Respiratory disease – the biggest problem in horses

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The respiratory tract in horses is prone to various problems, ranging from allergic reactions and inflammation to infections. Through early diagnosis, appropriate treatment, and preventive measures, horse owners can help maintain the respiratory health of their horses and promote their well-being and performance.

Respiratory diseases are a constant topic of suffering and irritation among horse owners. According to a study published in 2005, respiratory diseases account for about 40 % of all equine internal diseases recorded worldwide (Thein 2005).

The high-performance organ: the horse’s lung

The respiratory tract of our horses is a high-performance system with a large exchange surface between the inside of the body and the environment. The lungs enable the so-called gas exchange, i.e., the transfer of oxygen from the air into the horse´s bloodstream. Only when this gas exchange functions properly can the horse supply its muscles with sufficient oxygen.

Even at rest, about 50 to 80 liters of air per minute enter the lungs of a 600 kg horse. With increasing load, this value can rise up to 2.000 liters per minute at maximum load. If a horse is healthy, it breathes calmly and slowly and takes eight to sixteen deep breaths per minute.

In order to protect the lungs as best as possible from harmful influences, the entire respiratory tract is equipped with a special mucous membrane. When irritated by pathogens or foreign bodies, for example, this mucous membrane forms more mucous and transports it towards the mouth cavity with the help of the finest cilia. In this way, most harmful particles are usually intercepted quickly, reliably and, above all, effectively and, if necessary, coughed up before they can even reach the alveoli and cause damage there.

The most common causes of respiratory diseases in horses

Chronic obstructive bronchitis

Chronic obstructive bronchitis is better known as COB or equine asthma. COB is more common in horses that are regularly kept in dusty or poorly ventilated environments, such as cramped stables or pastures with high levels of mold. Inhalation of dust particles and allergens can cause inflammation of the respiratory tract, resulting in coughing, increased mucus expectoration and breathing difficulties. The clinical picture of COB can vary greatly. From occasional poor performance in show horses to chronic coughing with purulent nasal discharge or significant weight loss.

Tracheitis

Another common respiratory disease in horses is tracheitis. This disease is often caused by bacterial or viral infections. Young horses, older horses or those with a weakened immune system are particularly susceptible to tracheitis. Besides infections, irritating factors such as dust, smoke or chemicals can also irritate the mucous membrane of the trachea and trigger inflammation.

Hay fever

Hay fever, also know as allergic respiratory disease or allergic rhinitis, is a common condition that can also affect horses. Like humans, it is an allergic reaction to certain pollens, molds or other environmental allergens that are suspended in the air. Common signs include sneezing, a runny nose and itchy eyes.

However, some horses may also suffer from coughing or respiratory symptoms. Hay fever in horses can occur seasonally, depending on the pollen seasons. Depending on the region and season, the symptoms may be more serve during spring, summer or autumn.

Asthma

Asthma in horses, also known as equine asthma or heaves, is a chronic respiratory disease that occurs mainly in horses. It is similar to in many ways to asthma in humans. The main cause of this disease is hypersensitivity of the respiratory tract to dust, allergens or mold spores in the horse´s environment.

Respiratory distress or harmless rattling?

Horse owners know it – the four-legged friends have an impressive range of breathing sounds. But which are harmless, such as the exited trumpeting through the nostrils during a fright? And which ones could be symptoms of a respiratory disease?

Diagnosing respiratory problems in horses can be challenging because symptoms can often be non-specific and/or show signs similar to several diseases.

Snorting: When horses snort, it is a sign of relaxation. There is usually no cause for concern. Quite the opposite.

Snorting at gallop: Many horses snort rhythmically at a gallop. This is also considered harmless. Snorting is particularly common in thoroughbreds.

Coughing, for example when trotting: Occurs so often that it is often perceived as normal. But it is not. Coughing is always an alarm sign and can indicate an allergy, asthma or a viral or bacterial infection.

Whistling when inhaling: To be on the safe side, a veterinarian should be consulted.

Consequences of respiratory disease

Respiratory disease in horses can have significant economic consequences. If a horse suffers from chronic obstructive bronchitis or another respiratory disease, this can lead to various problems:

- Veterinary costs: The diagnosis and treatment of respiratory diseases often require veterinary visits, medication, and possibly further examinations such as x-rays or endoscopy.
- Reduced performance: A horse with respiratory problems may be severely limited in its performance. It may have difficulty breathing, which can have a negative effect on its athletic performance, equestrian work, or other activities.
- Downtime: During the treatment or recovery period, horses may have to take a break or be taken out of training. This may result in loss of income, especially if the horse was intended for competition or showing.
- Decrease in value: A horse with chronic respiratory problems may lose its value as a sport or breeding horse. Selling price might decrease and the demand for such a horse might decrease too.

To minimize economic impact, early diagnosis and treatment is important, as the implementation of appropriate preventive measures to reduce the risk of respiratory disease.

Prevention

Prevention of equine cough is of big importance to reduce the incidence and severity of the disease.

Clean stable environment

Dust is a common trigger of respiratory symptoms in horses. Regular removal of dust, dirt and mold spores from the stable and horse boxes can help to improve air quality and reduce respiratory stress.

Pasture management

When possible, horses should be allowed access to fresh pastures. The natural outdoor environment helps horses breathe cleaner air and inhale fewer harmful particles.

Hay feeding

Choosing high quality, low dust hay can reduce exposure to allergens. Moist soaking of hay before feeding can also help reduce dust levels.

Ventilation in the stable

Good ventilation in stables is essential to avoid stagnant air and dust accumulation. The use of fans or natural ventilation systems can improve air circulation.

Feed management

Feeding high quality feed that is free of mold and allergens can reduce the risk of respiratory problems. It is important to adjust feed rations to the individual needs of each horse.

Supplements

Supplements can play a positive role in the prevention of respiratory problems in horses if they are used selectively and with expert advice.

- Immune system support: Supplements such as vitamins, minerals and antioxidants can strengthen the immune system. A healthy immune system helps the horse to better defend itself against infections and inflammation of the respiratory tract.
- Certain supplements contain ingredients with anti-inflammatory properties, such as omega-3-fatty acids or herbal extracts. These can help reduce inflammation in the respiratory tract and thus reduce the risk of respiratory problems.
- Supporting respiratory health: Some supplements on the market have been specially designed to support respiratory function. They can help to regulate mucus production, improve respiratory protection, and facilitate the expectoration of mucus.
- Strengthening lung capacity: Certain ingredients in supplements can support the horse´s lung capacity and promote better oxygen uptake, which is important for performance and respiratory health.

Conclusion

If there are noticeable breathing sounds, coughing, fever or a drop in performance, the vet should come quickly. A respiratory disease tends to develop into a long-term problem if it is not treated appropriately. Without treatment, it can become chronic in some cases. Fresh air and species-appropriate husbandry, as well as feed that is free of mold und dust, are the first steps to supporting the normal function of your horse´s respiratory tract. Supplements can be an excellent tool for prevention. A holistic approach to equine health is crucial. This includes proper stable and feed hygiene, sufficient exercise, and good air quality in stables.

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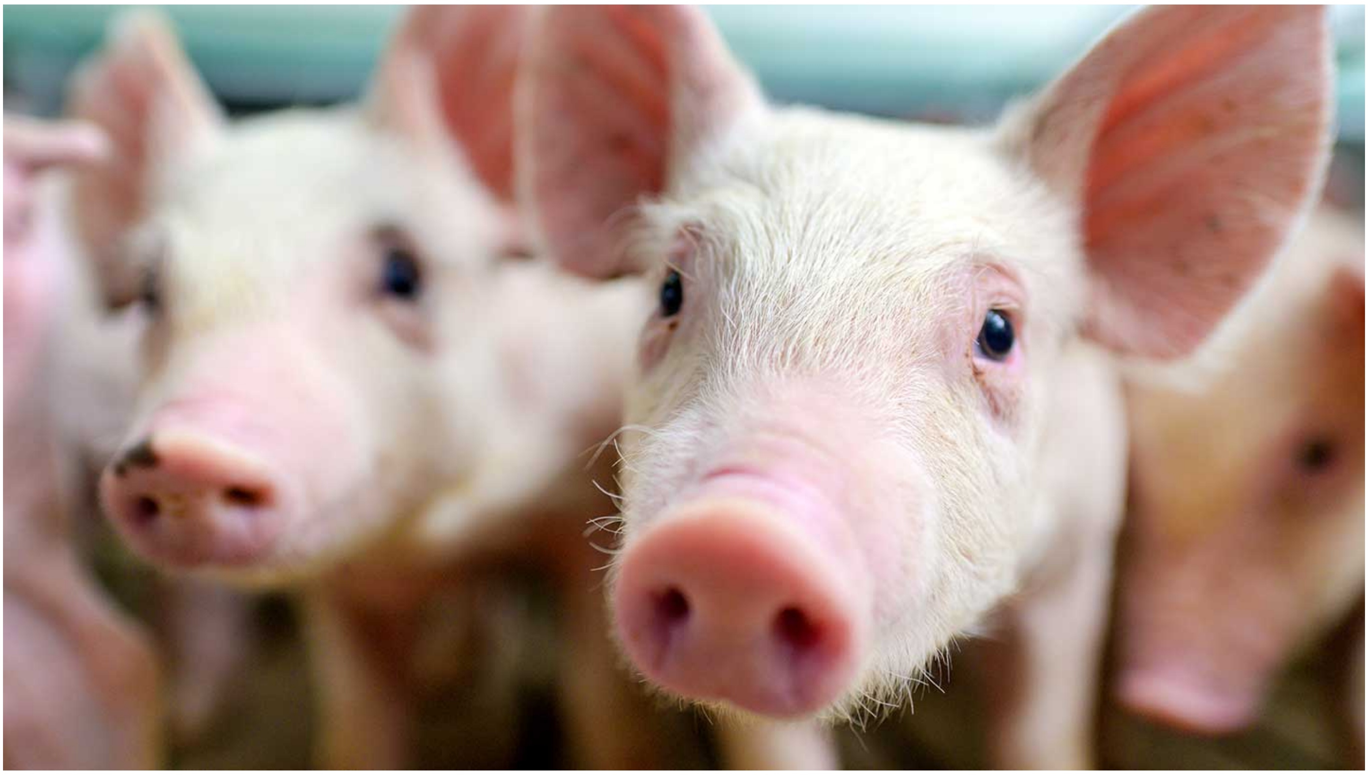
Minimizing Collateral Effects of Antibiotic Administration in Swine Farms: A Balancing Act



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We care for our animals, and antibiotics are a crucial component in the management of disease due to susceptible pathogens, supporting animal health and welfare. However, the administration of antibiotics in pig farming has become a common practice to prevent bacterial infections, reduce economic losses, and increase productivity.

All antibiotic applications have collateral consequences of significance, bringing a deeper consideration to their non-essential application. This article aims to challenge the choice to administer antibiotics by exploring the broader impact that antibiotics have on animal and human health, economies, and the environment.

Antibiotics disrupt microbial communities

Antibiotics do not specifically target pathogenic bacteria. By impacting beneficial microorganisms, they disrupt the natural balance of microbial communities within animals. They reduce the microbiota diversity and abundance of all susceptible bacteria – beneficial and pathogenic ones… many of which play crucial roles in digestion, brain function, the immune system, and respiratory and overall health. Resulting microbiota imbalances may present themselves in animals showing health performance changes associated with non-target systems, including the nasal, respiratory, or gut microbiome[7, 8, 14]. The gut-respiratory microbiome axis is well-established in mammals. Gut microbiota health, diversity, and nutrient supply directly impact respiratory health and function[13]. In pigs specifically, the modulation of the gut microbiome is being considered as an additional tool in the control of respiratory diseases such as PRRS due to the link between the digestion of nutrients, systemic immunity, and response to pulmonary infections[11].

The collateral effect of antibiotic administration disrupting not only the microbial communities throughout the animal but also linked body systems needs to be considered significant in the context of optimal animal health, welfare, and productivity.

Antibiotic use can lead to the release of toxins

The consideration of the pathogenesis of individual bacteria is critical to mitigate potential for direct collateral effects associated with antibiotic administration. For example, in cases of toxin producing bacteria, when animals are medicated either orally or parenterally, mortality may increase due to the associated release of toxins when large numbers of toxin producing bacteria are killed quickly[2].

Modulation of the brain function can be critical

Numerous animal studies have investigated the modulatory role of intestinal microbes on the gut-brain axis. One identified mechanism seen with antibiotic-induced changes in fecal microbiota is the decreased concentrations of hypothalamic neurotransmitter precursors, 5-hydroxytryptamine (serotonin), and dopamine[5]. Neurotransmitters are essential for communication between the nerve cells. Animals with oral antibiotic-induced microbiota depletion have been shown to experience changes in brain function, such as spatial memory deficits and depressive-like behaviors.

Processing of waste materials can be impacted

Anaerobic treatment technology is well accepted as a feasible management process for swine farm wastewater due to its relatively low cost with the benefit of bioenergy production. Additionally, the much smaller volume of sludge remaining after anaerobic processing further eases the safe disposal and decreases the risk associated with the disposal of swine waste containing residual antibiotics[4].

The excretion of antibiotics in animal waste, and the resulting presence of antibiotics in wastewater, can impact the success of anaerobic treatment technologies, which already could be demonstrated by several studies[6, 11]. The degree to which antibiotics affect this process will vary by type, combination, and concentration. Furthermore, the presence of antibiotics within the anaerobic system may result in a population shift towards less sensitive microbes or the development of strains with antibiotic-resistant genes[1, 12].

Antibiotics can be transferred to the human food chain

Regulatory authorities specify detailed withdrawal periods after antibiotic treatment. However, residues of antibiotics and their metabolites may persist in animal tissues, such as meat and milk, even after this period. These residues can enter the human food chain if not adequately monitored and controlled.

Prolonged exposure to low levels of antibiotics through the consumption of animal products may contribute to the emergence of antibiotic-resistant bacteria in humans, posing a significant public health risk.

Contamination of the environment

As mentioned, the administration of antibiotics to livestock can result in the release of these compounds into the environment. Antibiotics can enter the soil, waterways, and surrounding ecosystems through excretions from treated animals, inappropriate disposal of manure, and runoff from agricultural fields. Once in the environment, antibiotics can contribute to the selection and spread of antibiotic-resistant bacteria in natural bacterial communities. This contamination poses a potential risk to wildlife, including birds, fish, and other aquatic organisms, as well as the broader ecological balance of affected ecosystems.

Every use of antibiotics can create resistance

One of the widely researched concerns associated with antibiotic use in livestock is the development of antibiotic resistance. The development of AMR does not require prolonged antibiotic use and, along with other collateral effects, also occurs when antibiotics are used within recommended therapeutic or preventive applications.

Gene mutations can supply bacteria with abilities that make them resistant to certain antibiotics (e.g., a mechanism to destroy or discharge the antibiotic). This resistance can be transferred to other microorganisms, as seen with the effect of carbadox on Escherichia coli[5] and Salmonella enterica[2] and the carbadox and metronidazole effect on *Brachyspira hyodysenteriae*[15]. Additionally, there is an indication that the zinc resistance of Staphylococcus of animal origin is associated with the methicillin resistance coming from humans[3].

Consequently, the effectiveness of antibiotics in treating infections in target animals becomes compromised, and the risk of exposure to resistant pathogens for in-contact animals and across species increases, including humans.

Alternative solutions are available

To successfully minimize the collateral effects of antibiotic administration in livestock, a unified strategy with support from all stakeholders in the production system is essential. The European Innovation Partnership – Agriculture[9] concisely summarizes such a process as requiring…

1. Changing human mindsets and habits: this is the first and defining step to successful antimicrobial reduction
2. Improving pig health and welfare: Prevention of disease with optimal husbandry, hygiene, biosecurity, vaccination programs, and nutritional support.
3. Effective antibiotic alternatives: for this purpose, phytomolecules, pro/pre-biotics, organic acids, and immunoglobulins are considerations.

In general, implementing responsible antibiotic stewardship practices is paramount. This includes limiting antibiotic use to the treatment of diagnosed infections with an effective antibiotic, and eliminating their use as growth promotors or for prophylactic purposes.

Keeping the balance is of crucial importance

While antibiotics play a crucial role in ensuring the health and welfare of livestock, their extensive administration in the agricultural industry has collateral effects that cannot be ignored. The development of antibiotic resistance, environmental contamination, disruption of microbial communities, and the potential transfer of antibiotic residues to food pose significant challenges.

Adopting responsible antibiotic stewardship practices, including veterinary oversight, disease prevention programs, optimal animal husbandry practices, and alternatives to antibiotics, can strike a balance between animal health, efficient productive performance, and environmental and human health concerns.

The collaboration of stakeholders, including farmers, veterinarians, policymakers, industry and consumers, is essential in implementing and supporting these measures to create a sustainable and resilient livestock industry.

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Coccidiostats in the European Union: Challenges and Perspectives

*by **Technical Team**, EW Nutrition*

Controlling coccidiosis has been and continuous to be a major concern for poultry operations. However, for decades, some of these control measures have been taking an increasingly visible toll on the overall health of the flocks, the economics of poultry production, and the environment itself. Regulations have been put in place to defend consumer health and animal welfare while maintaining profitability in poultry production.

In the European Union and elsewhere, coccidiostats or anticoccidials are an essential means of control and are categorized either as feed additives or as veterinary medicinal products. The category is dictated by the pharmacologically active substance, mode of action, pharmaceutical form, target species and route of application.

In the European Union, there are currently 11 different coccidiostats which have been granted 28 different authorizations as feed additives allowed for specific usage in chickens, turkeys, and rabbits.

Coccidiostats: the basics

Compounds designed to kill the coccidial population are known as coccidiocidal; those designed to prevent the replication and development of coccidia are known as coccidiostats. Quite often, coccidiostat or anticoccidial is the term used to describe both categories.

Coccidiostats are antimicrobial compounds which either inhibit or destroy the protozoan parasites that cause coccidiosis in livestock. Each coccidiostat has individual inhibitory mechanisms. In the case of ionophores, the compounds affect transmembrane ion transport. In the case of synthetic compounds, the molecules' mode of action is varied and, in some cases, not even entirely known (Patyra et al., 2023).

The production, manufacture, and marketing of coccidiostats, premixes with coccidiostats, and feed with coccidiostats are regulated by the Regulation (EC) No 183/2005 of the European Parliament and of the Council of 12 January 2005 laying down requirements for feed hygiene.

Coccidiostat categories

Coccidiostats fall under two categories:

Ionophores

Ionophores, sometimes called polyether ionophore antibiotics, are substances which contain a polyether group and are of bacterial origin. They are produced by fermentation with several strains of *Streptomyces* spp and *Actinomadura* spp. Six substances are allowed in the EU:

- monensin sodium (MON)
- lasalocid sodium (LAS)
- maduramicin ammonium (MAD)
- narasin (NAR)
- salinomycin sodium (SAL)
- semduramicin sodium (SEM)

Synthetic

Synthetic compounds include:

- decoquinate (DEC)
- diclazuril (DIC)
- halofuginone (HFG)
- nicarbazin (NIC)
- robenidine hydrochloride (ROB)

EU authorizations for ionophores are granted under specific conditions of usage, including animal category, minimum and maximum dosage, MRL (Maximum Residue Limits), and withdrawal periods.

Regulation (EC) No 1831/2003 [13] of the European Parliament and of the Council of 22 September 2003 distinguishes between coccidiostats and antibiotics used as growth promoters. Unlike the antibiotic growth promoters (forbidden in the EU since 2006), whose primary action site is the gut microflora, coccidiostats only have a secondary and residual activity against the gut microflora. That still signals that they have the potential to trigger resistance and to alter the natural balance and immune response of the farmed animals. Their potential to cause resistance has been widely acknowledged by science and practitioners alike (see below).

Why were some antimicrobial growth promoters withdrawn in 1997-1998 – but not others?

Five designated "antibiotic feed additives" were prohibited in 1997-98: Avoparcin, Bacitracin zinc, Spiramycin, Virginiamycin, and Tylosin phosphate. The EU withdrew their authorization in order to "help decrease resistance to antibiotics used in medical therapy". The motivation specified that these antibiotics belonged to classes of compounds also used in human medicine.

On the other hand, the EU at the time allowed the remaining antibiotics for use in feed as they did not belong to classes of compounds used in human medicine. That, of course, did not mean that resistance did not develop in birds.

The Commission did acknowledge the need to phase out the remaining antibiotics. At the same time, it stated that the use of coccidiostats would not presently be ruled out "even if of antibiotic origin" (MEMO/02/66, 2022). The reason was that "hygienic precautions and adaptive husbandry measures are not sufficient to keep poultry free of coccidiosis. Modern poultry husbandry is currently only practicable if coccidiosis can be prevented by inhibiting or killing parasites during their development."

In other words, the Commission acknowledged that the only reason ionophores were still authorized was that it believed there were no other means of controlling coccidiosis in profitable poultry production.

What issues are raised by current coccidiosis control measures?

In its 2022 Position Paper on Coccidia Control in Poultry, the European Veterinaries Federation states that "challenges in coccidia control are due to parasitic and bacterial drug (cross-)resistance. Coccidiostats also interact with other veterinary medicinal products and have a secondary residual activity against gram-positive bacteria" (FVE, 2022).

Resistance

Ever since 1939, when sulphanilamide was shown to cure coccidiosis in chickens, the industry increased the use of similar (chemical) compounds. It quickly added sulfaquinoxaline, then nitrofurazone and 3-notroroxarsone, amprolium and nicarbazin (Martins et al., 2022).

Prior to the introduction of the first ionophore, monensin, in the early 1970s, producers only had synthetic (non-ionophores) coccidiostats, characterized by rapid parasite resistance development. With the addition of ionophores, poultry operations started to rotate products between production cycles, or to use shuttle programs, with the express purpose of controlling the development of resistance. Synthetic compounds can, however, result in increased resistance in the long run (Martins et al., 2022). Moreover, studies in farmed animals indicate that sometimes even single use of antibiotics can promote the selection of resistant bacterial strains.

Another issue is the design of the rotation system, which, some researchers claim, could only delay the appearance of resistance (Daeseleire et al., 2017).

To make matters worse, for instance in the case of broilers, coccidiostats are generally administered throughout life to protect against re-infection. This may also lead to the next item on the list.

Residues

Regulation (EC) No 1831/2003 establishes Maximum Residue Limits (MRLs) for residues of an additive in relevant foodstuffs of animal origin. The goal is to control the use of coccidiostats in feed and ensure that there is no excess residue that ends up on the consumers' plate.

Broilers can be fed with coccidiostats throughout life, with the exception of a certain withdrawal period before slaughter. Cross-contamination of feed batches and residue formation in edible tissues of nontarget species represent valid concerns for end consumers.

Coccidiostats in food have been regulated in the Commission Regulation (EC) No 124/2009, including maximum levels for meat ranging between 2 µg/kg (monensin, salinomycin, semduramycin, and manduramycin) and 100 µg/kg (nicarbazin in liver and kidney). However, Daeseleire et al. state that “in the period 2011–14, noncompliant results were reported for maduramycin, monensin, diclazuril, lasalocid, nicarbazin, robenidine, salinomycin, narasin, semduramicin, decoquinate, halofuginone, and toltrazuril. The matrices/animals species affected were in descending order eggs, poultry, farmed game, horses, pigs, and sheep/goat (EURL workshop, 2015)”. Residues in eggs are widely seen as a serious concern (Bello et al., 2023). The fact that regulations are in place constitute no safeguard against defective practices.

What alternatives to coccidiostats does the EU support?

Vaccination

Coccidiosis vaccines have been in use for the last three decades. They are based on precocious oocysts and are commonly used in breeding and laying birds, and the use in broilers is steadily increasing. There is a limited number of vaccines authorized in the EU. As vaccines are relatively costly to apply, vaccination is typically performed during 2-3 cycles only, afterwards reverting to the use of coccidiostats, which leads to a suppression of the precocious vaccine-origin strains, allowing persistent coccidiostat-resistant field strains to flourish.

Herbal products (phytomolecules)

Phytomolecules have been widely used for a variety of poultry gut health issues. Their usage in flocks at risk of coccidiosis is predicated on their ability to strengthen the natural defenses of the animal. Infection severity and consequences depend to a large extent on co-infections, gut health, and the general immunity of the bird.

Prescription veterinary medicines

Toltrazuril, amprolium, and some sulfamides (sulfamiderazin, sulfadimethoxin, trimethoprime) are used against (clinical) coccidiosis outbreaks. However, these medicines are also prone to triggering resistance and should not be widely used. Moreover, they are used when coccidiosis is already manifest on the farm, so they do not prevent economical and performance losses.

Other research

There is limited research on acidifiers, enzymes, prebiotics or probiotics acting as defenses against infection. Furthermore, oocysts are highly resistant to the common disinfectants, but there are some highly specialized types available. In general, producers are reluctant to use these methods as their benefits are limited or indemonstrable.

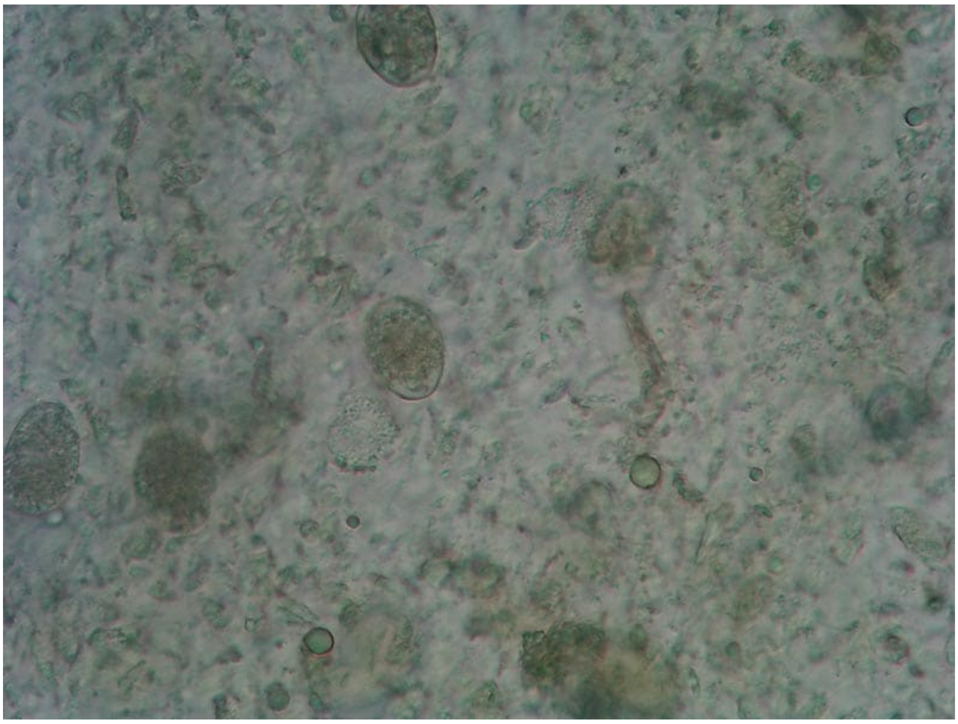
Genetic selection of the animals is also unable to offer solutions for the moment.

Ionophores as antibiotics: The U.S. case

Ionophores have demonstrated antibacterial activity (e.g., Rutkowski and Brzezinski, 2013). As opposed to their regime in the EU, where they are allowed as feed additives, in the United States, coccidiostats belonging to the polyether-ionophore class (ionophores) are not allowed in NAE (No Antibiotics Ever) and RWA (Raised Without Antibiotics) programs.

Instead of using ionophores, coccidiosis is approached by NAE/RWA US producers with a veterinary-led combination of live vaccines, synthetic compounds, phytomolecules, and farm management.

What are the perspectives of coccidiosis control?



In 2019, The European Medicines Agency (EMA) published the new Veterinary Medicinal Products Regulation (EU2019/6), emphasizing the necessity of fighting antimicrobial resistance. In response to the VMP Regulation, in November 2022, the FVE (European Veterinaries Federation) recommended tackling coccidiosis through “a combination of holistic flock health management, optimized stocking density, litter management, feeding and drinking regime as well as nutraceuticals, accompanied by appropriate biosecurity measures, vaccination and coccidiostats, where indicated”.

In its position paper, FVE advocates a “prudent and responsible use of coccidiostats”, as well as monitoring of polyether ionophores coccidiostats sales through ESVAC (European Surveillance of Veterinary Antimicrobial Consumption). European Union past experiences show that strong urges for monitoring are usually implemented and signal a need for regulation. As other countries and regions have shown excellent productivity in the absence of ionophores, it may be that, sooner or later, the EU will revise its lax attitude and embrace a stricter control of antimicrobial resistance.

FVE also recommends the development of rapid, low-cost and especially quantitative diagnostic tests for ongoing surveillance and monitoring purposes. Through fast, reliable, on-site oocyst counts, producers can cut cost and time resources and improve reaction time to preserve the health of their flocks.

From a scientific perspective, considering the range of micro-organisms affected, ionophores can be seen as antibiotics, with the usual associated risks for cross-resistance or co-selection (Wong 2019). While their current status in the European Union represents a concession to the economic security of a large and important industry, best practices in other regions show that coccidiosis can be approached holistically with solutions that reduce antimicrobial resistance and support the profitability of poultry operations.

Bio-shuttle with natural anticoccidial additives: the all-encompassing solution

As producers optimize the use of biological interventions such as vaccines, their effect on broiler performance becomes more predictable and constant.

The current common practice of rotating coccidiostats fails to take advantage of the milder precocious Eimeria population that has developed within the broiler house. Instead, the use of new, natural feed additives with anticoccidial activity that is directly related to the coccidiostat-resistant Eimeria (field) strains, as well as the precocious Eimeria strains, can help to maintain a favorable ratio between mild precocious and more virulent field strains. This can help increase the number of cycles that benefit from the vaccinations applied, even when discontinuing vaccination. Careful monitoring of oocyst shedding patterns, preferably accompanied by gut health and coccidiosis lesion scoring and performance monitoring, can guide the producer on the right time to restart vaccination and repeat the same rotation program.

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From basketball to feed milling: a common tactic for winning in 2023

*By **Ivan Ilic**, Global Manager Technical Product Applications, EW Nutrition*

It has been a rough couple of years for the world. And from climate change to war, all negative impacts have reverberated down to feed millers.

- Climate change affected raw material prices and availability
- COVID-19 impacted shipping costs and manpower
- War impacted energy prices and raw material availability

And that´s without even considering market trends toward sustainability, shifting resources to biofuel, and so on.

With all these challenges going on, working to improve feed mill efficiency has lately kept me extremely busy. I´ve been traveling and talking to customers around the world about SurfAce and how we bring benefits in energy cost savings, process efficiency, moisture optimization, and so on. But when I am at home, I take a walk every evening in the woods near my house. I often use the time to reflect on personal and professional issues.

At some point, I found myself thinking about the European Basketball Championship (in Serbia, basketball is a national sport). Last year, the head coach of the Serbian national team decided not to call one of our best players to the national team. Lots of people criticized this decision, as for the past few years he had been one of the top players in Europe.

So, I started to think about choosing a team over a star. How do you balance your strong points to make sure of a win? (Yes, there is a connection to feed mills. I´m getting there.)

Winning through strategy rather than showmanship

Bozidar Maljkovic is a Serbian legend, who trained several winning teams, among which the European champion team Limoges. This was a French team he picked up mid-season, with moderate resources on the basketball court as well as outside it. The entire 1993 Euro season, Maljkovic chose to play extreme defense and score a very low number of points. In the finals, he played against a big favorite: Benneton Treviso, a wealthier team that, at that time, had a roster of excellent players. He won the game using the same strategy: tight defense, highly tactical game. A championship won not on artistic merit but on strategy.

After that final game, his good friend and well-known coach of Treviso, Petar Skansi, accused Maljkovic that he was destroying the basketball game with that tactic. Maljkovic answered to Skansi in more or less these words: you give me Kukoc (Treviso´s best player) and I´ll win on a different tactic.

When I remembered this episode during my walk, I suddenly saw a pattern in basketball coaching and feedmill management.

Know your objective

As in basketball, in feed milling you must be clear about your target, your main objective. In Maljkovic´s case, the objective was not to make basketball games attractive for the public, just as it was not to his objective to showcase his players. His target was to win the Euro title.

The same goes for the feed mill. Sure, you have several objectives, but there must be a main one. Say your primary objective is to maximize profit. If that is the case, then the next step is to be sure of what the market demands. This way you can avoid spending money for added value on something that the market is unwilling to pay for.

Know your players

Once you know what outcome you can deliver and what the market is prepared to pay for, the next step is analytics.

You must dive deep into your feed mill and get all the data on your "players": raw materials, technology, people, machines, parameters, logistics etc. You must understand the current status and capabilities of your players, with advantages and limitations. Your job is to use them to the best of their capabilities in order to achieve your objective.

Know the interconnections between players

Just as every player depends on others, also feed mill processes are related and interdependent. If you want to have fine grinding, you will achieve better PDI, but it will cost more energy in milling and the result may not be as good for some categories of animals. Is this efficient and acceptable? It all depends on your main objective.

Balancing between pros and cons and walking that thin line is what efficiency means. With these challenges looming large, finding that balance will be the main task in feed milling.

Be curious

"Be curious" is one of the values of our company, but I would prompt anyone to adopt it. Play with parameters, support operators to do it, and find the point that yields maximum return for your specific objective.

Literature without your own data is fiction. In literature you can find data that says, for instance, that for every 15°C you have 1% more moisture. You can also find literature that says you have 1% more moisture for every 12°C or every 17°C. But what is the ratio in your feedmill? If you do not know, you are still not diving deep enough.

You need to figure out the interconnected factors in your own production. If you calculate by the books and official recommendations, you are adjusting work in some other feed mill, not yours. Yes: guidance is very important to understand relations and to be aware of margins. But inside those margins, you have to find your own numbers.

Find the least opportunity cost

Very often I see goals that are rebels without a cause. Take PDI, for instance. PDI is an important value, no doubt. It has been shown that better PDI correlates with better FCR etc.

However, when you set a target value for PDI you need to be sure that future investment in increasing PDI is relevant to your customers – and that they are willing to pay for that. Even if you are an integrator, first do the math on the benefits and the cost. With rising costs not just for you but also for your end customers, make sure the market can support the premium you are struggling to deliver. If you are sure, then find the most adequate way to win it. You can increase your PDI in lots of different ways, so you will need to calculate the least opportunity cost.

Production is a game of interdependencies. So is any team sport, in fact. When a coach makes a decision to put a star player in the spotlight, there may be a show but not always a win.

In a feed mill, the end game is always played around winning. It is a complex tactic of balancing all players and getting the most in your very specific circumstances. Our job is to identify and maximize these „synergies" in each specific case – and I can confirm that each case is different. In the end, Kukoc may have played the same game in Jugoplastika or Treviso, but no two feed mills are quite the same; even in same feed mill, no two lines will be adjusted the same way.

The future of coccidiosis control

*By **Madalina Diaconu**, Product Manager Pretect D, EW Nutrition and*

With costs of over 14 billion USD per year (Blake, 2020), coccidiosis is one of the most devastating enteric challenges in the poultry industry. With regard to costs, subclinical forms of coccidiosis account for the majority of production losses, as damage to intestinal cells results in lower body weight, higher feed conversion rates, lack of flock uniformity, and failures in skin pigmentation. This challenge can only be tackled, if we understand the basics of coccidiosis control in poultry and what options producers have to manage coccidiosis risks.

Current strategies show weak points

Good farm management, litter management, and coccidiosis control programs such as shuttle and rotation programs form the basis for preventing clinical coccidiosis. More successful strategies include disease monitoring, strategic use of coccidiostats, and increasingly coccidiosis vaccines. However, the intrinsic properties of coccidia make these parasites often frustrating to control. Acquired resistance to available coccidiostats is the most difficult and challenging factor to overcome.

Optimally, coccidiosis control programs are developed based on the farm history and the severity of infection. The coccidiostats traditionally used were chemicals and ionophores, with ionophores being polyether antibiotics. To prevent the development of resistance, the coccidiostats were used in shuttle or rotation programs, at which in the rotation program, the anticoccidial changes from flock to flock, and in the shuttle program within one production cycle (Chapman, 1997).

The control strategies, however, are not 100% effective. The reason for that is a lack of diversity in available drug molecules and the overuse of some molecules within programs. An additional lack of sufficient coccidiosis monitoring and rigorous financial optimization often leads to cost-saving but only marginally effective solutions. At first glance, they seem effective, but in reality, they promote resistance, the development of subclinical coccidiosis, expressed in a worsened feed conversion rate, and possibly also clinical coccidiosis.

Market requests and regulations drive coccidiosis control strategies

Changing coccidiosis control strategies has two main drivers: the global interest in mitigating antimicrobial resistance and the consumer's demand for antibiotic-free meat production.

Authorities have left ionophores untouched

Already in the late 1990s, due to the fear of growing antimicrobial resistance, the EU withdrew the authorization for Avoparcin, Bacitracin zinc, Spiramycin, Virginiamycin, and Tylosin phosphate, typical growth promoters, to "help decrease resistance to antibiotics used in medical therapy". However, ionophores, being also antibiotics, were left untouched: The regulation (EC) No 1831/2003 [13]of the European Parliament and the Council of 22 September 2003 clearly distinguished between coccidiostats and antibiotic growth promoters. Unlike the antibiotic growth promoters, whose primary action site is the gut microflora, coccidiostats only have a secondary and residual activity against the gut microflora. Furthermore, the Commission declared in 2022 that the use of coccidiostats would not presently be ruled out "even if of antibiotic origin" (MEMO/02/66, 2022) as "hygienic precautions and adaptive husbandry measures are not sufficient to keep poultry free of coccidiosis" and that "modern poultry husbandry is currently only practicable if coccidiosis can be prevented by inhibiting or killing parasites during their development". In other words, the Commission acknowledged that ionophores were only still authorized because it believed there were no other means of controlling coccidiosis in profitable poultry production.

Consumer trends drove research on natural solutions

Due to consumers' demand for antibiotic-reduced or, even better, antibiotic-free meat production, intensified industrial research to fight coccidiosis with natural solutions has shown success. Knowledge, research, and technological developments are now at the stage of offering solutions that can be an effective part of the coccidia control program and open up opportunities to make poultry production even more sustainable by reducing drug dependency.

Producers from other countries have already reacted. Different from the handling of ionophores regime in the EU, where they are allowed as feed additives, in the United States, coccidiostats belonging to the polyether-ionophore class are not permitted in NAE (No Antibiotics Ever) and RWE (Raised Without Antibiotics) programs. Instead of using ionophores, coccidiosis is controlled with a veterinary-led combination of live vaccines, synthetic compounds, phytomolecules, and farm management. This approach can be successful, as demonstrated by the fact that over 50% of broiler meat production in the US is NAE. Another example is Australia, where the two leading retail store chains also exclude chemical coccidiostats from broiler production. In certain European countries, e.g., Norway, the focus is increasingly on banning ionophores.

The transition to natural solutions needs knowledge and finesse

In the beginning, the transition from conventional to NAE production can be difficult. There is the possibility to leave out the ionophores and manage the control program only with chemicals of different modes of action. More effective, however, is a combination of vaccination and chemicals (bio-shuttle program) or the combination of phytomolecules with vaccination and/or chemicals (Gaydos, 2022).

Coccidiosis vaccination essentials

When it is decided that natural solutions shall be used to control coccidiosis, some things about vaccination must be known:

1. There are different strains of vaccines, natural ones selected from the field and attenuated strains. The formers show medium pathogenicity and enable a controlled infection of the flock. The latter, being early mature lower pathogenicity strains, usually cause only low or no post-vaccinal reactions.
2. A coccidiosis program that includes vaccination should cover the period from the hatchery till the end of the production cycle. Perfect application of the vaccines and effective recirculation of vaccine strains amongst the broilers are only two examples of preconditions that must be fulfilled for striking success and, therefore, early and homogenous immunity of the flock.
3. Perfect handling of the vaccines is of vital importance. For that purpose, the personnel conducting the vaccinations in the hatchery or on the farms must be trained. In some situations, consistent high-quality application at the farm has shown to be challenging. As a result**,** interest in vaccine application at the hatchery is growing.

Phytochemicals are a perfect tool to complement coccidiosis control programs

As the availability of vaccines is limited and the application costs are relatively high, the industry has been researching supportive measures or products and discovered phytochemicals as the best choice. Effective phytochemical substances have antimicrobial and antiparasitic properties and enhance protective immunity in poultry infected by coccidiosis. They can be used in rotation with vaccination, to curtail vaccination reactions of (non-attenuated) wild strain vaccines, or in combination with chemical coccidiostats in a shuttle program.

In a recent review paper (El-Shall et al., 2022), natural herbal products and their extracts have been described to effectively reduce oocyst output by inhibiting Eimeria species' invasion, replication, and development in chicken gut tissues. Phenolic compounds in herbal extracts cause coccidia cell death and lower oocyst counts. Additionally, herbal additives offer benefits such as reducing intestinal lipid peroxidation, facilitating epithelial repair, and decreasing Eimeria-induced intestinal permeability.

Various phytochemical remedies are shown in this simplified adaptation of a table from El-Shall et al. (2022), indicating the effects exerted on poultry in connection to coccidia infection.

Bioactive compound	Effect
Saponins	*Inhibition of coccidia:* By binding to membrane cholesterol, the saponins disturb the lipids in the parasite cell membrane. The impact on the enzymatic activity and metabolism leads to cell death, which then induces a toxic effect in mature enterocytes in the intestinal mucosa. As a result, sporozoite-infected cells are released before the protozoa reach the merozoite phase.*Support for the chicken:* Saponins enhance non-specific immunity and increase productive performance (higher daily gain and improved FCR, lower mortality rate). They decrease fecal oocyst shedding and reduce ammonia production.
Tannins	*Inhibition of coccidia:* Tannins penetrate the coccidia oocyst wall and inactivate the endogenous enzymes responsible for sporulation.*Support for the chicken:* Additionally, they enhance anticoccidial antibodies' activity by increasing cellular and humoral immunity.
Flavonoids and terpenoids	*Inhibition of coccidia:* They inhibit the invasion and replication of different species of coccidia.*Support for the chicken:* They bind to the mannose receptor on macrophages and stimulate them to produce inflammatory cytokines such as IL-1 through IL-6 and TNF. Higher weight gain and lower fecal oocyst output are an indication of suppression of coccidiosis.
Artemisinin	*Inhibition of coccidia:* Its impact on calcium homeostasis compromises the oocyst wall formation and leads to a defective cell wall and, in the end, to the death of the oocyst. Enhancing the production of ROS directly inhibits sporulation and also wall formation and, therefore, affects the Eimeria life cycle.*Support for the chicken:* Reduction of oocyst shedding
Leaf powder of Artemisia annua	*Support for the chicken:* Protection from pathological symptoms and mortality associated with Eimeria tenella infection. Reduced lesion score and fecal oocyst output. The leaf powder was more efficient than the essential oil, which could be due to a lack of Artemisinin in the oil, and to the greater antioxidant ability of A. annua leaves than the oil.
Phenols	*Inhibition of coccidia:* Phenols change the cytoplasmic membrane's permeability for cations (H+ and K+), impairing essential processes in the cell. The resulting leakage of cellular constituents leads to water unbalance, collapse of the membrane potential, inhibition of ATP synthesis, and, finally, cell death. Due to their toxic effect on the upper layer of mature enterocytes of the intestinal mucosa, they accelerate the natural renewal process, and, therefore, sporozoite-infected cells are shed before the coccidia reaches the merozoite phase.

Table 1: Bioactive compounds and their anticoccidial effect exerted in poultry

Consumers vote for natural – phytochemicals are the solution

Due to still rising antimicrobial resistance, consumers push for meat production without antimicrobial usage. Phytomolecules, as a natural solution, create opportunities to make poultry production more sustainable by reducing dependency on harmful drugs. With their advent, there is hope that antibiotic resistance can be held in check without affecting the profitability of poultry farming.

Masked mycotoxins – particularly dangerous for dairy cows

*By **Si-Trung Tran**, SEAP Regional Technical Manager, EW Nutrition*

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Mycotoxins are secondary metabolites of fungi, commonly found as contaminants in agricultural products. In some cases, these compounds are used in medicine or industry, such as penicillin and patulin. In most cases, however, they are considered xenobiotics that are toxic to animals and humans, causing the disease collectively known as mycotoxicosis. The adverse effects of mycotoxins on human and animal health have been documented in many publications. Aflatoxins (AFs) and deoxynivalenol (DON, vomitoxin) are amongst the most critical mycotoxins affecting milk production and -quality.

Aflatoxins do not only affect cows

Aflatoxins (AFs) are highly oxygenated, heterocyclic difuranocoumarin compounds produced by *Aspergillus flavus* and *Aspergillus parasiticus*. They colonize crops, including many staple foods and feed ingredients. Within a group of over 20 AFs and derivatives, aflatoxin B1 (AFB1), B2, G1, and G2 are the most important naturally occurring compounds.

Among the aflatoxins, AFB1 is the most widespread and most toxic to humans and animals. Concern about mycotoxin contamination in dairy products began in the 1960s with the first reported cases of contamination by aflatoxin M1 (AFM1), a metabolite of AFB1 formed in the liver of animals and excreted in the milk.

There is ample evidence that lactating cows exhibit a significant reduction in feed efficiency and milk yield within a few days of consuming aflatoxin-contaminated feed. At the cellular level, aflatoxins cause degranulation of endoplasmic membranes, loss of ribosomes from the endoplasmic reticulum, loss of nuclear chromatin material, and altered nuclear shapes. The liver, as the organ mainly dealing with the decontamination of the organism, gets damaged, and performance drops. Immune cells are also affected, reducing immune competence and vaccination success (Arnold and Gaskill, 2023).

DON reduces cows' performance

Another mycotoxin that can also reduce milk quality and affect metabolic parameters, as well as the immune function of dairy cows, is DON. DON is produced by different fungi of the *Fusarium* genus that infect plants. DON synthesis is associated with rainy weather from crop flowering to harvest. Whitlow and co-workers (1994) reported the association between DON and poor performance in dairy herds and showed decreased milk production in dairy cows fed 2.5 mg DON/kg. However, in cows fed 6 to 12 mg DON/kg dry matter for 10 weeks, no DON or its metabolite DOM-1 residues were detected in milk.

Masked mycotoxins hide themselves during analysis

Plants suffering from fungal infestations and thus confronted with mycotoxins convert the harmful forms of mycotoxins into less harmful or harmless ones for themselves by conjugation to sulfates, organic acids, or sugars. Conjugated mycotoxins cannot always be detected by standard analytical methods. However, in animals, these forms can be released and transformed into parent compounds by enzymes and microorganisms in the gastrointestinal tract. Thus, the feed may show a concentration of mycotoxins that is still below the limit value, but in the animal, this concentration is suddenly much higher. In dairy cows, the release of free mycotoxins from conjugates during digestion may play an important role in understanding the silent effects of mycotoxins.

Fusarium toxins, in particular, frequently occur in this "masked form". They represent a serious health risk for animals and humans.

Aflatoxins first show up in the milk

Masked aflatoxins may also play a role in total aflatoxin contamination of feed materials. Research has harvested little information on masked aflatoxins that may be present in TMR ingredients. So far, metabolites such as Aflatoxin M2 have been identified (Righetti, 2021), which may reappear later in milk as AFM1.

DON-related symptoms without DON?

Sometimes, animals show DON-related symptoms, with low levels detected in the feed or raw materials. Besides sampling errors, this enigma could be due to conjugated or masked DON, which is structurally altered DON bound to various compounds such as glucose, fatty acids, and amino acids. These compounds escape conventional feed analysis techniques because of their modified chemical properties but can be released as their toxic precursors after acid hydrolysis.

Masked DON was first described in 1984 by Young and co-workers, who found that the DON content of yeast-fermented foods was higher than that of the contaminated wheat flour used in their production. The most plausible reason for this apparent increase was that the toxin from the wheat had been converted to a compound other than DON, which could be converted back to DON under certain conditions. Since this report, there has been much interest in conjugated or masked DON.

Silage: masked DON is a challenge for dairy producers

Silage is an essential feed for dairy cows, supporting milk production. Most silage is made from corn and other grains. The whole green plant is used, which can be infected by fungi. Since infection of corn with Fusarium spp. and subsequent DON contamination is usually a major problem in the field worldwide, a relatively high occurrence of this toxin in silage must be expected. The ensiling process may reduce the amount of Fusarium fungi, but the DON formed before ensiling is very stable.

Silage samples show DON levels of concern

It is reasonable to assume that the DON biosynthesized by the fungi was metabolized by the plants to a new compound and thus masked DON. Under ensiling conditions, masked DON can be hydrolyzed, producing free DON again. Therefore, the level of free DON in the silage may not reflect the concentration measured in the plants before ensiling.

A study analyzed 50 silage samples from different farms in Ontario, Canada. Free DON was found in all samples, with levels ranging from 0.38 to 1.72 µg/g silage (unpublished data). Eighty-six percent of the samples contained DON at concentrations higher than 0.5 µg/g. Together with masked DON, it poses a potential threat to dairy cattle.

Specific hydrolysis conditions allow detection

However, in the natural ensiling process, the conditions for hydrolysis of masked DON are not optimal. The conditions that allow improved analysis of masked DON were recently described. This method detected masked DON in 32 of 50 silage samples (64%) along with free DON, increasing DON concentration by 23% in some cases (unpublished data).

Mycotoxins impact humans and animals

Aflatoxins, as well as DON, have adverse effects. In the case of DON, the impact on the animal is significant; in the case of aflatoxin, the possible long-term effects on humans are of higher relevance.

DON has more adverse effects on the animal and its performance

Unlike AFs, DON may be found in milk at low or trace concentrations. It is more associated with negative effects in the animal, altered rumen fermentation, and reduced flow of usable protein into the duodenum. For example, milk fat content was significantly reduced when cows were fed 6 µg DON/kg. However, the presence of DON also indicates that the feed probably contains other mycotoxins, such as zearalenone (ZEA) (estrogenic mycotoxin) and fusaric acid (pharmacologically active compound). All these mycotoxins may interact to cause symptoms that are different or more severe than expected, considering their individual effects. DON and related compounds also have immunosuppressive effects, resulting in increased somatic cell counts in milk. The U.S. FDA has established an action level for DON in wheat and wheat-derived products intended for cows, which is 5µg DON/g feed and the contaminated ingredient must not exceed 40% of the ration.

Aflatoxins decrease milk quality and pose a risk to humans

Aflatoxins are poorly degraded in the rumen, with aflatoxicol being the main metabolite that can be reconverted to AFB1. Most AFs are absorbed and extensively metabolized/hydrolyzed by enzymes found mainly in the liver. This results in the formation of AFM1, a part of which is conjugated to glucuronic acid and subsequently excreted in the bile. The other part enters the systemic circulation. It is either excreted in urine or milk. AFM1 appears within 12-48 hours after ingestion in cow's milk. The excreted amount of AFM1 in milk from dairy cows usually ranges from 0.17% to 3% of the ingested AFB1. However, this carryover rate may vary from day to day and from one milking to the next in individual animals, as it is influenced by various factors, such as feeding regime, health status, individual biotransformation capacity, and, of course, by actual milk production. Carryover rates of up to 6.2% have been reported in high-yielding dairy cows producing up to 40 liters of milk per day.

In various experiments, AFM1 showed both carcinogenic and immunosuppressive effects. Accordingly, the International Agency for Research on Cancer (IARC) classified AFM1 as being in Group 2B and, thus, possibly carcinogenic in humans. The action level of 0.50 ppb and 0.05 ppb for AFM1 in milk is strictly adhered to by the U.S. Food and Drug Administration (FDA) and the European Food Safety Authority (EFSA), respectively.

Trials show the high adsorption capacity of Solis Max

A trial was conducted at an independent laboratory located in Spain. The evaluation of the performance of Solis Max was executed with the following inclusion levels:

- 0.10% equivalent to 1.0 kg of Solis Max per ton of feed
- 0.20% equivalent to 2.0 kg of Solis Max per ton of feed

A phosphate buffer solution at pH 7 was prepared for the trial to simulate rumen conditions. Each mycotoxin was tested separately, preparing solutions with known contamination (final concentration described in the table below). The contaminated solutions were divided into 3 parts: A positive control, 0.10% Solis Max and 0.20% Solis Max. All samples were incubated at 41°C for 1 hour, centrifuged, and the supernatant was analyzed for the mycotoxin added to determine the binding efficacy. All analyses were carried out by high-performance liquid chromatography (HPLC) with standard detectors.

Mycotoxin	Contamination Level (ppb)
Aflatoxin B1	800

DON	800
Fumonisin B1	2000
ZEA	1200

Results:
The higher concentration of Solis max showed a higher adsorption rate for most mycotoxins. The high dose of Solis Max adsorbed 99% of the AFB1 contamination. In the case of DON, more than 70% was bound. For fumonisin B1 and zearalenone, Solis max showed excellent binding rates of 87.7% and 78.9%, respectively (Figure 1).

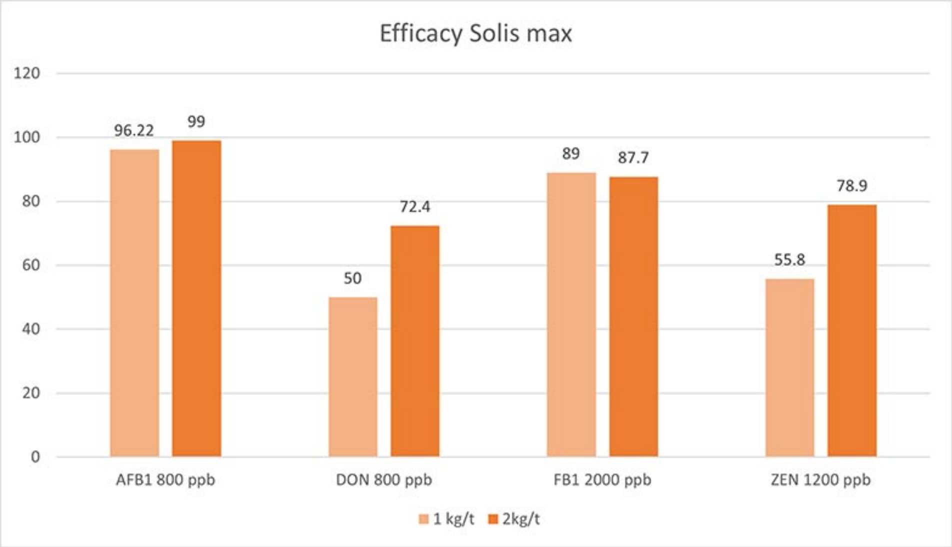


Figure 1: Solis Max showed a high binding capacity for the most relevant mycotoxins

Another trial was conducted at an independent laboratory serving the food and feed industry and located in Valladolid, Spain.

All tests were carried out as duplicates and using a standard liquid chromatography/mass spectrometry (LC/MS/MS) quantification. Interpretation and data analysis were carried out with the corresponding software. The used pH was 3.0, toxin concentrations and anti-mycotoxin agent application rates were set as follows (Table 1):

Mycotoxin	Challenge level	Challenge (ppb)	Solis Plus 2.0 inclusion	Assay time
Aflatoxin	Low	150	0.2%	30 min.
	High	1500	0.2%	30 min.
Fumonisin	Low	500	0.2%	30 min.
	High	5000	0.2%	30 min.
Ochratoxin	Low	150	0.2%	30 min.
	High	1500	0.2%	30 min.

Table 1: Trial set-up testing the binding capacity of Solis Plus 2.0 for several mycotoxins in different contamination levels

Results:

Under acidic conditions (pH3), Solis Plus 2.0 effectively adsorbs the three tested mycotoxins at low and high levels. 100% binding of aflatoxin was achieved at a level of 150ppb and 98% at 1500ppb.In the case of fumonisin, 87% adsorption could be reached at 500ppb and 86 for a challenge with 5000ppb. 43% ochratoxin was adsorbed at the contamination level of 150ppb and 52% at 1500ppb.

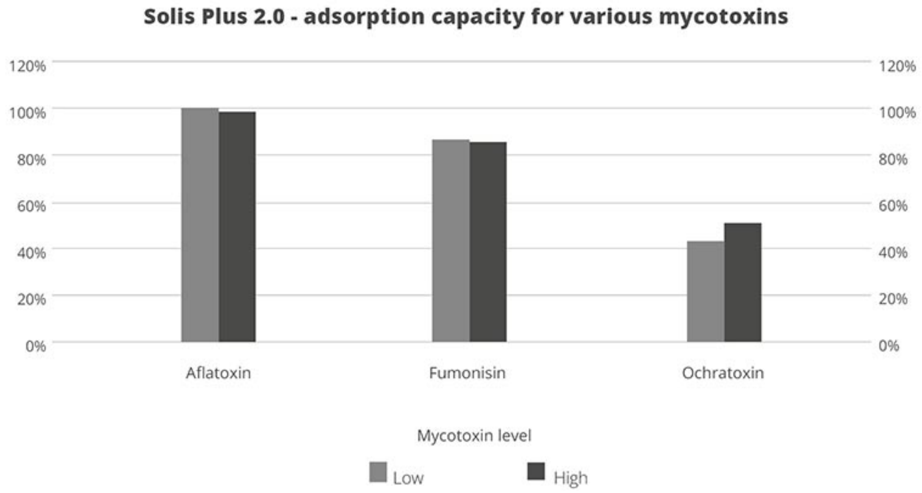


Figure 2: The adsorption capacity of Solis Plus 2.0 for three different mycotoxins at two challenge levels

Mycotoxins – Effective risk management is of paramount importance

Although the rumen microflora may be responsible for conferring some mycotoxin resistance to ruminants compared to monogastric animals, there are still effects of mycotoxins on rumen fermentation and milk quality. In addition, masked mycotoxins in feed present an additional challenge for dairy farms because they are not readily detectable by standard analyses.

Feeding dairy cows with feed contaminated with mycotoxins can lead to a reduction in milk production. Milk quality may also deteriorate due to an adverse change in milk composition and mycotoxin residues, threatening the innocuousness of dairy products. Dairy farmers should therefore have feed tested regularly, consider masked mycotoxins, and take action. EW Nutrition's MasterRisk tool provides a risk evaluation and corresponding recommendations for the use of products that mitigate the effects of mycotoxin contamination and, in the end, guarantee the safety of all of us.

Fighting antimicrobial resistance with immunoglobulins

*By **Lea Poppe**, Regional Technical Manager On-Farm Solutions Europe, and **Dr. Inge Heinzl**, Editor*

One of the ten global public health threats is antimicrobial resistance (AMR). Jim O'Neill predicted 10 million people dying from AMR annually by 2050 (O'Neill, 2016). The following article will show the causes of antimicrobial resistance and how antibodies from the egg could help mitigate the problem of AMR.

Global problem of AMR results from the incorrect use of antimicrobials

Antimicrobial substances are used to prevent and cure diseases in humans, animals, and plants and include antibiotics, antivirals, antiparasitics, and antifungals. The use of these medicines does not always happen consciously, partially due to ignorance and partially for economic reasons.

There are various possibilities for the wrong therapy

1. The use of antibiotics against diseases that household remedies could cure. A recently published German study (Merle et al., 2023) confirmed the linear relationship between treatment frequency and resistant scores in calves younger than eight months.
2. The use of antibiotics against viral diseases: antibiotics only act against bacteria and not against viruses. Flu, e.g., is caused by a virus, but doctors often prescribe an antibiotic.
3. Using broad-spectrum antibiotics instead of determining an antibiogram and applying a specific

antibiotic.
4. A too-long treatment with antimicrobials so that the microorganisms have the time to adapt. For a long time, the only mistake you could make was to stop the antibiotic therapy too early. Today, the motto is “as short as possible”.

Let’s take the example of neonatal calf diarrhea, one of the most common diseases with a high economic impact. Calf diarrhea can be caused by a wide range of bacteria, viruses, or parasites. This infectious form can be a complication of non-infectious diarrhea caused by dietary, psychological, and environmental stress (Uetake, 2012). The pathogens causing diarrhea in calves can vary with the region. In Switzerland and the UK, e.g., rotaviruses and cryptosporidia are the most common pathogens, whereas, in Germany, E. coli is also one of the leading causes. To minimize the occurrence of AMR, it is always crucial to know which pathogen is behind the disease.

Prophylactic use of antibiotics is still a problem

1. The use of low doses of antibiotics to promote growth. This use has been banned in the EU now for 17 years now, but in other parts of the world, it is still common practice. Especially in countries with low hygienic standards, antibiotics show high efficacy.
2. The preventive use of antibiotics to help, e.g., piglets overcome the critical step of weaning or to support purchased animals for the first time in their new environment. Antibiotics reduce pathogenic pressure, decrease the incidence of diarrhea, and ensure the maintenance of growth.
3. Within the scope of prophylactic use of antimicrobials, also group treatment must be mentioned. In veal calves, group treatments are far more common than individual treatments (97.9% of all treatments), as reported in a study documenting medication in veal calf production in Belgium and the Netherlands. Treatment indications were respiratory diseases (53%), arrival prophylaxis (13%), and diarrhea (12%). On top, the study found that nearly half of the antimicrobial group treatment was underdosed (43.7%), and a large part (37.1%) was overdosed.

However, in several countries, consumers request reduced or even no usage of antibiotics (“No Antibiotics Ever” – NAE), and animal producers must react.

Today’s mobility enables the spreading of AMR worldwide

Bacteria, viruses, parasites, and fungi that no longer respond to antimicrobial therapy are classified as resistant. The drugs become ineffective and, therefore, the treatment of disease inefficient or even impossible. All the different usages mentioned before offer the possibility that resistant bacteria/microorganisms will occur and proliferate. Due to global trade and the mobility of people, drug-resistant pathogens are spreading rapidly throughout the world, and common diseases cannot be treated anymore with existing antimicrobial medicines like antibiotics. Standard surgeries can become a risk, and, in the worst case, humans die from diseases once considered treatable. If new antibiotics are developed, their long-term efficacy again depends on their correct and limited use.

Different approaches are taken to fight AMR

There have already been different approaches to fighting AMR. As examples, the annually published MARAN Report compiled in the Netherlands, the EU ban on antibiotic growth promoters in 2006, “No antibiotics ever (NAE) programs” in the US, or the annually published “Antimicrobial resistance surveillance in Europe” can be mentioned. One of the latest approaches is an advisory “One Health High-Level Expert Panel” (OHHLEP) founded by the Food and Agriculture Organization of the United Nations (FAO), the World Organization for Animal Health (OIE), the United Nations Environment Program (UNEP), and the World Health Organization (WHO) in May 2021. As AMR has many causes and, consequently, many players are involved in its reduction, the OHHLEP wants to improve communication and collaboration between all sectors and stakeholders. The goal is to design and implement programs, policies, legislations, and research to improve human, animal, and environmental health, which are closely linked. Approaches like those mentioned help reduce the spread of resistant pathogens and, with this, remain able to treat diseases in humans, animals, and plants.

On top of the pure health benefits, reducing AMR improves food security and safety and contributes to achieving the Sustainable Development Goals (e.g., zero hunger, good health and well-being, and clean water).

Prevention is better than treatment

Young animals like calves, lambs, and piglets do not receive immunological equipment in the womb and need a passive immune transfer by maternal colostrum. Accordingly, optimal colostrum management is the first way to protect newborn animals from infection, confirmed by the general discussion on the Failure of Passive Transfer: various studies suggest that calves with poor immunoglobulin supply suffer from diarrhea more frequently than calves with adequate supply.

Especially during the immunological gap when the maternal immunoglobulins are decreasing and the own immunocompetence is still not fully developed, it is crucial to have a look at housing, stress triggers, biosecurity, and the diet to reduce the risk of infectious diseases and the need for treatments.

Immunoglobulins from eggs additionally support young animals

Also, if newborn animals receive enough colostrum in time and if everything goes optimally, the animals suffer from two immunity gaps: the first one occurs just after birth before the first intake of colostrum, and the second one occurs when the maternal antibodies decrease, and the immune system of the young animal is still not developed completely. These immunity gaps raise the question of whether something else can be done to support newborns during their first days of life.

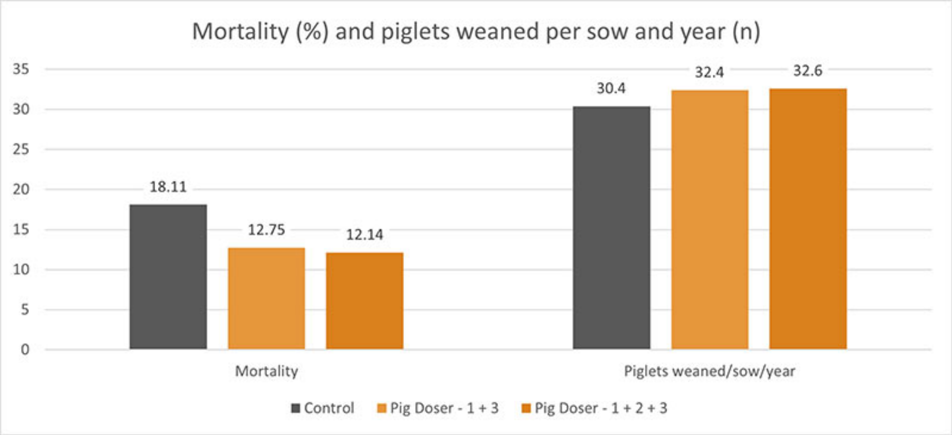
The answer was provided by Felix Klemperer (1893), a German internist researching immunity. He found that hens coming in contact with pathogens produce antibodies against these agents and transfer them to the egg. It is unimportant if the pathogens are relevant for chickens or other animals. In the egg, the immunoglobulins usually serve as an immune starter kit for the chick.

Technology enables us today to produce a high-value product based on egg powder containing natural egg immunoglobulins (IgY – **i**mmuno**g**lobulins from the **y**olk). These egg antibodies mainly act in the gut. There, they recognize and tie up, for example, diarrhea-causing pathogens and, in this way, render them ineffective.

The efficacy of egg antibodies was demonstrated in different studies (Kellner et al., 1994; Erhard et al., 1996; Ikemori et al., 1997; Yokoyama et al., 1992; Marquart, 1999; Yokoyama et al., 1997) for piglets and calves.

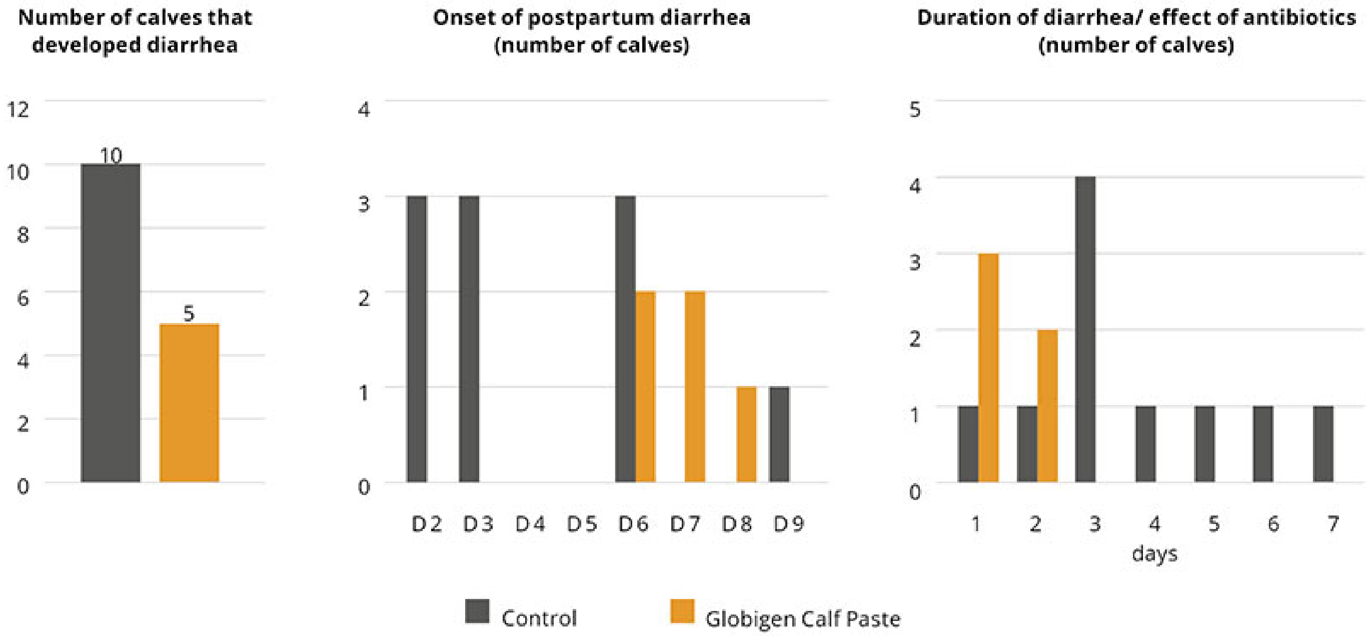
Trial proves high efficacy of egg immunoglobulins in piglets

One trial conducted in Germany showed promising results concerning the reduction of mortality in the farrowing unit. For the trial, 96 sows and their litters were divided into three groups with 32 sows each. Two of the groups orally received a product containing egg immunoglobulins, the EP -1 + 3 group on days 1 and 3 and the EP – 1 + 2 + 3 group on the first three days. The third group served as a control. Regardless of the frequency of application, the egg powder product was very supportive and significantly reduced mortality compared to the control group. The measure resulted in 2 additionally weaned piglets than in the control group.



Egg immunoglobulins support young dairy calves

IgY-based products were also tested in calves to demonstrate their efficacy. In a field trial conducted on a Portuguese dairy farm with 12 calves per group, an IgY-containing oral application was compared to a control group without supplementation. The test product was applied on the day of birth and the two consecutive days. Key observation parameters during a two-week observation period were diarrhea incidence, onset, duration, and antibiotic treatments, the standard procedure on the trial farm in case of diarrhea. On-farm tests to check for the pathogenic cause of diarrhea were not part of the farm's standards.



In this trial, 10 of 12 calves in the control group suffered from diarrhea, but in the trial group, only 5 calves. Total diarrhea and antibiotic treatment duration in the control group was 37 days (average 3.08 days/animal), and in the trial group, only 7 days (average 0.58 days/animal). Additionally, diarrhea in calves of the Globigen Calf Paste group started later, so the animals already had the chance to develop an at least minimally working immune system.

The supplement served as an effective tool to support calves during their first days of life and to reduce antibiotic treatments dramatically.

Conclusion

Antimicrobial reduction is one of the biggest tasks for global animal production. It must be done without impacting animal health and parameters like growth performance and general cost-efficacy. This overall demand can be supported with a holistic approach considering biosecurity, stress reduction, and nutritional support. Feed supplements such as egg immunoglobulins are commercial options showing great results and benefits in the field and making global animal production take the right direction in the future.

References upon request.

Heat Stress in Poultry

What oxidative stress and inflammation have to do with it, why it affects gut health, and how in-feed products support mitigation strategies

Stress in animals can be defined as any factor causing disruptions to their homeostasis, their stable internal balance. Stress engenders a biological response to regain equilibrium. High environmental temperatures are among the most important environmental stressors for poultry production, causing significant economic losses for the industry.

Climate change, thermoregulation, and stress

Climate change has increased the prevalence and intensity of heat stress conditions in most poultry production areas all over the world.

The optimum temperature for poultry animals' well-being and performance –the so-called thermoneutral zone– is between 18 and 22°C. When birds are kept within this temperature range, they do not have to spend energy on maintaining constant body temperature.

Heat stress is the result of unsuccessful thermoregulation in the animals, as they produce a higher quantity of heat than they can lose. It means that there is a negative balance between the net amount of heat produced by the animal and its capacity to dissipate this body heat to the environment.

Heat stress – contributing factors

This energy imbalance is influenced by environmental factors such as sunlight, thermal irradiation, air temperature, humidity, and stocking density, but also by animal-related factors such as body weight, feather coverage and distribution, hydration status, metabolic rate, and thermoregulatory mechanisms. Moreover, stressors can be additive and different factors such as feed quality and disease can convene leading to severe losses in health and performance.

Increasing the respiratory rate -panting- is the main mechanism of chickens to loss heat, which is achieve by the evaporation of water from the respiratory tract however, relative humidity imposes a ceiling on water evaporation and subsequent dissipation of heat. Thus, the association of heat stress not only with high temperature, but also with high relative humidity.

Heat stress can be classified into two main categories, acute and chronic:

- Acute heat stress refers to a short and fast increase in environmental temperature (a few hours), in general, poultry animals show a degree of resilience to acute heat stress.
- Chronic heat stress is when the high temperatures persist for more extended periods (several days), and their compensatory mechanisms are not sufficient to maintain tissue integrity and thus health and performance are hindered.

The animal's response to heat stress

When the environmental temperature is above the thermoneutral zone, the animals activate thermoregulation mechanisms to lose heat through behavioral, biochemical, and physiological changes and responses.

Behavioral changes

Panting and exposure of low/non-feathered body areas (raising wings) are the main behavioral mechanisms in which chickens regulate their body temperature when exposed to heat stress. These actions help the chickens to cool down, at a high toll: high energy demands, dehydration, respiratory alkalosis, lethargy, decrease in feed intake, loss of intestinal function and oxidative stress.

Physiological changes

The cardiovascular system also responds to high temperatures by deviating blood to the peripheral areas of the body to maximize the dissipation of heat. This implicates a reduced supply of nutrients and oxygen to the gastrointestinal tract, hindering its functions and provoking inflammation and oxidative stress.

The hypothalamic-pituitary-adrenal (HPA) axis gets activated, increasing the levels of circulating corticosterone, skeletal protein synthesis and the immune system is suppressed, therefore the animals stop growing and are more susceptible to disease.

Heat stress also changes the gene expression of cytokines, upregulates heat shock proteins (HSP), and reduces the concentration of thyroid hormones. When heat stress persists, these cascades of cellular reactions result in tissue damage and malfunction. The animals exposed to heat stress suffer adverse effects in terms of performance, which are widely known and include high mortality, lower growth, and production (Figure 1), and a decline in meat and egg quality.

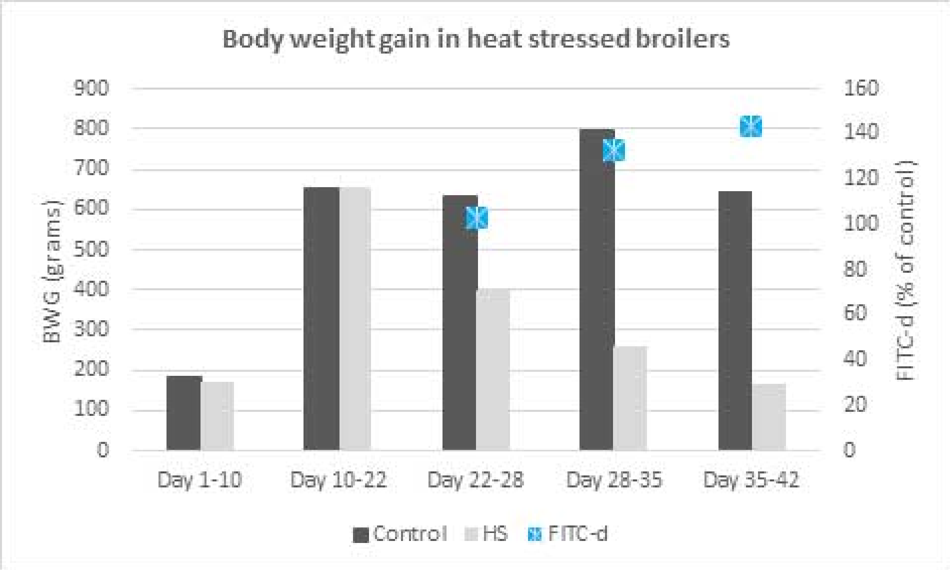


Figure 1: Body weight gain of broilers exposed to chronic heat stress (35°C continuously from day 21). A marker for tight junction permeability was added to feed (FITC-d – fluorescein isothiocyanate dextran); its fluorescence (in serum) increased with heat stress exposure time, showing higher intestinal permeability. (Adapted from Ruff et al., 2020)

Outcomes of heat stress

Oxidative stress

Oxidative stress, simply put, occurs when the amount of reactive oxygen species (ROS) and nitrogen reactive species (NRS), exceed the antioxidant capacity of the cells. Oxidative stress is regarded as one of the most critical stressors in poultry production as it is a response to diverse challenges affecting the animals.

The normal metabolism of the animal – its energy production – generates ROS and RNS, such as hydroxyl radicals, superoxide anions, hydrogen peroxide, and nitric oxide. These usually are further processed by antioxidant enzymes produced by the cell, including superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GSH-Px). Nutrients such as selenium and vitamins E, C, and A also participate in antioxidant processes. When the generation of ROS exceeds the capacity of the antioxidant system, oxidative stress ensues.

Heat stress leads to higher cellular energy demand, promoting an overload of ROS in the mitochondria. Consequently, oxidative stress occurs in several tissues, leading to cell apoptosis or necrosis as oxidized molecules can take electrons from other molecules, resulting in a chain reaction. Among these tissues, the gastrointestinal tract can be highly affected.

Impaired gut function

In the gastrointestinal tract, oxidative stress and the consequent tissue damage, lower feed digestion and absorption, increase intestinal permeability and modify the microbiome.

Changes in intestinal morphology and digestive function

Heat stress affects intestinal weight, length, barrier function, and microbiota, resulting in animals that have lower total and relative weight of the small intestine, with shorter jejunum and duodenum, shorter villi (Figure 2), and reduced absorption areas, in comparison to non-stressed animals.

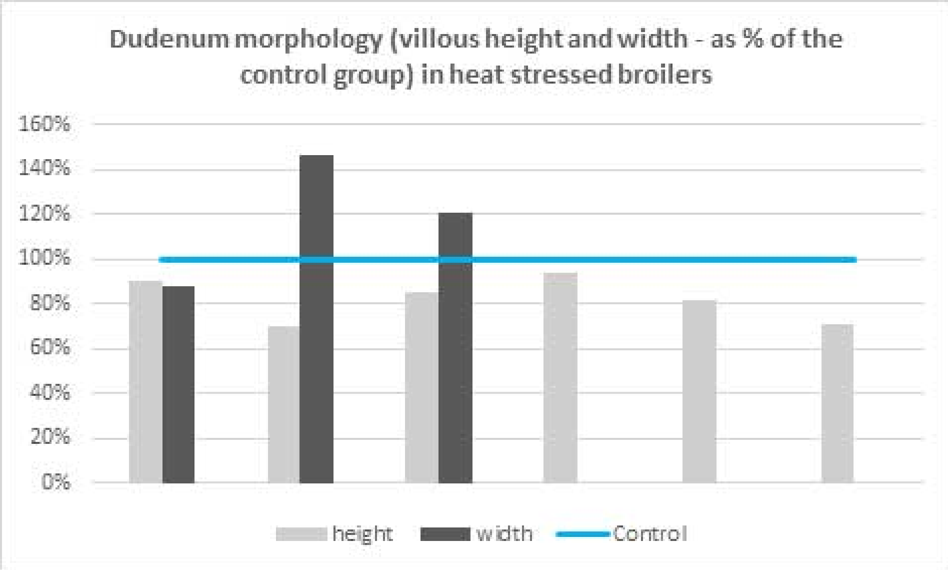


Figure 2: Villous height and width of broilers exposed to heat stress in relation with the control group (100%). Villous height is always shorter than the control group, but width can increase as the organisms shows resilience to the stressful situations and aims to recover intestinal surface. (Adapted from Jahejo et al., 2016; Santos et al., 2019; Wu et al., 2018; Abdelqader et al., 2016 ; Santos et al., 2015 and Awad et al., 2018 – by order of appearance in the graph from left to right)

Changes in the intestinal microbiome

Due to reduced feed intake and impaired intestinal function, the presence and activity of the commensal microbiota can also be modified. Heat stress can lead to reduced populations of beneficial microbes, boost the growth of potential pathogens leading to dysbiosis and necrotic enteritis.

Changes in intestinal permeability

Several studies indicate that both acute and chronic heat stress increase gut permeability, not only by lowering feed intake, but also by increasing intestinal oxidative stress and disrupting the expression of tight junction proteins.

Heat and oxidative stress in the gut result in cell injury and apoptosis. When the tight junction barrier is compromised, luminal substances leak into the bloodstream, which constitutes the condition known as "leaky gut". This includes the translocation of pathogenic bacteria, including zoonotic pathogens (e.g. *Salmonella* and *Campylobacter*); consequently, a higher risk of contamination of food products can be expected.

Endotoxins

Bacterial lipopolysaccharides (LPS), also known as endotoxins, constitute the main components of the outer membrane of all gram-negative bacteria and are essential for their survival. LPS have direct contact with the bacteria's surroundings. They function as a protection mechanism against the host's immunological response and chemical attacks from bile salts, lysozymes, or other antimicrobial agents.

Gram-negative bacteria are part of poultry animals' microbiota; thus, there are always LPS in the intestine. Under optimal conditions, this does not affect animals because intestinal epithelial cells are not responsive to LPS when stimulated from the apical side. In stress situations, the intestinal barrier function is impaired, allowing the passage of endotoxins into the blood stream. When LPS are detected by the immune system either in the blood or in the basolateral side of the intestine, inflammation and changes in the gut epithelial structure and functionality occur.

An increased release and passage of endotoxins has been demonstrated in heat stress (Figure 3) as well as a higher expression of TLR-4 and other inflammation biomarkers, which contributes to the deleterious effects of heat stress in the animals. Moreover, blood LPS induces systemic inflammatory reactions that force the organism to divert energy to support the immune system which furthermore depresses performance.

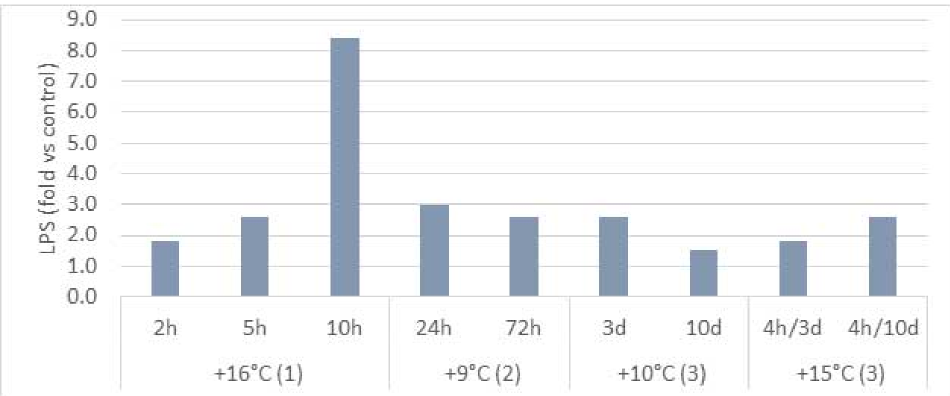


Figure 3 – Systemic LPS increase (in comparison with a non-stressed control) after different heat stress challenges in broilers:16°C increased for 2, 5 and 10 hours (Huang et al., 2018); 9°C increased for 24 and 72 hours (Nanto-Hara et al., 2020); 10°C continuously for 3 and 10 days, and 15°C 4 hours daily for 3 and 10 days (Alhenaky et al., 2017).

Mitigation strategies

Most intervention strategies deal with heat stress through a wide range of measures, including environmental management, housing design, ventilation, sprinkling, and shading, amongst others. Understanding and controlling environmental conditions is a crucial part of heat stress management.

Feed management and nutrition interventions are also recommended to reduce the effects of heat stress. They include feeding pelletized diets with increased energy coming from fats and oils, reduction of total protein with additional supplemental amino acids, increasing levels of vitamins and minerals, and adjusting the dietary electrolyte balance.

Antioxidants

Under oxidative stress conditions in the gut, there is a demand for antioxidants to counteract the excess of ROS; hence, dietary antioxidants can help reduce ROS and improve animal performance.

Research shows that certain phytomolecules, including thymol, carvacrol, cinnamaldehyde, silybinin and quercetin have antioxidant properties and improve performance under conditions of oxidative stress. The antioxidant capacity of phytomolecules manifests itself in free radical scavenging, increased production of natural antioxidants, and the activation of transcription factors. Moreover, menthol and cineol, also aid animals under heat stress by simulating the sensory cold receptors of the oral mucosa, giving the animals a cooling sensation, and reducing heat stress behavior.

Controlling LPS and oxidative stress

An experiment conducted by EW Nutrition GmbH had the objective to evaluate the ability of a product (Solis Max 2.0) in mitigating heat-stress induced LPS as well as oxidative stress.

For the experiment, Cobb 500 breeder pullets were divided in two groups, each group was placed in 11 pens of 80 hens, in a single house. One of the groups received feed containing 2kg/ton of the product from the first day. From week 8 to week 12, the temperature of the house was raised 10°C for 8 hours every day.

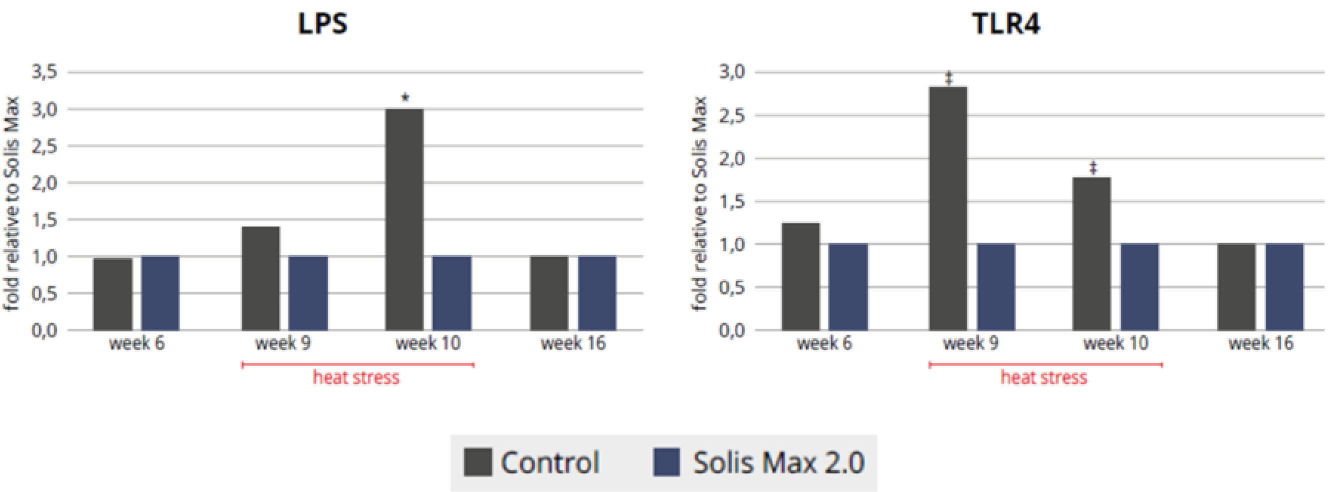


Figure 4 and 5: Blood LPS and expression of toll-like receptor 4 (TLR4) in lymphocites of pullets before (wk 6), and during heat stress (wk 9 and 10). (*) indicates significant differences (P<0,05), and (‡) a tendency to be different against the control group (P<0,1).

Throughout the heat stress period, blood LPS (Fig 4) was lower in the pullets receiving the product, which allowed lower inflammation evidenced by the lower expression of TLR4 (Fig. 5). Oxidative stress was also mitigated with the help of the combination of phytomolecules in the product (Fig. 6), obtaining 8.5% improvement on serum total antioxidant capacity (TAC), supported by an increase in in superoxide dismutase (SOD glutathione peroxidase (GSH) and a decrease in malondialdehyde (MDH).

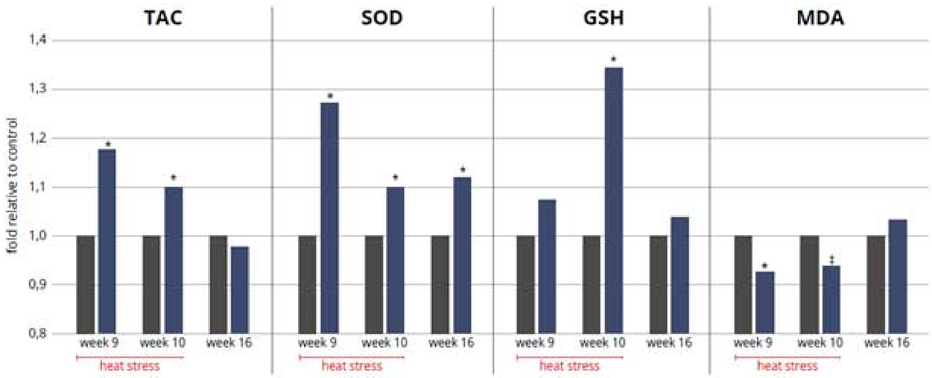


Figure 6: Antioxidant capacity of pullets during heat stress (wk 9 and 10). (*) indicates significant differences (P<0,05), and (‡) a tendency to be different against the control group (P<0,1). Parameters measured are total antioxidant capacity (TAC), super oxide dismutase (SOD), gluthatione peroxidase (GSH), and malondialdehyde (MDA).

In the bottom line, the heat stress challenge also affected performance, affecting feed conversion (9 points lower) and body weight (3% lower). The optimal supporting product was able to efficiently reduce the LPS exposure for the pullets and thus inflammation and oxidative stress were reduced, as a consequence energy could be driven to performance evidenced by a better BW and FCR.

Summary

Heat stress is a common reality in poultry production, its effects are quite complex and harmful and depend on the intensity and duration of the exposure to high temperatures.

By lowering feed digestibility, increasing gut permeability, and compromising immunity, heat stress leaves animals more susceptible to gut-health related issues such as dysbacteriosis and necrotic enteritis – and thus may increase the need to use antibiotics. Additionally, the passage of LPS through the permeable gut induces inflammation and further damage to animal welfare, health and performance.

Mitigation strategies, including support to the gut oxidative balance and lowering LPS-induced inflammation are crucial to support poultry animals in these critical periods.

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Climate change in poultry production: 5 major threats and what you can do to mitigate the impact

"Every single social and global issue of our day is a business opportunity in disguise."
Peter Drucker

*By **Ajay Bhoyar**, Global Technical Manager, EW Nutrition*

Topics covered

Major areas impacted by climate change
- Feed quality
- Genetics
- Farm management
- Animal performance
- On- and off-farm logistics

The cost of doing nothing

Global livestock systems constitute an industrial asset worth over $1.4 trillion. Projections indicate that the global livestock population, now at 60+ billion, could exceed 100 billion by 2050 – more than ten times the expected human population at that time (Yitbarek 2019, Herrero 2009).

Our industry bears an enormous responsibility: to feed the growing population, sustainably and consistently, despite increasing challenges. And one of the biggest challenges is already looming large.

Animal agriculture, including poultry farming, is particularly susceptible to the adverse effects of climate change. Increased extreme weather events, farm fires facilitated by drought, thermal pressure on farmed animals, reduced availability or increased prices of water, raw materials, and electricity, and much more are already impacting the industry.

This is, in all likelihood, just the beginning. How exactly will poultry production be affected in the future – and what can you do to future-proof your operation against the coming challenges?

Major impact areas of climate change – and what to do about them

1. Feed quality

Excessive heat, droughts, or floods can reduce crop yields, decrease nutritional content, and increase the risk of pests, pathogens, and weed outbreaks.

Plants with a C_3 photosynthetic pathway such as wheat, rice, or soybean can benefit from increased temperature more than the so-called C_4 plants such as corn or sorghum (Cui 2021). NASA projections show corn crop yields are expected to decline 24% in the next 30 years (Gray 2021).

Moreover, increased temperature, shifts in rainfall patterns, and elevated surface greenhouse gas (GHG) concentrations can also lead to lower grain protein concentration (Godde 2010, Myers 2014), as well as affect mineral and vitamin concentrations in plants.

Pollinator-dependent crops like soybean or rapeseed could also see decreased yield under climactic challenges (Godde 2020).

Fast fact

In 2020, 75% of soil in Mexico was declared too dry to cultivate crops. In 2021, 70% of the country was impacted by crop loss and water shortages caused by drought. Corn yield decreased by 18% in five years and is expected to fall further (Carlin 2023).

Warmer temperatures and changes in precipitation patterns can create favorable conditions for the growth of mycotoxins, leading to reduced feed quality and health problems in poultry. Especially corn and sorghum are vulnerable to aflatoxin contamination in hot and humid conditions. On top of this, storage will become more challenging as pathogen growth will further erode feed quality.

ACTION

- **Diversification of feed sources**: Exploring alternative feed ingredients that are less reliant on climate-sensitive crops can help mitigate the impact of changing weather patterns on feed availability and costs.
- **Mycotoxin mitigation**: Not all toxin mitigation solutions are created equal. Choose standardized toxins mitigation solutions based on their efficacy instead of upfront cost. The products that are regularly tested against undesirable and harmful impurities like dioxins, dioxins-like PCBs and heavy metals.

2. Genetics

Rising temperatures may lead to reduced fertility and hatchability, affecting the overall health and reproductive performance of chickens. Extreme heat can also impact the expression of genes related to growth, feed efficiency, and resistance to diseases. As a result, poultry breeders and geneticists face the challenge of developing more heat-tolerant poultry breeds to ensure sustainable production under changing climatic conditions.

ACTION

- **Genetic selection for thermotolerance**: Breeding programs can focus on developing more heat-tolerant chicken breeds that exhibit improved performance and resilience in challenging climatic conditions. Producers need to pay attention to the specifics of the breed's genetic makeup.

3. Farm Management

3.1 Solving for thermal comfort: Electricity costs

The thermal comfort of livestock is no longer a concern for tropical zones only. Temperate zones are also seeing sustained increases in ambient temperatures.
High temperatures and prolonged heat waves increase electricity consumption as farmers rely on ventilation, cooling systems, and artificial lighting to maintain optimal conditions for chickens. Consequently, energy costs will rise, impacting the profitability of poultry farms.

3.2 Solving for water availability: Resource management

Water scarcity, changing precipitation patterns, and droughts can limit the availability of water resources, affecting poultry farms' water consumption and overall operational efficiency.
The quality of water is also an increasing concern. The UN states that "higher water temperatures and more frequent floods and droughts are projected to exacerbate many forms of water pollution – from sediments to pathogens and pesticides". Reduced raw water quality "can decrease animal water intake, feed intake and health" (Valente-Campos 2019). Especially in Asia and Africa, which have seen massive

increases in floods and droughts, respectively, water scarcity and quality will pose severe issues.

ACTION

- **Improved farm management practices**: Implementing energy-efficient systems, such as solar power and energy-saving technologies, can reduce electricity consumption and associated costs. Water management techniques, such as rainwater harvesting and efficient irrigation systems, can help mitigate the impact of water scarcity. As always, strict biosecurity will play a critical role.
- **Enhanced ventilation and cooling systems**: Upgrading ventilation systems and implementing efficient cooling mechanisms can alleviate heat stress on chickens, enhancing their overall health and productivity. Regular maintenance and sensor technologies also play an important preventive role.

3.3 Built-up and human capital risk

In high-risk areas, machinery, electricity networks, telecommunications, building infrastructure in general can be impacted by extreme weather events, rising sea levels etc. (Nardone 2010).

Labor availability and productivity might, on the other hand, be impacted in many areas. Disease outbreaks, including new strains, as well as decreased air quality, extreme events etc. might in the future contribute to labor shortages. The number of unsafe hot workdays is expected to double by 2050, which will impact especially rural India, sub-Saharan Africa, and Southeast Asia (Carlin 2023).

ACTION

- **Climate-resilient infrastructure**: Investing in resilient infrastructure, such as elevated coops, flood-resistant buildings, or disease surveillance technology can minimize the risk of incidents from weather events and can support early action against disease pressure. Investments in smart farming can also relieve pressure on labor and improve speed of action.
- **Insurability and loan math**: Any future-looking business needs to work with the likelihood of increased insurance costs and higher insurability requirements. Also, a point will come at which non-resilient infrastructure will not be financed.

4. Animal performance

> **Fast fact**
> Heat stress reduces productivity, impacts fertility, and increases susceptibility to disease. It can also reduce the size of eggs and thickness of eggshells (Godde 2021)

While colder areas will benefit from reduced house heating and ventilation needs, warm areas will be at increased risk. A hot environment “impairs production (growth, meat and milk yield and quality, egg yield, weight, and quality) and reproductive performance, metabolic and health status, and immune response” (Nardone 2010, Ali 2020).
The proliferation of pathogens in warm environments will pose further challenges. Antibiotic resistance from attempts to control these issues will only compound the problem.

Additionally, as mentioned before, changes in weather patterns can impact crop yields, including the availability and affordability of feed ingredients for chickens. Producers will have to reformulate often to match availability, cost, and nutritional value.

ACTION

- **Stress and pathogenic impact mitigation solutions**: Phytogenic feed additives can support poultry gut health and strengthen the immune response when confronted with stress factors, including heat stress, humid environments, pen density, and pathogen pressure. With the added benefit of reducing dependence on antibiotics and other medication, they can naturally stimulate or support a healthy response to challenges.

5. On- and off-farm logistics

Transportation is also affected all along the supply chain, from bringing feed or young stock to the farm to moving livestock to processing facilities and further distribution along the chain. Extreme weather events, such as hurricanes, floods, or heavy snowfall, can lead to power outages and/or disrupt transportation routes and infrastructure, hindering the timely delivery of chicks, feed, and other essential supplies to poultry farms.

In addition to the challenge of transportation, packaging will soon fall under regulatory scrutiny. Sustainability requirements may be national, but compliance will have to follow across borders for any producers eyeing international markets.

ACTION

- **Data is your friend**: Transportation and logistics data can helps improve efficiency and reduce your environmental impact. Start tracking fuel consumption, carbon emissions, transportation costs, and other relevant metrics to identify areas for optimization.
- **Think globally**: ESG (Environmental, Social and Governance) guidance will become a standard in many important markets, including Europe and the US. Keep an eye on international regulations, especially for your target markets. Their ESG requirements are *your* ESG requirements.

The world needs more meat

The bad news is that climate change is coming at us fast. Animal agriculture will be among the most heavily impacted. Major adjustments will be needed to mitigate the effects and to embrace the long view.

The good news is that livestock systems remain critical to our growing population. The world population is projected to grow to 9.8 billion by 2050 (UNDESA, 2017). Livestock products (meat, milk and eggs) account for about 30% of the population's protein supply, with large regional variations (FAOSTAT, 2022; Godde et al, 2021).

To answer this growing demand, world meat production is expected to increase by 14% by the end of the decade, compared to current figures (Carlin 2023). The increase in meat demand might be as high as 76% compared to 2005/2007 (Alexandratos 2012).

Fast fact

1.5% annual growth in livestock and fish production will result from improvements in per-animal productivity. Poultry will account for over 50% of meat production growth, due to sustained profitability and favorable meat-to-feed price ratio (OECD FAO 2022).

The cost of doing nothing

We must look at the challenges of climate change, in the words of Peter Drucker, as a business opportunity. As always, those who act early will reap important rewards – not just through market differentiation but through economic resilience.

What awaits those who do not take action?

The United Nations Environment Programme warns of some foreseeable consequences of inaction, most of which can be grouped under three categories:

- **Rising costs**: Cost of decreased performance, increased cost of doing business, carbon taxes
- **Policy restrictions**: Once a few major markets have implemented restrictive labeling, packaging, or production regulations, anyone who wants to operate in these markets is subject to the same restrictions.
- **Reputational risk / Market and investor preferences**: The risk of falling behind or not taking action, in other words the opportunity cost, is hard to quantify until it's too late. Banks and investors may give up on unsustainable financing as soon as consumers and/or regulators show signs of concern. Acting ahead of the curve is also a market positioning win as well as economic win. The market rewards first movers.

The impact of climate change on genetics, farm management, animal performance, farm logistics, and transportation necessitate proactive adaptation and mitigation strategies, in coordination with local and global expertise. Responses will vary depending on geography, production type, and more – but *doing nothing is no longer an option*. By implementing sustainable practices across the board and investing in resilient infrastructure, poultry producers can maintain a robust, high-performing, sustainable production system.

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Toxin Mitigation 101: Essentials for Animal Production

*By **Monish Raj**, Assistant Manager-Technical Services, EW Nutrition*
***Inge Heinzl**, Editor, EW Nutrition*

Mycotoxins, toxic secondary metabolites produced by fungi, are a constant and severe threat to animal production. They can contaminate grains used for animal feed and are highly stable, invisible, and resistant to high temperatures and normal feed manufacturing processes. Mycotoxin-producing fungi can be found during plant growth and in stored grains; the prevalence of fungi species depends on environmental conditions, though in grains, we find mainly three genera: Aspergillus, Penicillium, and Fusarium. The most critical mycotoxins for poultry production and the fungi that produce them are detailed in Fig 1.

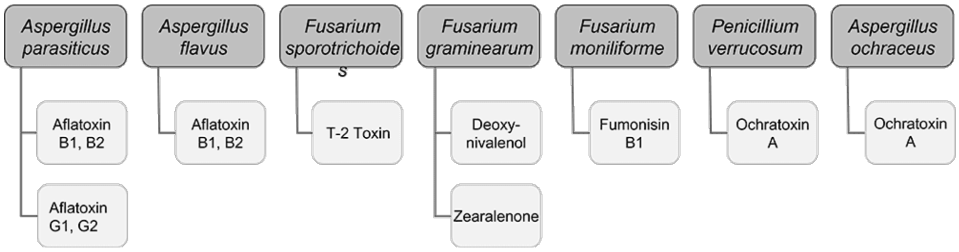

Figure 1: Fungi species and their mycotoxins of worldwide importance for poultry production (adapted from Bryden, 2012).

The effects of mycotoxins on the animal are manifold

When, usually, more than one mycotoxin enters the animal, they "cooperate" with each other, which means that they combine their effects in different ways. Also, not all mycotoxins have the same targets.

The synergistic effect: When 1+1 ≥3

Even at low concentrations, mycotoxins can display synergistic effects, which means that the toxicological consequences of two or more mycotoxins present in the same sample will be higher than the sum of the toxicological effects of the individual mycotoxins. So, disregarded mycotoxins can suddenly get important due to their additive or synergistic effect.

Table 1: Synergistic effects of mycotoxins in poultry

Synergistic interactions				
	DON	ZEN	T-2	DAS
FUM	*	*	*	
NIV	*	*	*	
AFL			*	*

Table 2: Additive effects of mycotoxins in poultry

Additive interactions				
	AFL	T2	DAS	MON
FUM	+	+	+	+
DON	+	+		
OTA	+	+		

Recognize the effects of mycotoxins in animals is not easy

The mode of action of mycotoxins in animals is complex and has many implications. Research so far could identify the main target organs and effects of high levels of individual mycotoxins. However, the impact of low contamination levels and interactions are not entirely understood, as they are subtle, and their identification requires diverse analytical methods and closer observation.

With regard to the gastrointestinal tract, mycotoxins can inhibit the absorption of nutrients vital for maintaining health, growth, productivity, and reproduction. The nutrients affected include amino acids, lipid-soluble vitamins (vitamins A, D, E, and K), and minerals, especially Ca and P (Devegowda and Murthy, 2005). As a result of improper absorption of nutrients, egg production, eggshell formation, fertility, and hatchability are also negatively influenced.

Most mycotoxins also have a negative impact on the immune system, causing a higher susceptibility to disease and compromising the success of vaccinations. Besides that, organs like kidneys, the liver, and lungs, but also reproduction, endocrine, and nervous systems get battered.

Mycotoxins have specific targets

Aflatoxins, fumonisins, and ochratoxin impair the liver and thus the physiological processes modulated and performed by it:

- lipid and carbohydrate metabolism and storage
- synthesis of functional proteins such as hormones, enzymes, and nutrient transporters
- metabolism of proteins, vitamins, and minerals.

For trichothecenes, the gastrointestinal tract is the main target. There, they hamper digestion, absorption, and intestinal integrity. T-2 can even produce necrosis in the oral cavity and esophagus.

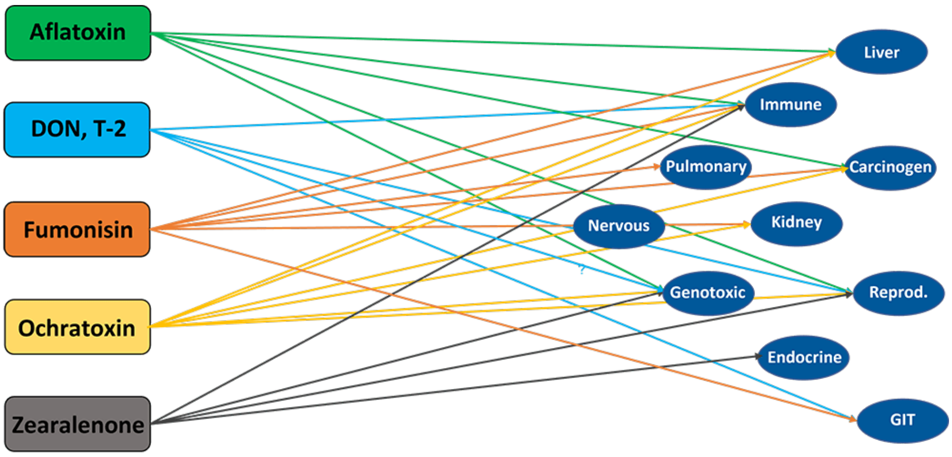

Figure 2: Main target organs of important mycotoxins

How to reduce mycotoxicosis?

There are two main paths of action, depending on whether you are placed along the crop production, feed production, or animal production cycle. Essentially, you can either prevent the formation of mycotoxins on the plant on the field during harvest and storage or, if placed at a further point along the chain, mitigate their impact.

Preventing mycotoxin production means preventing mold growth

To minimize the production of mycotoxins, the development of molds must be inhibited already during the cultivation of the plants and later on throughout storage. For this purpose, different measures can be taken:

Selection of the suitable crop variety, good practices, and

optimal harvesting conditions are half of the battle

Already before and during the production of the grains, actions can be taken to minimize mold growth as far as possible:

- Choose varieties of grain that are area-specific and resistant to insects and fungal attacks.
- Practice crop rotation
- Harvest proper and timely
- Avoid damage to kernels by maintaining the proper condition of harvesting equipment.

Optimal moisture of the grains and the best hygienic conditions are essential

The next step is storage. Here too, try to provide the best conditions.

- Dry properly: grains should be stored at <13% of moisture
- Control moisture: minimize chances of moisture to increase due to condensation, and rain-water leakage
- Biosecurity: clean the bins and silos routinely.
- Prevent mold growth: organic acids can help prevent mold growth and increase storage life.

Mold production does not mean that the war is lost

Even if molds and, therefore, mycotoxins occur, there is still the possibility to change tack with several actions. There are measures to improve feed and support the animal when it has already ingested the contaminated feed.

1. Feed can sometimes be decontaminated

If a high level of mycotoxin contamination is detected, removing, replacing, or diluting contaminated raw materials is possible. However, this is not very practical, economically costly, and not always very effective, as many molds cannot be seen. Also, heat treatment does not have the desired effect, as mycotoxins are highly heat stable.

2. Effects of mycotoxins can be mitigated

Even when mycotoxins are already present in raw materials or finished feed, you still can act. Adding products adsorbing the mycotoxins or mitigating the effects of mycotoxins in the organism has been considered a highly-effective measure to protect the animals (Galvano et al., 2001).

This type of mycotoxin mitigation happens at the animal production stage and consists of suppressing or reducing the absorption of mycotoxins in the animal. Suppose the mycotoxins get absorbed in the animal to a certain degree. In that case, mycotoxin mitigation agents help by promoting the excretion of mycotoxins, modifying their mode of action, or reducing their effects. As toxin-mitigating agents, the following are very common:

Aluminosilicates: inorganic compounds widely found in nature that are the most common agents used to mitigate the impact of mycotoxins in animals. Their layered (phyllosilicates) or porous (tectosilicates) structure helps “trap” mycotoxins and adsorbs them.

- Bentonite / Montmorillonite: classified as phyllosilicate, originated from volcanic ash. This absorbent clay is known to bind multiple toxins in vivo. Incidentally, its name derives from the Benton Shale in the USA, where large formations were discovered 150 years ago.
  Bentonite mainly consists of smectite minerals, especially montmorillonite (a layered silicate with a larger surface area and laminar structure).

- Zeolites: porous crystalline tectosilicates, consisting of aluminum, oxygen, and silicon. They have a framework structure with channels that fit cations and small molecules. The name "zeolite" means "boiling stone" in Greek, alluding to the steam this type of mineral can give off in the heat). The large pores of this material help to trap toxins.

Activated charcoal: the charcoal is "activated" when heated at very high temperatures together with gas. Afterward, it is submitted to chemical processes to remove impurities and expand the surface area. This porous, powdered, non-soluble organic compound is sometimes used as a binder, including in cases of treating acute poisoning with certain substances.

Yeast cell wall: derived from *Saccharomyces cerevisiae.* Yeast cell walls are widely used as adsorbing agents. Esterified glucomannan polymer extracted from the yeast cell wall was shown to bind to aflatoxin, ochratoxin, and T-2 toxin, individually and combined (Raju and Devegowda 2000).

Bacteria: In some studies, Lactic Acid Bacteria (LAB), particularly *Lactobacillus rhamnosus*, were found to have the ability to reduce mycotoxin contamination.

Which characteristics are crucial for an effective toxin-mitigating solution

If you are looking for an effective solution to mitigate the adverse effects of mycotoxins, you should keep some essential requirements:

1. The product must be safe to use:
    a. safe for the feed-mill workers.
    b. does not have any adverse effect on the animal
    c. does not leave residues in the animal
    d. does not bind with nutrients in the feed.
2. It must show the following effects:
    a. effectively adsorbs the toxins relevant to your operation.
    b. helps the animals to cope with the consequences of non-bound toxins.
3. It must be practical to use:
    a. cost-effective
    b. easy to store and add to the feed.

Depending on

- the challenge (one mycotoxin or several, aflatoxin or another mycotoxin),
- the animals (short-cycle or long-living animals), and
- the economical resources that can be invested,

different solutions are available on the market. The more cost-effective solutions mainly contain clay to adsorb the toxins. Higher-in-price products often additionally contain substances such as phytogenics supporting the animal to cope with the consequences of non-bound mycotoxins.

Solis – the cost-effective solution

In the case of contamination with only aflatoxin, the cost-effective solution Solis is recommended. Solis consists of well-selected superior silicates with high surface area due to its layered structure. Solis shows high adsorption of aflatoxin B1, which was proven in a trial:

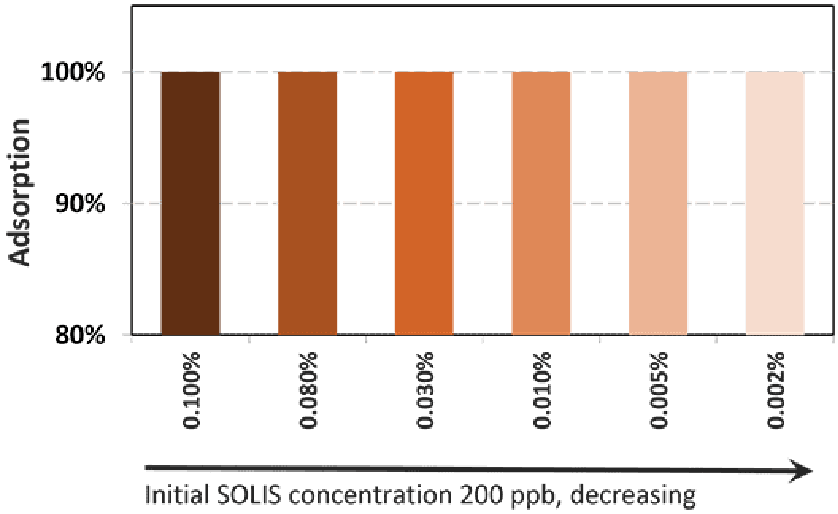

Figure 3: Binding capacity of Solis for Aflatoxin

Even at a low inclusion rate, Solis effectively binds the tested mycotoxin at a very high rate of nearly 100%. It is a high-efficient, cost-effective solution for aflatoxin contamination.

Solis Max 2.0: The effective mycotoxin solution for sustainable profitability

Solis Max 2.0 has a synergistic combination of ingredients that acts by chemi- and physisorption to prevent toxic fungal metabolites from damaging the animal's gastrointestinal tract and entering the bloodstream.

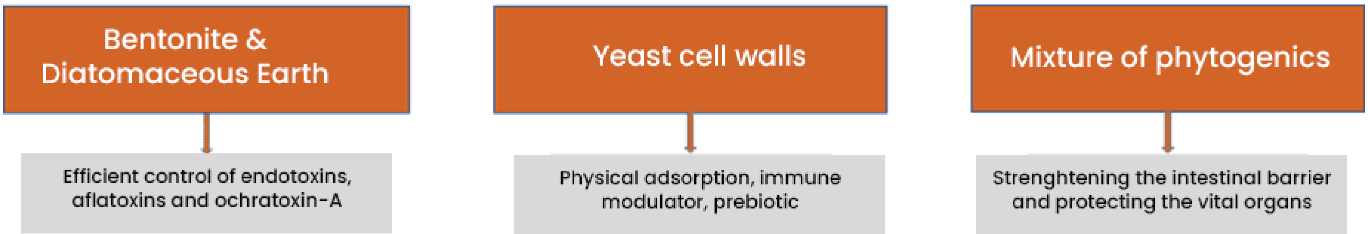

Figure 4: Composition and effects of Solis Max 2.0

Solis Max 2.0 is suitable for more complex challenges and longer-living animals: in addition to the pure mycotoxin adsorption, Solis Max 2.0 also effectively supports the liver and, thus, the animal in its fight against mycotoxins.

In an in vitro trial, the adsorption capacity of Solis Max 2.0 for the most relevant mycotoxins was tested. For the test, the concentrations of Solis Max 2.0 in the test solutions equated to 1kg/t and 2kg/t of feed.

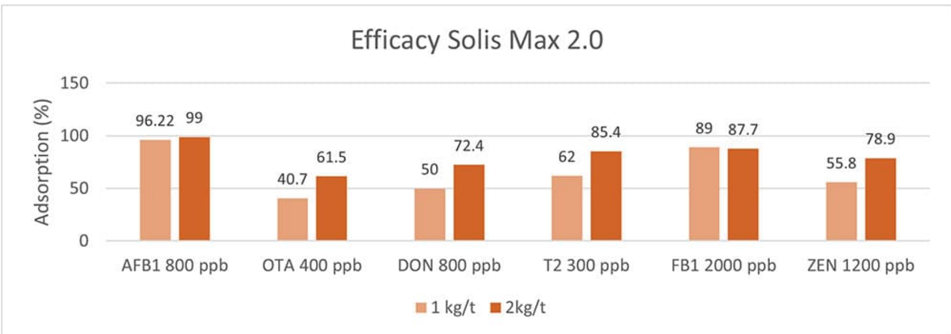

Figure 5: Efficacy of Solis Max 2.0 against different mycotoxins relevant in poultry production

The test showed a high adsorption capacity: between 80% and 90% for Aflatoxin B1, T-2 Toxin (2kg/t), and Fumonisin B1. For OTA, DON, and Zearalenone, adsorption rates between 40% and 80% could be achieved at both concentrations (Figure 5). This test demonstrated that Solis Max 2.0 could be considered a valuable tool to mitigate the effects of mycotoxins in poultry.

Broiler trial shows improved performance in broilers

Protected and, therefore, healthier animals can use their resources for growing/laying eggs. A trial showed improved liver health and performance in broilers challenged with two different mycotoxins but supported with Solis Max 2.0.

For the trial, 480 Ross-308 broilers were divided into three groups of 160 birds each. Each group was placed in 8 pens of 20 birds in a single house. Nutrition and management were the same for all groups. If the birds were challenged, they received feed contaminated with 30 ppb of Aflatoxin B1 (AFB1) and 500 ppb of Ochratoxin Alpha (OTA).

Negative control:	no challenge	no mycotoxin-mitigating product
Challenged group:	challenge	no mycotoxin-mitigating product
Challenge + Solis Max 2.0	challenge	Solis Max 2.0, 1kg/t

The body weight and FCR performance parameters were measured, as well as the blood parameters of alanine aminotransferase and aspartate aminotransferase, both related to liver damage when increased.

Concerning performance as well as liver health, the trial showed partly even better results for the challenged group fed with Solis Max 2.0 than for the negative, unchallenged control (Figures 6 and 7):

- 6% higher body weight than the negative control and 18.5% higher body weight than the challenged group
- 12 points and 49 points better FCR than the negative control and the challenged group, respectively
- Lower levels of AST and ALT compared to the challenged group, showing a better liver health

The values for body weight, FCR, and AST, even better than the negative control, may be owed to the content of different gut and liver health-supporting phytomolecules.

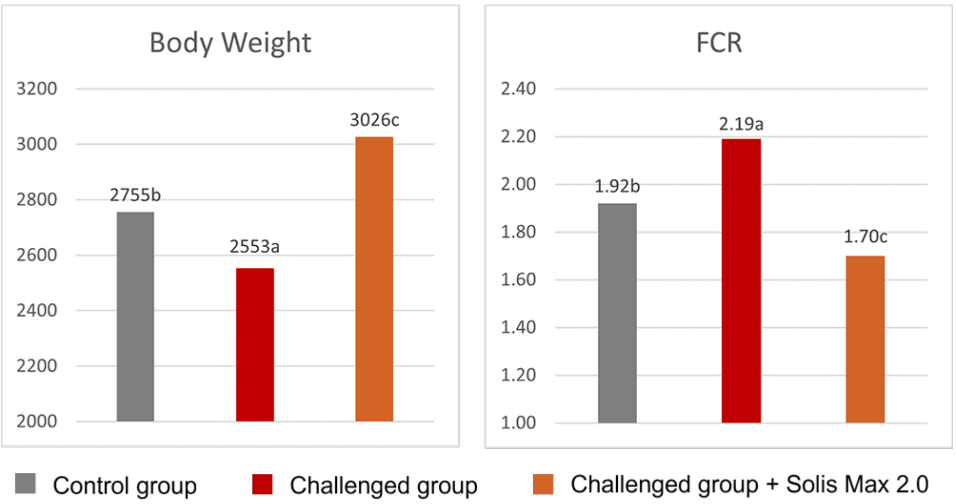

Figure 6: Better performance data due to the addition of Solis Max 2.0

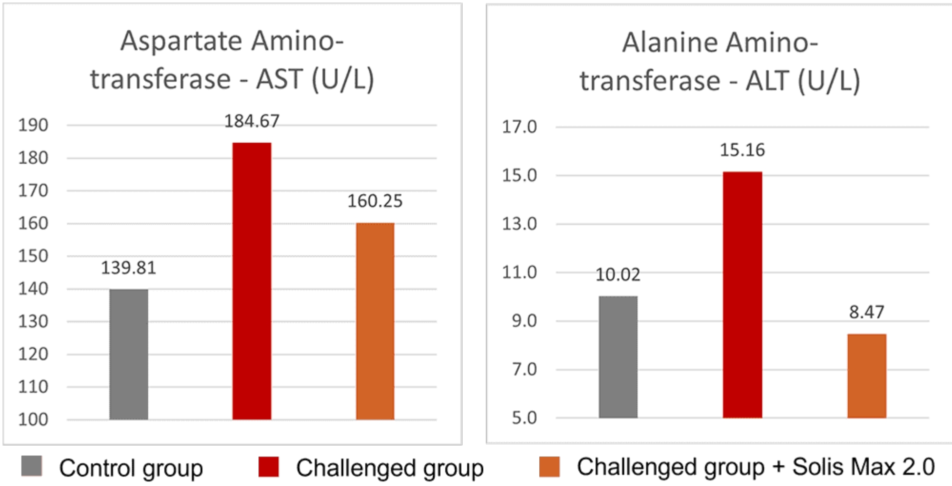

Figure 7: Healthier liver shown by lower values of AST and ALT

Effective toxin risk management: staying power is required

Mycotoxin mitigation requires many different approaches. Mycotoxin mitigation starts with sewing the appropriate plants and continues up to the post-ingestion moment. From various studies and field experience, we find that besides the right decisions about grain crops, storage management, and hygiene, the use of effective products which mitigate the adverse effects of mycotoxins is the most practical and effective way to maintain animals healthy and well-performing. According to Eskola and co-workers (2020), the worldwide contamination of crops with mycotoxins can be up to 80% due to the impact of climate change and the availability of sensitive technologies for analysis and detection. Using a proper mycotoxin mitigation program as a precautionary measure is, therefore, always recommended in animal production.

Toxin Risk Management

EW Nutrition's Toxin Risk Management Program supports farmers by offering a tool (MasterRisk) that helps identify and evaluate the risk and gives recommendations concerning using toxin solutions.