the quantity it eats, the acids in the drinking water can have a beneficial effect in the crop, reducing pathogenic development.

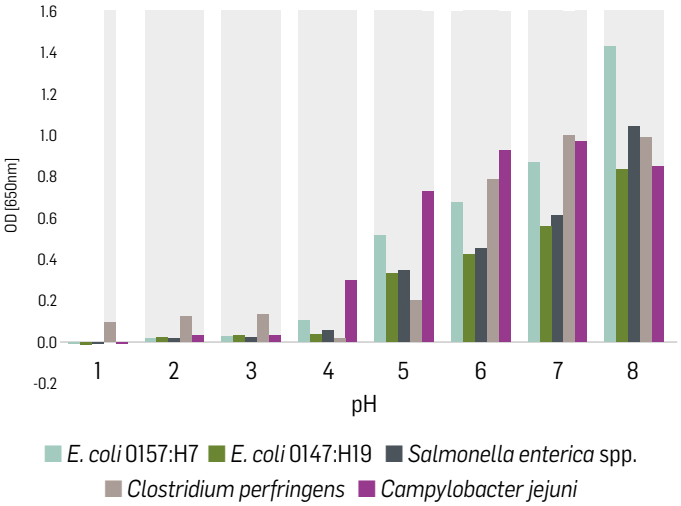
Figure 2 shows that below pH 5, many pathogens are stable and not increasing. However, pathogenic bacteria will start rapidly multiplying once the pH goes above pH 5, peaking at pH 7 – 8. While Gram-negative bacteria are sensitive to acids, they also have an in-built protection against water-soluble agents in the lipopolysaccharide

Figure 1.
Effect of pH on the proportion of hypochlorous acid when chlorinating water



Source: BIOMIN

Figure 2.
Effect of pH on pathogenic bacterial development



Source: BIOMIN

outer membrane of their cell wall. This limits the passage of antimicrobial agents into the cell wall, thereby giving them a degree of protection.

However, adding a permeabilizing agent to the acidifier, for instance Biotronic® Top Liquid, can increase the direct antimicrobial activity in the drinking water and in the upper intestinal tract. This is due to the disruption of the outer lipopolysaccharide layer by the permeabilizing complex, enabling a greater uptake of acids into the cell, enhancing the antimicrobial effect.

Benefit 2
Acidification does not affect in-feed probiotics (direct-fed microbials)

Many of the probiotics rapidly gaining popularity in poultry production are Gram-positive. They are either lactobacilliales, lactic acid producing bacteria, or sporulated bacillus bacteria, which are much less sensitive to acidic environments. As a result, acidifying drinking water has no impact on probiotic products in feed.

If probiotics are administered in the drinking water via a dosing machine, and only one dosing machine is available,

water acidification should be stopped during the time the probiotics are administered, and then recommenced once they have been consumed. A similar approach should be taken when vaccinating through the water supply. If the vaccine is applied directly into the header tank, this will have no detrimental impact on the probiotics, but the water should not be acidified when vaccinating.

Benefit 3
Acidification helps keep limescale and biofilm at bay

Acidification of the drinking water can also reduce the build-up of limescale in the drinker lines, which in turn will also reduce the levels of biofilm due to a lower level of bacterial contamination. This will not negate the need to clean the drinker lines between flocks, but it may help prevent blockages or leaking drinkers caused when biofilm breaks loose within the pipelines, affecting drinker function.

Benefit 4
Acidification can help early protein digestion

Acidity also plays a major factor in the transformation of pepsinogen to pepsin, which is essential for protein digestion. Lysine digestibility in day-old broilers is 78%, but rises to above 89% by 14 days of age (Batal and Parsons, 2002). Therefore, acidification of the water may benefit early protein digestion by slightly reducing the buffering of the feed passing from the crop to the proventriculus.

Chick starter diets are one of the most buffered diets the animal will receive, with the exception of layers and breeders in production, due to the calcium and protein content. This may explain increasing successes in acidifying drinking water in the early stages of production.

Biotronic® Top liquid

The correct acidification of drinking water with an enhanced

acidifier, such as Biotronic® Top liquid from BIOMIN, will benefit performance and enhance gut health through microbial modulation, reducing the pathogen challenge in the intestine and increasing protein digestion. Adding Biotronic® Top liquid goes further to inhibit bacterial growth and prevent limescale and biofilm build up, while also boosting early protein digestion without interfering with in-feed probiotics.

Conclusion

Water is an essential part of optimal flock performance. However, since water is able to transport pathogens into the poultry house, its quality and management is extremely important. Sanitization, regular testing, checking for biofilm in pipes and thoroughly cleaning lines between flocks can all help to ensure water quality is as high as possible. Adding an enhanced acidifier product will deliver additional performance benefits as well as reducing the level of bacteria in the water.

Reference

Batal, A.B. and Parsons, C.M. 2002. Effects of age on nutrient digestibility in chicks fed different diets. Poultry Science, v.81. 400-407.

ISA Management Guide. 2014. Management Guide: Alternative production systems. ISA: A Hendrix Genetics Company. [On-line]. Available at: http://cpif.org/wp-content/uploads/2014/04/ISA-Alternative-Productions-Management-Guide-copy.pdf. [Accessed 16.09.18].

Rynsburger, J.M. 2009. Physiological and nutritional factors affecting protein digestion in broiler chickens. Master Thesis. University of Saskatchewan. [On-line]. Available at https://ecommons.usask.ca/bitstream/handle/10388/etd-09182009-184057/JMRMScThesis.pdf [Accessed 22 May 2018].

10 Tips to Control *Campylobacter* on Your Poultry Farm

Understand the scope and extent of the risk posed by *Campylobacter* in broilers, and apply these 10 tips to make improvements to food safety.

Mark Karimi MSc
Technical Sales Manager Poultry

Richard Markus PhD
Key Account Manager Europe

Campylobacter makes people sick at a cost of billions per year

Campylobacter spp. is one of the most important food-borne bacteria, causing gastroenteritis in humans. Campylobacteriosis is considered the most frequently reported food-borne disease in humans in developed countries.

The annual cost of campylobacteriosis to public health systems, including the loss of individual health and productivity is estimated at:

- over €2.4 billion in the EU
- US$1.2 to $4 billion in the United States

Worryingly, the number of confirmed *Campylobacter* spp. infection cases in humans has gone up in recent years, as shown in *Figure 1*.

Poultry under the spotlight

Campylobacter spp. are part of the microflora present in the digestive tracts of many wild and domestic animals including pigs, cattle and poultry, without inducing clinical signs.

However, scientists around the world widely agree that poultry products, including meat, are the primary source of campylobacteriosis in humans.

According to the European Food Safety Authority (EFSA), in 2017, 37.4% of 13445 sampling units (single and batch samples) of fresh broiler meat were found to be positive for *Campylobacter* spp. This number for turkey birds were 31.5% (in 1028 sampling units tested for campylobacter). The proportion of positive units in poultry birds, other than broilers and turkeys were 27.7% (in 1425 sample units).

In light of the economic and health problems associated with campylobacteriosis, serious discussions between government officials in different countries about the possibility of imposing obligatory controls for reducing *Campylobacter* spp. in poultry operations have been started.

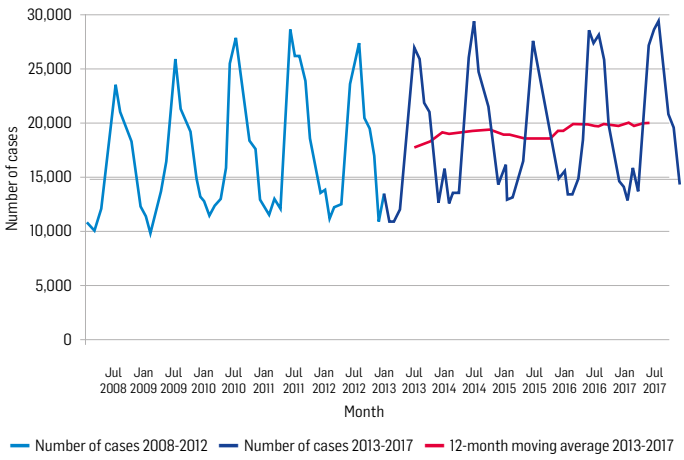
Why *Campylobacter* spp. is hard to control

Campylobacter bacteria do not proliferate outside the alimentary tract of warm-blooded animals. They can survive up to several weeks in food products, particularly those stored at low temperatures. *Campylobacter* spp. colonize the mucosa of the cecum and cloaca crypts of infected chickens. They may also infect the spleen and liver, and circulate in the blood.

IN BRIEF

- *Campylobacter* is one of the most common and costly food-borne bacteria, infecting humans primarily through contaminated poultry products.
- Chickens can carry *Campylobacter* without exhibiting any signs or symptoms of illness, hence it is not recognized or treated as a pathogen in poultry flocks.
- Prevention is the most effective tool against *Campylobacter*. Follow the 10 tips suggested in this article to prevent contamination in poultry products.

Figure 1.
Trend in reported confirmed human cases of campylobacteriosis in the EU/EEA, 2017



Source: EFSA, 2016

A single gram of infected chicken feces can contain up to one hundred billion *Campylobacter*. Even this level of infection may not cause changes in cecal mucosa.

In commercial production, birds carry high levels of *Campylobacter* spp. in the intestine as part of their normal microflora without showing any signs of clinical disease. In addition, there is no change in mortality or feed conversion rates in infected flocks.

When and how *Campylobacter* infect poultry

The prevalence of *Campylobacter*-positive poultry flocks is generally high, though this varies by region, season and production type (intensive, free range, organic, etc.). In some cases, the contamination is as little as 2% of the flock, and in other cases, contamination can reach 100%.

It is rare to find *Campylobacter* in birds younger than three weeks old. Scientists believe that this may relate to the presence of maternal antibodies and the rapid development of a chick's gastrointestinal tract and microbiota. However, after three weeks, even if one bird in the flock becomes infected, the whole flock can be infected in less than four days.

Vectors of *Campylobacter* transmission include:

- Feces
- Insects
- Water
- Rodents
- People
- Vehicles
- Equipment

Effective vaccine lacking

Work to develop vaccines against campylobacteriosis both in animal and human health sectors is already well established.

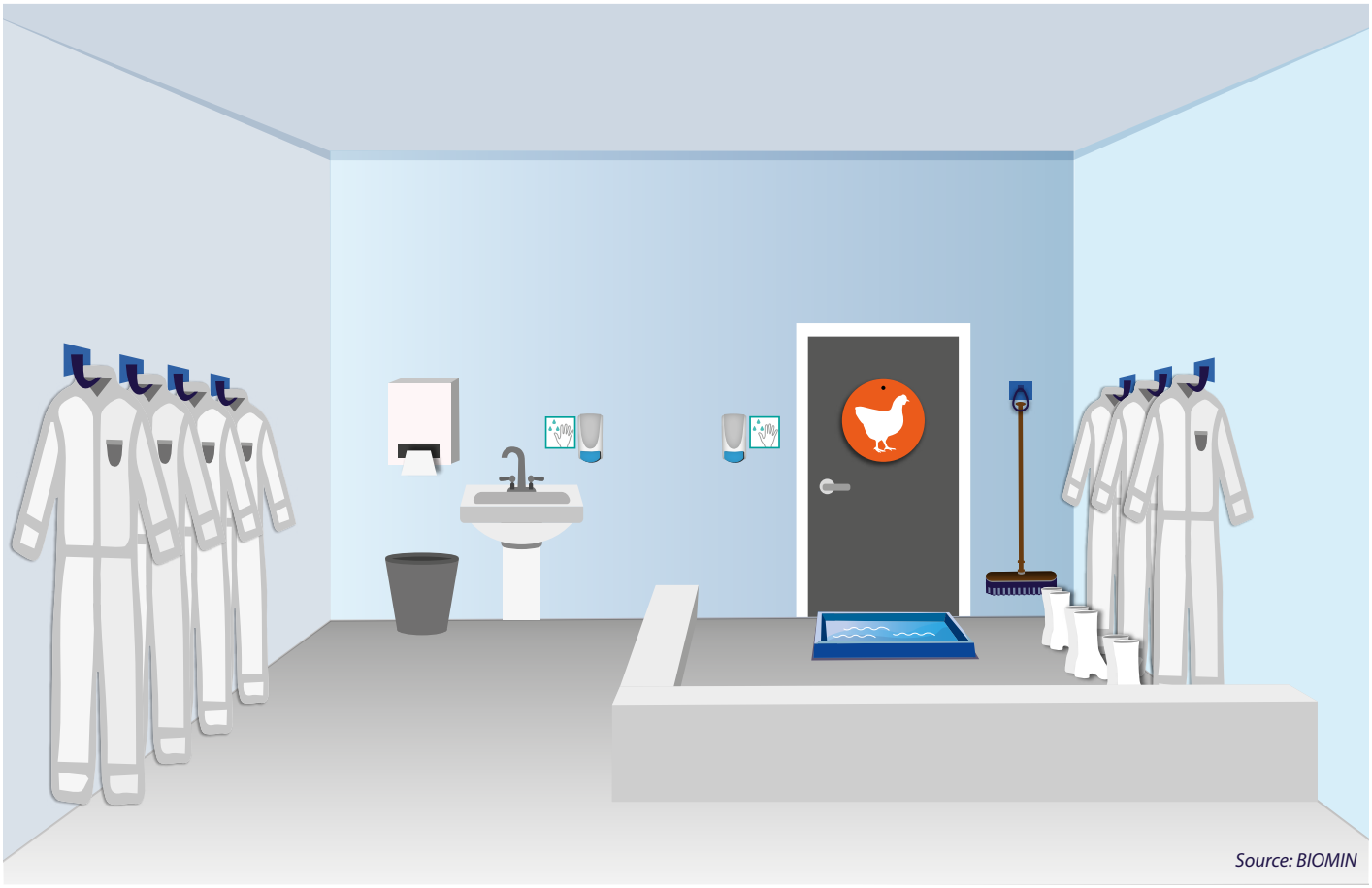
Within the human sector, no vaccine to prevent *Campylobacter*-associated illness has been approved by a regulatory authority anywhere in the world. The main problem likely stems from an incomplete understanding of *Campylobacter jejuni* pathogenesis and antigenic diversity, as well as its association with some post-infectious syndromes.

Within the poultry industry, numerous strategies have been developed and experimentally checked in attempts to create an effective vaccine. However, no efficient vaccine against *Campylobacter* is currently available.

Why antibiotics are not effective against campylobacter infection in poultry

Campylobacter spp. is not recognized as a specific pathogen under commercial conditions. Therefore, treatment of the flock is not a consideration. One must be cautious of the zoonotic risk associated with *C. jejuni* and its ability to rapidly develop antibiotic resistance. In reality, an antibiotic control strategy would not be a practical choice for management of *Campylobacter* on commercial poultry farms.

Figure 2.
Illustration of a dwarf wall in a poultry house



Scandinavian experiences point to a preventive approach

Scandinavian countries have historically had a much lower prevalence of campylobacteriosis compared to elsewhere. The approach to *Campylobacter* control in Scandinavia is based on prevention. A preventative approach spans the entire broiler meat production chain from farm to fork.

A preventative approach to *Campylobacter* focuses on three main risk factors:
1. Poultry flock prevalence
2. Carcass contamination
3. Kitchen hygiene

Among these three, flock prevalence is likely the most important one. Poultry flock prevalence can be addressed in two ways, namely by 1) preventing birds from being infected by *Campylobacter* and 2) reducing the concentration of *Campylobacter* within birds' gastrointestinal tracts. Biosecurity plays a role in both types of prevention. Here are 10 tips for maintaining high levels of biosecurity and keeping *Campylobacter* at bay.

Tip 1
Segregate the clean and dirty areas of the poultry house entrance with a physical barrier (dwarf wall)

A dwarf wall (*Figure 2*) represents a small investment, though they are widely appreciated on farms that have them because they help stop the cross contamination of *Campylobacter* and other pathogens.

- ✔ Use dedicated footwear and overalls in the clean area for the entire growing cycle.
- ✔ Have one disinfectant bath inside the clean area and one disinfectant bath outside the clean area directly in front of the actual chicken house door.
- ✔ Better to permanently keep clean footwear in the disinfectant bath when not in use. Change the content of the disinfectant baths every three days.
- ✔ Clean the area within the wall boundary regularly with a dedicated dustpan and broom that stay within the clean area and is not used anywhere else.

EFSA found *Campylobacter* in nearly 50% of fresh broiler meat samples!

Photo: Sebastian Kaulitzki/Science Photo Library

Tip 2
Keep equipment in the poultry house for the whole cycle

Things such as stepladders, buckets, catching bird fences, brooms, etc. should stay in the poultry house for an entire cycle. Avoid transporting these items from one house to another to reduce the risk of contamination.

Tip 3
Practice regular hand hygiene

Equip the entrance of each poultry house with a sink or wash basin with warm water, soap, paper towels, and hand sanitizer. If the full list is cost prohibitive, be sure to stock up on hand sanitizer, which can still be a big help.

Tip 4
Wear disposable overalls

Disposable overalls are a cheap and practical way to greatly reduce cross contamination. Be sure to dispose of them after each house visit.

Tip 5
Apply rodent control

Most farmers are familiar with the process of rodent control. It is important to follow through with the opening, cleaning, and placing of new bait in rat bait stations at the beginning of each crop. Remember to record rodent observations and dates. Rodent bait suppliers are able to provide more education and training as required.

Tip 6
Ensure good water quality

Regardless of the quality of water coming to your farm, the drinking water system should be properly cleaned and maintained to prevent it becoming a vector for pathogens. It is common to wash and clean lines at the beginning and end of each crop, but this overlooks hygiene measures that can be taken during the growing period. Chlorine, hydrogen peroxide and acidifiers are commonly used to ensure proper water sanitation, control water hardness and acid levels, and prevent biofilm.

Tip 7
Withdraw feed between 8 and 12 hours prior to slaughter

Broilers' gastrointestinal tract is emptied and flattened with relatively mild sloughing after 8 to 12 hours of fasting. The extent of cross-contamination will be considerably decreased if birds experience a correct feed withdrawal period before their transport to the slaughterhouse.

Birds that have had a proper feed withdrawal period prior to their entry to the slaughterhouse may carry less contamination on their feathers and feet, etc., because they excrete much less fecal material during transport. Also, cleaner birds going into scalding tanks may cause less contamination to the water which is largely recycled during the operation.

Do not withdraw feed too early. As withdrawal time increases over 14 hours, intestinal integrity will decrease and the probability of intestinal breakage and subsequent contamination will increase.

Tip 8
Educate catching and transport teams

Catching teams are one of the main sources of *Campylobacter* cross-contamination between farms. Stress makes birds more susceptible to pathogens as well. Ensure that all visitors and staff adhere to your biosecurity protocols, and follow proper catch and transport procedures in order to keep stress and disease to a minimum.

Tip 9
Discuss lairage and slaughterhouse practices

Cross-contamination between slaughterhouse and farms is another major cause of *Campylobacter* occurrence in farms. Catching vehicles contaminated during transport may travel to three or four farms every day. Catching crates should be properly cleaned and disinfected after each delivery.

Birds may be kept in lairage (I.e the factory yard) or even in the transport vehicle for up to six hours. In such conditions, birds shed a considerable number of microorganisms present in their gut, including *Campylobacter*.

Speak to your slaughterhouse manager regularly to see that the necessary steps are followed and that everyone involved understands their roles and responsibilities.

Tip 10
Control contamination within the birds' gut

Certain feed additives that support gut health and integrity can play a role in limiting *Campylobacter* growth and colonization. Look for probiotic products that support beneficial bacteria: these competitively exclude harmful or unwanted bacteria in the birds' gastrointestinal tracts by colonizing the gut and using up nutrients before problems arise; a microbial solution to a microbial problem.

Reference

European Food Safety Authority. (2016). The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2017.

Proving the efficacy of Biotronic® Top liquid in water sanitation

Seung Hwan Jeong MSc, DVM
Technical Sales Manager Poultry

Biotronic® Top liquid reduced *E. coli* counts in the intestinal tract and liver, and reduced colibacilliosis lesion scores.

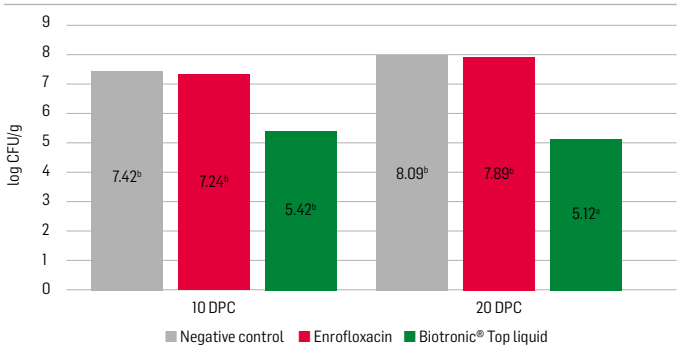
A trial was conducted to evaluate the efficacy of Biotronic® Top liquid on the reduction of *E. coli* in the gut and liver of poultry in a challenge model compared with broad spectrum antibiotics.

In this trial, three groups of 60 1-day-old female turkey were assigned: a control group without a water sanitation program, an antibiotic group with 0.5 ml of enrofloxacin per liter of drinking water, and an organic acid group with 1.25 ml of Biotronic® Top liquid per liter of drinking water. At 10 days old, all birds were orally challenged with *E. coli* O78 ($1.3x10^8$ CFU/mL). Ten birds from each group were sacrificed at 10 and 20 days post challenge (DPC) for bacterial count and lesion scoring.

In this trial, Biotronic® Top liquid in water showed efficacy in reducing the number of *E. coli* in the intestinal tract and liver (*Figures 1* and *2*). Lesion scores at 10 and 20 DPC also showed that Biotronic® Top liquid could protect the birds from an *E. coli* challenge (*Figure 3*). All parameters evaluated in this trial indicated that Biotronic® Top liquid was the most effective tool to reduce the risk of bacterial infection in poultry production.

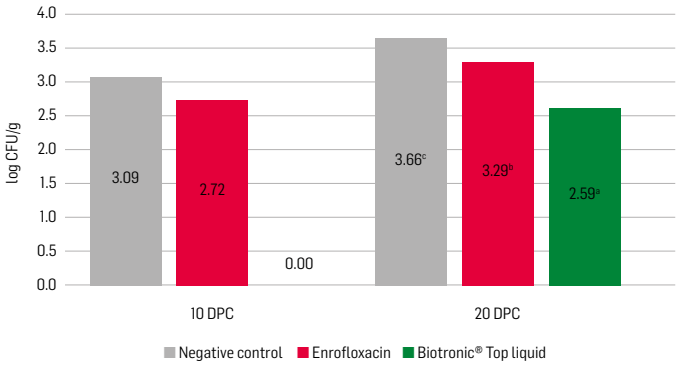
For more information about Biotronic® Top liquid, please contact your local BIOMIN representative or visit our website: https://www.biomin.net/en/products/biotronic/

Figure 1.
E. coli count results in intestinal tract (log CFU/g)



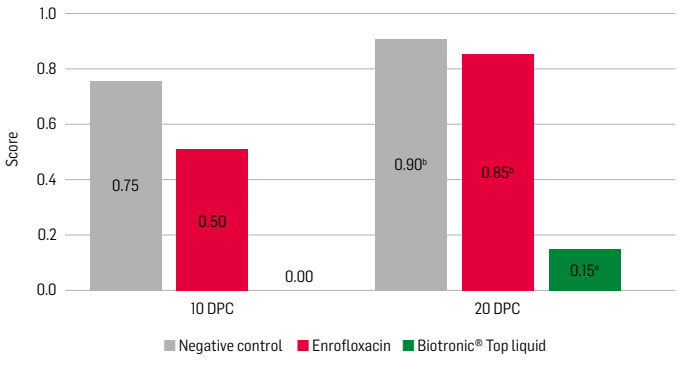
Different superscripts indicate statistically significant differences ($P<0.05$)
Source: BIOMIN

Figure 2.
E. coli count in the liver (log CFU/g)



Different superscripts indicate statistically significant differences ($P<0.05$)
Source: BIOMIN

Figure 3.
Lesion score[1] for colibacillosis



Different superscripts indicate statistically significant differences ($P<0.05$)

[1] Lesion scores (graded 0 to 3): 0 = no lesions; 0.5 = one yellow or brown pinhead-sized spot indicative of inflammation; 1.0 = two or more pinhead-sized spots indicative of inflammation; 2.0 = thin layer of fibrinous exudate on various locations; 3.0 = thick and extensive layer of fibrinous exudate.

Source: BIOMIN

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