science & solutions

Issue #01 | poultry

Precise microbiome modulation

The product tech that's ushering in a new era in microbiome management

Optimizing coccidiosis management strategies

Why and how your control program needs to adapt

Mycotoxins: an invisible problem in your hatchery

How to prevent mycotoxins from derailing your breeding program

"Zero *Salmonella*" in poultry meat and eggs

How to develop a multi-pronged strategy to reach the goal

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table of contents

quick takes

Success! Efforts to reduce antimicrobials are working across Europe

Efforts by animal producers to lower antimicrobial use are working, according the European Centre for Disease Prevention and Control. For the first time in more than a decade, antimicrobial consumption was lower in food-producing animals than in humans. What's more, additional US data show that reducing antibiotics in farm animals reduces antimicrobial resistance for humans, too.

2 questions to ask about EFSA-registered Ingredients

The European Food Safety Authority (EFSA) registers ingredients that are safe for animals, humans and the environment, but different levels of authorization can be confusing. With many companies making claims about their products, here are a few questions you should ask to ensure you know what you're getting:

1. What is this ingredient registered for? Bentonite, for instance, is registered by many companies as pellet-binder or anti-caking ingredient. This registration means that it is safe, but not necessarily that the formulation has been proven effective for other indications, such as binding mycotoxins.

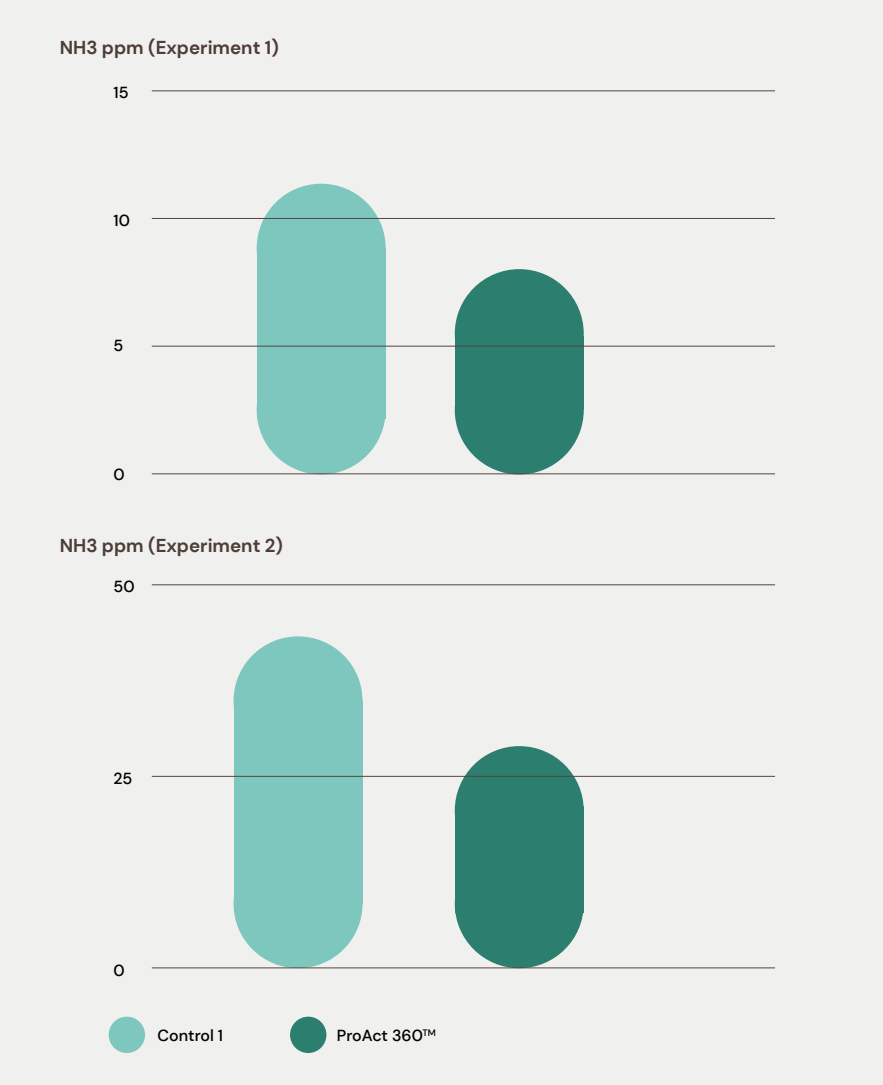
2. Is it registered for my species? A substance proven effective in one species is not necessarily effective in others.

Direct greenhouse gas emissions from agriculture are projected to increase by 6% in the next decade, with livestock accounting for 90% of this projected increase according to the latest OECD-FAO Agricultural Outlook.

Research spotlight: decreasing ammonia emissions with protease

With rising costs on everyone's minds, different levels of soy and alternative protein sources are being used in broiler diets to ensure least cost feed formulation. Undigested protein can be excreted into the environment and contribute to ammonia production. Different protein sources have different digestibility, so feed efficiency and protein excretion change when the raw material protein sources change.

A protease can be added to the diet to enhance protein utilization, speeding up the breakdown of proteins into nutrients that the broiler can use, which reduces both the feed cost and environmental impact. The effect of protease supplementation on ammonia (NH3) emissions was investigated in two broiler trials. Feed was formulated with or without 50 grams per ton of the novel protease (ProAct 360™) in a corn / soybean meal basal diet. The chickens were housed in floor pen systems covered with clean wood shavings in an environmentally controlled room. Gas emissions from the litters were measured within the floor pen after 42 days of supplementation.



Trial Results: observed reduction in ammonia (NH3) emissions from litters where animals were fed ProAct 360™

In both trials, a significant reduction of ammonia emissions was observed in litters where animals were fed ProAct 360™ compared to control litters without inclusion of a protease. In the first and second trial, ammonia emissions were reduced by 21% and 32%, respectively.

Based on these trials, the addition of ProAct 360™ can significantly reduce ammonia emissions in broilers fed standard corn/soybean meal-based diets. ProAct 360™ in combination with lower inclusion of crude protein and amino acids in the diet offers a substantiable reduction in ammonia emissions.

For optimal efficiency, dsm-firmenich offers ProAct 360™, the only second-generation protease on the market. ProAct 360™ goes beyond a standard protease by offering faster protein breakdown, higher digestibility of all amino acids and better degradation of antinutritional factors, leading to an improved feed conversion ratio. By improving protein utilization, ProAct 360™ can also reduce ammonia emissions, adding sustainability as another benefit to this second-generation protease.

Sustainability & the future of farm financing

Bas Rüter, Rabobank's head of Food System Transition, talks to us about value chains, lab-grown meats and how sustainability scores could soon impact your interest rates.

By Becky Ellis

Tell us a little about yourself, and about Rabobank.

I'm the Global Head of the Food System Transition at Rabobank. I took this role in January 2022, and before that I worked for 10 years as Rabobank's Global Head of Sustainability and Climate. My passion for the industry comes from my background as a biologist.

Rabobank is a global bank based in the Netherlands. We actually started as a cooperative to help farmers become successful, and we still focus strategically on food and agriculture both inside and outside the Netherlands.

We're a member of the Net Zero Banking Alliance, which was launched in the lead-up to COP26 in Glasgow. It represents well over half of all capital available in the developed markets for financing globally, and its members—including Rabobank—have committed to having our full balance sheet of clients at net zero by 2050, including their scope three emissions.

I imagine this is quite a challenge.

This is a challenge for any business operating in the food and agriculture space. We do not yet have the proper farm management tools in place to understand exactly the emissions from our clients. So, we definitely need to invest in better monitoring, better measurement, but at the same time we still need to agree upon how to actually apply this with the proper methodology to include it in the calculations for the Paris Agreement. Measurement is key. Methodologies are key, but we are not near a smoothly running monitoring system that helps us to see whether we are on track. We need these things to understand the business of our clients, to understand how we can help them improve their performance with investments in their farm practice, but also in the food companies, which are increasingly asked to clean up their supply chains.

Some people say, 'Well, that's nice, but that's just a voluntary initiative by banks,' but there's more on the way. The Dutch banking sector collectively agreed to make sure that we will reach net zero by 2050, with a 2030 target of at least a 49% carbon reduction. This doesn't just apply to our clients in the Netherlands, it looks at our balance sheet globally. It means that we need to enter into dialogue with our clients in Brazil, in New Zealand, in Australia, in the US to jointly lower their emissions, and often in markets that are not yet as aware of the problem as we are. This is a Dutch example, but we're increasingly seeing this around the world.

Having targets for 2050 is important, but many organizations are pressing for more rapid action. Are there interim targets for 2030 as well?

Absolutely. We've already set our 2030 targets – the Dutch climate agreement required it—but other organizations are demanding it as well. In 2020, the Shell oil company was sued by a climate organization called Friends of the Earth. The verdict was that Shell was legally forced to lower their carbon emissions by 45%, including scope one, two and three—which includes the emissions of their customers—by 2030. In 2022, we and 29 other companies in the Netherlands received similar demands from Friends of the Earth, and we expect this to be replicated around the world. We created 2030 targets in our annual report for the largest agricultural


“If businesses can prove that they are reducing their emissions in line with major targets, they will be able to attract better contracts with their off-takers.”

sectors globally, with a regional target for every sector coming up soon; it's the only way we can avoid litigation. We think we otherwise we run the risk of being forced by lawyers to actually sell part of our business that is underperforming. That is a significant change in your business model.

Still, we do that knowing that we do not yet have the detailed on-farm measurements or an agreed upon methodology. How do we measure progress against that target? It's a serious problem, but it is also a serious opportunity. We will not be the only ones looking at climate—markets are looking, too. Consumers are looking. If businesses can prove that they are reducing their emissions in line with major targets, they will be able to attract better contracts with their off-takers. So, we expect the winners if the next decade in this animal husbandry business to be the ones that are able to live up to the expectations of the Paris Agreement.

Alternative proteins have gotten a lot of attention in the past few years, from lab-grown meats to vegetable and even insect-derived proteins. How relevant are they in reshaping the global food market?

They are extremely relevant, even though they are small in size with the meat industry. We expect that to be a trend that will grow in the decades to come. At the same time, the animal protein sector won't substantially shrink. And that is because of the growth of the population worldwide and the extent to which more affluent people are better equipped have more money. To also buy animal protein, so we see both trends moving up. This implies that if we want to reach the Paris Agreement targets and we want to be net zero by 2050, we have an even bigger challenge. We at Rabobank look at the plant-based protein developments very proactively. There's a lot of mergers and acquisitions going on, and many involve. the classic animal protein players that want to build a portfolio in plant-based protein as well. We also see it spurring on different ways of trying to produce animal protein with less emissions. So yes, it's extremely important both on the level of increasing efficiency of the existing animal protein business, but also taking notice of different solutions, whether it's insects, whether it's plan- based. That's definitely going to play an important role in the transition over the next decade or the next 20 years towards reaching Paris Agreement targets.

You mentioned nature as an upcoming challenge for the sector. What are you seeing and how can the industry prepare itself?

Nature or biodiversity feels less urgent to many people. Yes, it may be less urgent, but it is equally important. The nature discussion has sped up much faster than the climate discussion did five or 10 years ago. People are more sensitive to the fact that things need to change and, of course, in food and agriculture, climate and nature are directly interrelated. I am involved in the Taskforce on Nature-related Financial Disclosures and I even went to the COP15 on biodiversity in Montreal to ask for an ambitious global level playing field with mandatory transparency for companies. I do

this because I think these societal expectations need to be met the right way, measuring impact and measuring dependencies in order to start managing them. It's important to maintain our license to operate as a sector because if we don't have a proper answer on the challenges of nature and biodiversity loss, people will start turning their backs on us and we'll be facing solutions that we no longer control.

As I said, measurement is lacking, and nature is far more complex than climate. Climate is four molecules that have the same impact in the same way across the planet, at every time of the year. Nature is fragmented, it's millions of species. It's different in every part of the world, and it's even different in every season, so it'll be tough. But it's going to come, and it's going to come with a lot of impact in the ag sector.

What kind of impacts should we be looking out for?

Supply chain responsibility is definitely on the horizon. As a result of land use change causing a lot of biodiversity loss, this will impact any player in the animal protein business where feed comes from areas where people see that biodiversity is being lost. Certification of feed is going to come up so that people know that, despite the fact that there's an animal protein business that uses feeds globally, you are not involved in land use change. Fertilizer is also related to both climate change and to nature, so we need to optimize the use of fertilizers as part of the solution. Similarly for pesticides and crop protection, as well as the need for more regional production. This is more pressing as a result of COVID, where people really saw that long supply chains create intrinsic imbalances and dangerous vulnerabilities in the food system. So, a lot is changing, and governments are already taking action. The UK has already made inroads to forbid the purchase of goods from deforested regions, and the European Parliament recently adopted similar legislation. We've been working on traceability tools for our clients for a number of years, hoping that we would be able to use them with our clients in, say, sustainability, as part of voluntary schemes to show that we're trying to do the right thing. This has now turned into a compliance tool. You will not be able to deliver your products, your goods, your food on the UK and European market in a few years from now if you can't prove that you didn't use feed or cattle from a region that is currently involved in deforestation, so it has become a necessity to comply. I also expect in the Food and Agriculture business regional solutions based on sound scientific evidence that is global to become more and more important.

How do you see alliances shaping up throughout the value chain, among consumer, retail, food, farm and big data organizations? What's interesting that's happening now or coming up soon.

Let me give you one small-scale but very practical example. It's a Dutch example, but we are working to replicate it in different regions worldwide. We have been in a partnership with the World Wide Fund for Nature for more than 10 years, and seven years ago we set up a cooperation with Royal FrieslandCampina and WWF to start a biodiversity monitor for dairy. It measures the biodiversity impact of dairy production and the interesting thing is our farmers are involved. The measurement is crucial and is integrated into how farmers regularly report to their dairy company. So, you cannot bring your milk to the factory anymore if you are not able to deliver those data with it. We already have voluntary certification in the supermarket with a higher price for farmers producing in a nature-inclusive manner, and we are trying to scale this up nationally. The interesting thing is that the last partner I thought would be enthusiastic about it was the consumer organization, because you always assume they want the best product for the lowest price. But they actually asked their members, and more than two-thirds of their members were in favor of joining this dialogue because they feel sustainability needs to be part of their lobbying as a consumer organization, too. Everyone from farm to fork is involved. I think the most important game to play is to have trust in the chain for the long run so everyone gets a realistic part of the upsideand has the opportunity to invest in sustainable production practices. The farmers don't want to produce nature-inclusive without being paid for it. The dairy company is concerned about the margin. Same for retail, but together they feel they need to act. I think supply chain integration is going to be a crucial element of sustainability solutions moving forward.

> "You will not be able to deliver your products, your goods, your food on the UK and European market in a few years from now if you can't prove that you didn't use feed from a region that is currently involved deforestation."

Will Rabobank propose different financing terms and conditions based on the sustainability of the customer?

We already measure our sustainability, and the sustainability performance of our clients on an annual basis. We apply a sustainability policy framework with more than 100 pages of minimum standards to all those clients, and those standards are being tightened year by year. In the Netherlands, we have already variable rates of interest depending on sustainability performance for all farmers in place, and plan to roll it out internationally as well. People will benefit if they outperform their peers. So, we're actually creating a race to the top.

Is there anything else you'd like to add?

There's a lot of legislation coming in, and there are a lot of societal expectations that will be very tough to comply with. At the same time, there is a tremendous opportunity for a business to actually make a difference.

We live in extremely exciting times with a lot of things changing much faster than before, both from a compliance perspective, a consumer awareness perspective, but also a purpose perspective. I think we're doing good things for our clients, we're doing good things for our colleagues, and we're also doing good things for society and the planet as well. So, it's really exciting, and I hope that it helps everyone think even more creatively to find solutions to help us grow a better world together.

“...if we don't have a proper answer on the challenges of nature and biodiversity loss, people will start turning their backs on us.”

Optimizing coccidiosis management strategies

Why and how your control program needs to adapt.

By Shelby Ramirez, Technical Manager Poultry Global, dsm-firmenich

Coccidia are found anywhere poultry are raised

The estimated cost of coccidiosis globally is between USD 9.2 and 15.6 billion, or approximately USD 0.2 per chicken (*Blake et al.*, 2020[1]). This estimate is derived not only from the cost of prophylactics and therapeutics, but also the associated performance and mortality loss. Additional losses due to secondary challenges associated with coccidiosis may also increase the overall economic impact. Many protozoa plague the livestock industry but, in poultry, there are seven *Eimeria* species of the protozoal parasite coccidia that infect different regions in the intestinal tract (*Shirley et al.*, 1986[2]).

Regardless of the site of infection, *Eimeria* have a complex life cycle that includes stages within the bird and environment. Depending on the *Eimeria* species, site of infection and life cycle stage, certain prevention strategies may be more effective than others (*Chapman and Rathinam*, 2022[3]).

> "... using chemicals with ionophores or ionophores alone can provide coverage for both coccidiosis and clostridial enteritis."

Evolution of rotation and shuttle programs

For more than 50 years, synthetic chemicals, ionophores and the combination of the two have been available for coccidiosis control; however, no new anticoccidial drugs have been developed for many years (*Novak et al.*, 2019). This makes optimizing the currently available coccidiosis strategies even more critical. Not all synthetic chemicals have known modes of action but, in general, chemicals disrupt *Eimeria* by altering their metabolism during their intracellular life cycle stages, and ionophores disrupt *Eimeria* by altering osmotic balance during their extracellular life cycle stages (*Chapman and Rathinam*, 2022[3]). These two anticoccidial drugs have often been used in combination because of their complimentary modes of action and the additional coverage ionophores have on gram positive bacteria.

This is advantageous because coccidiosis can predispose birds to clostridial enteritis resulting in high mortality rates and production losses. Thus, using chemicals with ionophores or ionophores alone can provide coverage for both coccidiosis and clostridial enteritis. Although the combination of chemicals and ionophores have been used successfully for several decades to combat coccidiosis, development of resistance has been reported (*Glorieux et al.*, 2022[4]).

In brief

Anticoccidial drugs have been used for decades, but new regulations, consumer preferences and resistance concerns are changing coccidiosis management.

Rotation, shuttle and bio-shuttle coccidiosis programs have become more widely used.

A strategic and comprehensive approach can help achieve optimal coccidiosis management.

Chemical anticoccidials tend to induce resistance more rapidly compared with ionophores because of their mode of action during the intracellular life cycle of *Eimeria*. However, this resistance may be masked while using chemical and ionophore blends as *Eimeria* that are resistant to chemical may still have susceptibility to the ionophore making the overall prophylactic use effective.

However, the challenge with ionophores is that they have a very narrow range for safety, can contribute to reduced performance and may impact heat tolerance. Many producers have implemented programs that rotate anticoccidials between flocks (rotation programs) or use different anticoccidials in starter, grower and finisher rations (shuttle programs) to maintain or improve *Eimeria* drug sensitivity.

Coccidia vaccines

Another strategy to improve drug sensitivity has been to switch from anticoccidial drugs to using a coccidia vaccine. Coccidia vaccines are based on specific *Eimeria* species and induce immunity three to four weeks after vaccination (Tewari and Maharana, 2011). Introducing non-resistant *Eimeria* via vaccination can repopulate the environment to restore drug sensitivity. However, the effectiveness of this strategy to restore environmental *Eimeria* drug sensitivity may be impacted by litter management strategies (i.e., raising birds on fresh litter for each cycle or using re-used litter for several cycles). One challenge with coccidia vaccines is that they tend to impact performance during the time the birds are acquiring immunity. This associated performance loss is more challenging to overcome when birds are marketed at a younger age compared to those marketed at an older

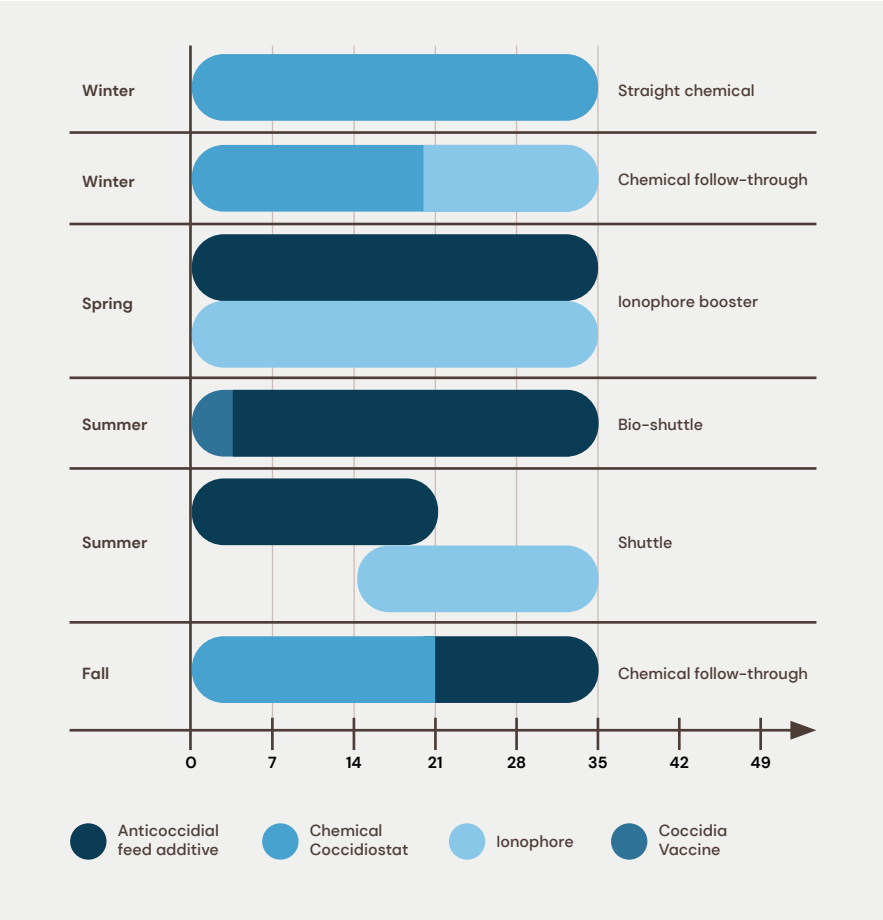


Fig 1. Example of rotation, shuttle and bio-shuttle programs

Descriptors	Chemicals	Ionophores	Vaccines	Feed additives
Mode of action	Eimeria inhibition during intracellular life stages	Eimeria inhibition during extracellular life stages	Host immunity	Direct & in-direct modes of action
Ability to induce resistance	+++	++	?	?
Anticoccidial strength	+++	++	+	++
Gram positive bacteria coverage	+	++	+	+
Compatibility with no antibiotic ever program	Yes	No	Yes	Yes
Relative cost	++	+	+	+
Examples	Clopidol, Nicarbazin, Decoquinate, Diclazuril, Amprolium, Narasin+ Nicarbazin (blend)	Narasin, Monensin, Salinomycin, Avilamycin, Lasalocid, Virginiamycin	Can include multiple *Eimeria* species	Phytogenics, prebiotics, probiotics, novel metabolic modulators

Table 1. Generalization of anticoccidial strategies

age because there is limited time to regain that lost performance. Recovering performance loss associated with vaccination is one area in which feed additives can be used as part of a coccidiosis management strategy.

Feed additives such as probiotics, prebiotics and phytogenics have become part of many coccidiosis management strategies due to their compliance with programs like no antibiotics ever or antibiotic-free, but they also have unique modes of action that compliment different rotation and shuttle programs. Phytogenics that include oregano and saponin components have direct anticoccidial properties and, depending on the specific probiotic or prebiotic, modes of action like improvements in intestinal integrity, protein utilization and antibacterial properties can work indirectly on aspects associated with coccidiosis. Incorporating feed additives into rotation, shuttle or bio-shuttle programs can help keep current anticoccidial drugs effective while keeping performance at the expected level when other strategies are implemented.

Optimize your current anticoccidial program

Identifying the gap in the current rotation or shuttle program is key to determining what strategy should be implemented. If a coccidia vaccine has been implemented but performance has been a challenge, nutrient leakage from mild coccidiosis may be the source. These leaked nutrients, especially protein, are coming into the lumen and away from bird growth potential, and they also then become available for potential opportunistic bacteria in the hindgut. A multifaceted approach using a combination of products* could help. Our tailored solutions include:

- **PoultryStar®**, a synbiotic that contains poultry derived probiotics, improves intestinal integrity reducing nutrient leakage.
- **Symphiome™**, the first of its kind precision biotic, specifically targets protein metabolism pathways of the microbiome to redirect protein towards productive processes and away from opportunistic pathogens. Utilizing these strategies compliment coccidia vaccines while maintaining bird performance.
- If the chemical or ionophore program has become less effective and an alternative is needed, **Digestarom® PEP-Y** contains both oregano and saponin components to directly target coccidia.

Many different programs can be developed depending on the need within the current implemented strategy. Additionally, identifying other challenges that may be enhancing enteric challenges such as mycotoxins or vitamin levels may be part of differential diagnosis. At dsm-firmenich, we offer a comprehensive portfolio that addresses specific gaps within rotation, shuttle or bio-shuttle programs and with the support of a broader portfolio can offer coverage from the multitude of predisposing factors associated with coccidiosis and clostridial enteritis.

In brief

Mycotoxins are widely present in poultry diets, but are frequently overlooked on parent stock farms, with negative effects appearing at hatcheries.

Mycotoxins can negatively impact fertility, eggshell quality, efficiency of vaccine response and quality of progeny.

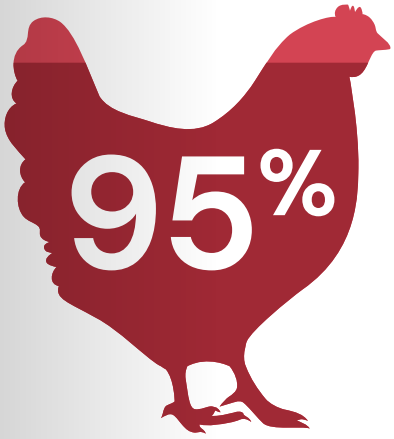
Identifying which mycotoxins are present and selecting appropriate methods of counteraction can help chicks reach their genetic potential.

Mycotoxins: an invisible problem in your hatchery

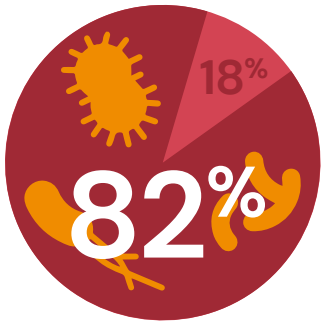
Low hatchability, reduced egg quality and impaired chick immunity are common hatchery challenges. Mycotoxins could be the culprit.

By Lorran Baeumle Gabardo, Global Product Manager, dsm-firmenich

Mycotoxins are unavoidable contaminants in feed that have toxic effects on bird health. They are highly present in poultry diets worldwide, but due to their often-invisible effects, mycotoxins are frequently overlooked in parent stock farms, with the negative outcomes appearing at the hatcheries. Mycotoxins can negatively impact a diversity of indices that are necessary for the success of breeder and hatchery production: fertility, eggshell quality, efficiency of vaccine response and quality of the progeny. Becoming informed and aware of this challenge and how to protect your birds is key to helping them reach their maximum genetic potential and, consequently, maximizing the economic success of your hatchery.



of poultry feed is contaminated by mycotoxins



is contaminated by more than one mycotoxin

Are there mycotoxins in your poultry feed?

The dsm-firmenich World Mycotoxin Survey has been measuring contamination levels in feed for nearly two decades, and has found that 98% of poultry feed samples are contaminated by mycotoxins. Moreover, 86% are positive for more than one mycotoxin, which means the toxic effects can be potentialized inside the bird's organism and have even more harmful effects. In poultry, for instance, there is frequent co-contamination with deoxynivalenol (DON) and fumonisins (FUM). When both mycotoxins are involved in degradation of the tight junctions, their effect is considered synergistic—that is, the total effects are greater than the simple sum of each individual effect—and can lead to severe cases of 'leaky gut'.

Although many regions have an overall risk that is considered medium/high, each region has a different mycotoxin contamination profile based on which specific mycotoxins are present, in which combinations and in what amounts. The map shows the six mycotoxins that cause the most harm in birds. DON and FUM are the most prevalent ones worldwide, and are related to gut health issues and immunosuppression. Zearalenone (ZEN) is also commonly found and impacts the fertility and egg production of breeders and layers. Aflatoxin (Afla) affects liver functionality and the immune system and, although toxin T2 (T2) and ochratoxin (OTA) are less prevalent, their toxic effects can be acute even at low dosages.

How mycotoxins impact chicks' incubation and hatch

Mycotoxins negatively impact a diversity of indices connected to the performance of the breeders and their chicks and consequently affect economic indices such as:

Impaired performance of breeders and roosters

ZEN has a similar chemical structure to the hormone estrogen, and is usually related to reproductive disorders. The presence of ZEN in breeder diets can modify the physiology of the reproductive tract by inducing hyperactivity of the ovaries and cystic oviducts. These alterations reflect in lower fertility rates, egg production and hatchability of eggs. OTA is another mycotoxin that alters embryo development, decreasing chick livability and reducing the progeny's ability to fight infections.

Reduced egg quality

Mycotoxins such as T2, OTA and ZEN influence eggshell formation through different modes of action: reduced calcium absorption, changes in the protein synthesis and/or modification of the reproductive physiology in such a way that breeders and layers are not able to produce high-quality eggs. Lower quality eggs result in fewer eggs hatching, reducing the hatchery's overall production output. Measurements that quantify the changes in egg quality due to mycotoxins include: reduced Haugh units, height of the albumen and egg weight as well as reduced eggshell thickness and alterations in egg size.

Impaired yolk formation and reduced chick livability

The liver is responsible for lipid metabolism, which is directly correlated with the yolk formation and formation of liposoluble vitamins. The most common pathological lesions associated with mycotoxicosis in poultry are found in the liver. When liver function of the breeder hen is impaired, there is a direct link to impaired yolk formation. Since the yolk is a key component in the nutrition and health of a developing chick, this results in higher initial chick mortality.

Predisposition to 'leaky gut' and contamination through the hatchery

DON and FUM have a large impact on gut integrity. They influence the formation and functionality of tight junctions, a multi-protein complex established between closely connected intestinal cells that maintains a barrier between the gut lumen and the blood circulation. Both mycotoxins contribute to an increased permeability causing 'leaky gut' syndrome. As result, the proliferation of intestinal pathogens, i.e., *Salmonella* sp, may also be increased. Moreover, liquid excreta lead to a higher percentage of dirty eggs, which reduces the overall hygienic status of the hatchery.

Impaired immunity and vaccine failure

Even at moderate levels of contamination, mycotoxins are considered immunosuppressive agents and are capable of downregulating antibodies and immunoglobulins synthesis. These mechanisms are attributed to mycotoxins including AFLA, trichothecenes, FUM and OTA. Their presence can be considered a driver of failure in vaccine programs. Several studies have shown that Fusarium mycotoxins such as DON reduce antibody titers for Newcastle disease and the infectious bronchitis virus in breeders.

How to avoid this risk in the hatchery

An integrated, three-step mycotoxin risk management system is key to protecting birds from mycotoxins and maximizing your hatchery's ability to produce viable progeny.

- Identify the mycotoxins present in your poultry feed using reference methodologies such as HPLC MS/MS.
- Once you know which mycotoxins are present, provide the right counteraction solution to protect the birds. Be aware that certain deactivation strategies aren't effective for all mycotoxins. For instance, common binders, such as aluminosilicates, are only effective for adsorbable mycotoxins like AFLA. Other mycotoxins such as FUM, DON, ZEN, OTA and T2 are considered non-adsorbable and can only be controlled through biotransformation, which breaks the toxic part of their chemical structure. Only precise biological compounds and enzymes are able to perform these specific reactions and guarantee the production of non-toxic and environmentally safe metabolites.
- Utilize bioprotection. Bioprotection utilizes selected plant extract to support the functionality of target mycotoxins organs such as the liver and gut.

This article originally appeared in Hatchery Practice.

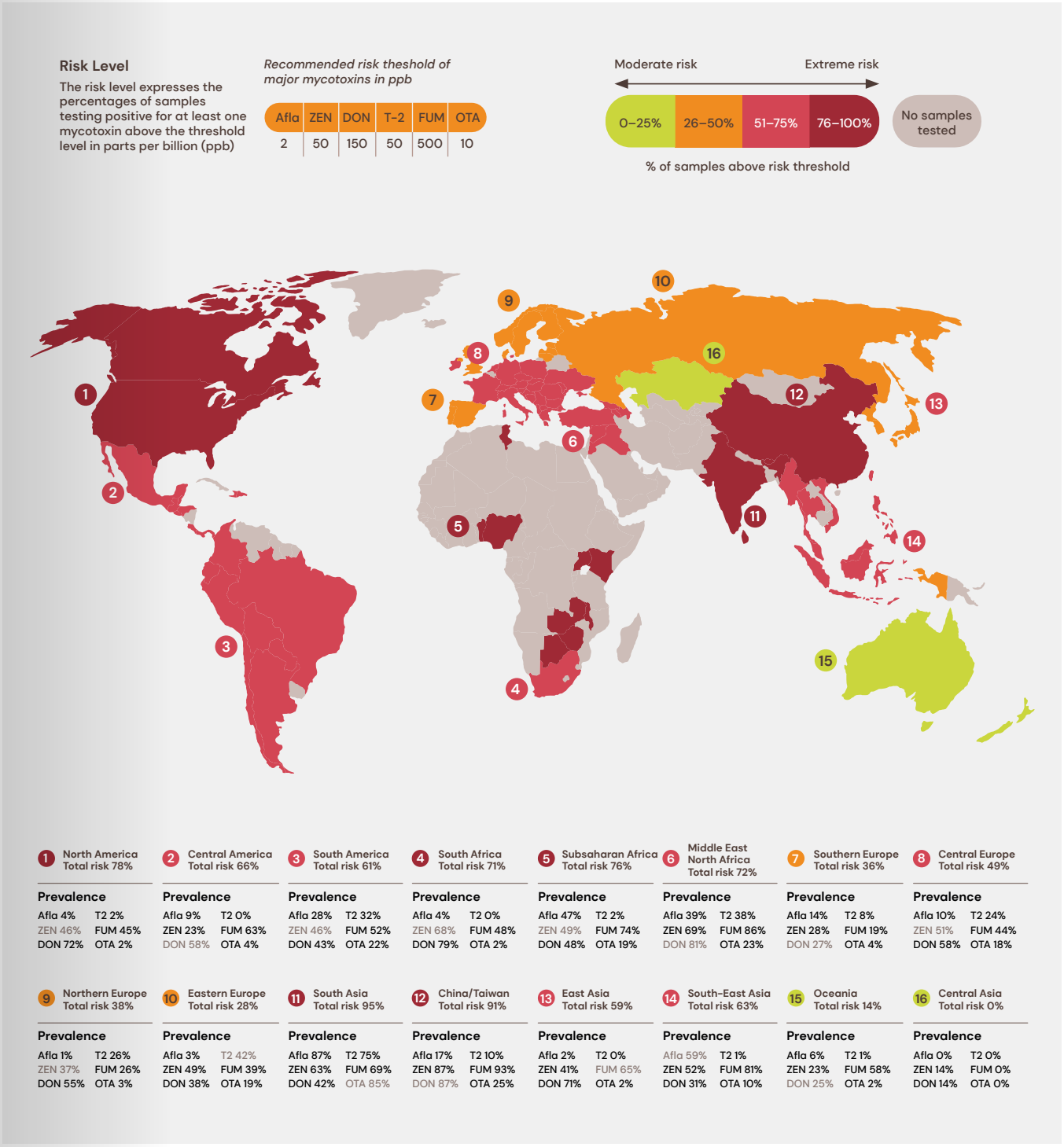


Fig 1. Global map of mycotoxin prevalence and risk in different regions

In brief

Precision Biotics (PBs) are a new type of feed additive that can help the poultry industry cope with challenges.

Rather than focusing only on which individual bacteria are present in the microbiome, it is key to understand and utilize how microorganisms interact with each other.

Modulating the functions—not just composition—of chickens' microbiomes better supports performance and welfare.

Precise microbiome modulation

A new era in microbiome research in poultry production.

By Cristiano Bortoluzzi and Jack Geremia

Imagine watching an orchestra: You are interested in the music produced by the musicians together, not what each individual is playing. Recent research suggests that we should look at the microbiome like that orchestra, focusing on what all the microbes are producing together, as a symphony, and how it benefits its animal host.

With this idea in mind, and with the development of more advanced technologies in microbiome research, it's time to change the paradigm: Instead of focusing on which bacteria are present in a microbial community, it's imperative that we examine what they are doing as a group. In doing this we consider one of the most important characteristics of the microbiome, cooperation, and how microorganisms interact with each other.

In the Human Microbiome Project, it became clear that the functions performed by all the bacteria together are far less dependent on the presence or absence of single microbes than previously thought. This functional view of the microbiome provides opportunities to explore what the microorganisms are doing and how the end products of their metabolism benefit the host. Indeed, a large portion of substances in the bloodstream of animals originate from the intestinal microbes, and these are key when linking physiological processes (e.g., digestion and fermentation) with health and welfare. Modulating the functions of the microbiome by adding nutrients or feed additives brings new opportunities to harness the full potential of the microbiome.

> "Instead of focusing on which bacteria are present in a microbial community, it's imperative that we examine what they are doing as a group."

Modulating the microbiome with Precision Biotics

Precision Biotics (PB), a new category of nutritional feed additives, are being developed to leverage the recent advances in microbiome sciences and to cope with challenges faced by the poultry industry. The mechanism of action employed by PBs is different from that of prebiotics or other conventional gut-health products. Precision biotics are carbohydrates with glycosidic linkages and size distributions selected specifically for their ability to modulate intestinal microbiome pathways. In other words, it is a very precise conductor of the microbiome that brings overall harmony to the gut. For instance, our specifically selected PB (Symphiome™, dsm-firmenich) increases the number of genes associated with protein and amino acid metabolism and short-chain fatty acid production, which reduces intestinal ammonia production. In studies, the result was an improvement in observed in litter quality and welfare indicators, such as foot pad dermatitis.

A publication from Walsh et al. (2021) reported that our PB modulated the functions of the cecal microbiome related to propionic acid production and nitrogen metabolism. A publication by Jacquier et al. (2022), comprising two studies of broiler chicken studies raised in floor pens to evaluate the effect of our PB, showed that PB supplementation improved litter score, ammonia output and gait score. As a consequence of improved welfare and gas emission indicators, the PB improved body weight gain (BWG) by 44g on day 35 and feed conversion ratio (FCR) by 11.4 points. In the second study, BWG was improved by 112 g, and FCR by 4.7 points.

Mechanism of action of Precision Biotics

Precision biotics are microbiome metabolic modulators that conduct bacterial functions, encouraging the production of substances that promote beneficial outcomes to the animal. The high-quality research conducted to understand the exact mechanism of action of PBs has demonstrated that it increases metabolic functions intrinsic to the microbiome that are able to detoxify unabsorbed amino acids and leaked host protein, independent of the microbiota composition. This leads to higher resilience to enteric stress, better nutrient utilization, improved welfare and reduced emissions.

Similar to its host, the microbiome possesses a metabolism that can be modulated in specific ways. For example, being able to positively alter the protein metabolism of microbes would lead to an enhanced production of beneficial substances, such as branched and short-chain fatty acids, and polyamines. On the other hand, suppressing undesirable functions of the bacteria can reduce ammonia/ammonium production and emission, and reduce the generation of skatole and other indoles that increase luminal pH, cause epithelial damage and negatively impact litter quality and welfare, among other negative effects.

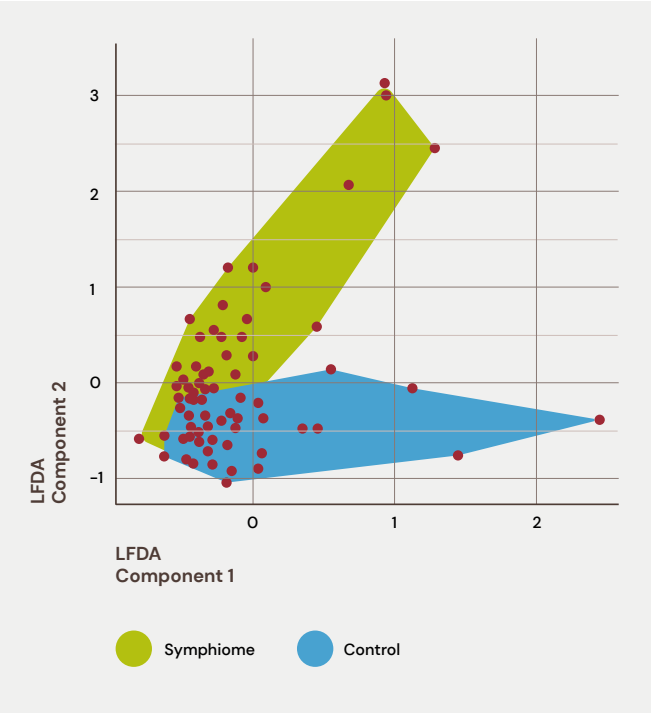


Fig. 1A. Overall microbiome metabolism shift promoted by Symphiome™

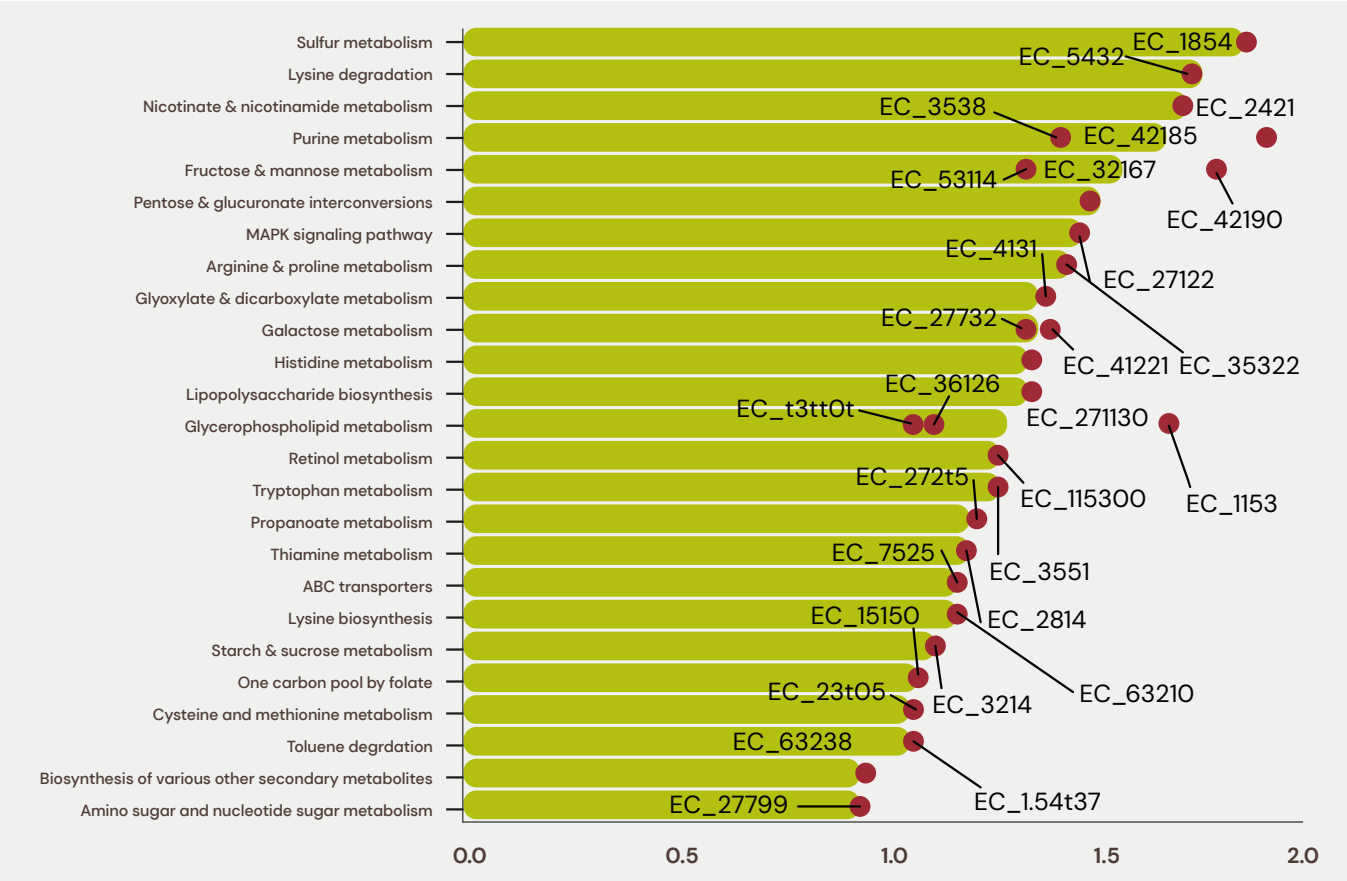


Fig. 1B. Abundance of pathways changed with Symphiome™ relative to control.

We have demonstrated that our PB consistently shifts overall microbial metabolism (*Fig.* 1A), by increasing the abundance of beneficial pathways and decreasing the abundance of putrefactive pathways (*Fig.* 1B).

It is essential to understand that it's not protein fermentation in general that is a concern, but specific functions of bacterial protein fermentation. Being able to specifically reduce these undesirable functions is important in poultry production. Increasing nitrogen metabolism and the conversion of ammonia into amino acids can influence the total amount of nitrogen and ammonia excreted, with the amino acids potentially used to build microbial protein. Decreasing nitrogen and ammonia secretions can help lower producers' environmental impact.

> "It's not protein fermentation in general that is a concern, but specific functions of bacterial protein fermentation."

Final considerations

Enteric bacterial infections are one consequence of modern intensive animal production, and can lead to major financial losses and increase the risk of foodborne illness from bacterial contamination of meat and meat products. However, influencing the functions of the microbiome that can lead to higher utilization of nitrogen, and lower production of undesirable products may be a viable approach to mitigate intestinal issues. The increased production of propionic and butyric acids by the bacteria may be another mechanism by which precision biotics act on the host and support nutrient use. By modulating what bacteria are produced in the intestines of chickens, we can support performance and welfare and deliver more consistent results for producers.

This article originally appeared in International Poultry Production magazine.

In brief

Rapid genetic improvements in modern broilers complicate the task of achieving high efficiency. Breeder companies provide a framework around the physiological changes in a hen's lifecycle to guide field managers and nutritionists based on the following six phases:

- starter – 1-6 weeks of age (WOA)
- maintenance – 7-12 WOA
- preparing for sexual maturity – 13-21 WOA
- managing sexual maturity – 22-25 WOA
- managing for optimum peak egg production – 26-32 WOA
- post peak management for egg production persistency

Each phase has desired outcomes, achieved by implementing the appropriate nutrition strategy to optimize the success of the breeder program.

Nutritional strategies for optimizing modern broiler breeder performance

Tailoring to each of the 6 phases to achieve desired outcomes.

By Shivaram Rao, Cobb-Vantress, USA.

Introduction

Breeder companies publish nutrition specifications to maximize performance. These recommendations are generalized for a global customer base and may need to be fine-tuned to improve performance further.

With a restricted feeding program (compared to ad libitum feeding in broilers), breeder hen nutritionists must use feed allocation to compute the optimum daily intake. Nutritionists must work closely with managers to implement the restricted feeding plan in the field.

Nutritional strategies for pullets and hens

Breeder companies have outlined the six production phases (Table 1, next page), each with a physiological purpose and desired outcomes. The nutritional strategy for each phase should be tailored to achieve those outcomes.

Rearing period nutritional strategies

The breeder company body weight (BW) plan, feed guide, and nutritional recommendations should be the starting point unless your existing program already exceeds performance objectives. Nutritionists should have access to rearing and production stage data and should regularly visit flocks to carry out visual checks of the birds and litter.

Implementing the same feeding plan for extended periods of time helps to execute and sustain a successful program. However, genetic advancements could improve feed conversion efficiency, meaning pullets and roosters get heavier under the same feeding plan. Breeder companies usually update their specifications once every three or four years. Breaking this trend by publishing ahead of schedule, Corzo and Silva (2020) from Aviagen recommended an 11% reduction in digestible lysine (dLys) for Ross 308 to help prevent excess fleshing and improve fat deposition. Similarly, customers may have to change feed nutrient specifications more often in response to genetic improvements.

“Nutritionists must work closely with managers to implement the restricted feeding plan in the field.”

Chick Starter (CS) feed:
Following the breeder company's nutrient specifications is most appropriate. Failing to meet the 4-week BW target may warrant a change in the CS feed. Breeder companies usually suggest feeding CS for the first four weeks; however, the author recommends feeding CS (with a higher protein content) for up to six weeks to ensure normal skeletal structure and feather development.

Pullet Grower (PG) feed (5–12 weeks):
PG is the most dilute feed in the breeder program to facilitate higher feed allocation volume while preventing excess BW gain and avoiding excessive fleshing. PG is critical in maintaining flock uniformity, preventing "feather picking," and keeping pullets calm under the restricted feed program. In the author's experience, using 0.01 units less dLys/year should work; however, if dLys was not changed for several years, a higher reduction may be necessary. A slight decrease in protein (0.15%/year) could be considered.

If a different BW plan is followed, published prediction equations for the Kcal/day/pullet could be used as a starting point (Sakomura, 2004). Once a database of several flocks is established, actual field data and field fleshing index information should be used to finetune the PG calories.

Pullet Developer (PD) feed (13–23 weeks):
PD could be fed up to 5% production, or better, up to the anticipated first egg to promote a slightly accelerated yet steady BW gain with gradual muscle (fleshing) and labile fat accretion. If excess BW gain is observed and fleshing exceeds the desired target, lowering feed protein and dLys should be considered and vice versa. Feed calorie content could be increased if labile fat deposition is lacking.

Production period nutritional strategies

Breeder 1 (B1) feed:
As egg production begins, requirements for calories, calcium, vitamins, and essential fatty acids increase. Switching to B1 feed containing higher calcium should occur before 5% production but not earlier than the anticipated first egg, which requires thorough planning and coordination between the nutritionist, feed mill team, and managers in the field.

Design the B1 as recommended by the breeder company and follow the recommended feeding plan. Subsequently, monitor BW gain in relation to the standard, the timing of onset of egg production, climb in the rate of egg production, mortality pattern, and fleshing index closely. If hens achieve the weekly BW gain but fail to reach or exceed standard egg production peaks, then a slight increase in feed calories may help. If hens fail to gain BW as planned, managers in the field should consider increasing feed allocation before nutritionists adjust feed protein and dLys levels. Aim to feed slightly excess calories daily (a positive calorie balance) but not to exceed daily protein and dLys intake.

Daily calorie requirement estimation (Sakomura, 2004; Reyes *et al.*, 2011) and dLys intake estimation (Ekmay *et al.*, 2013; De Paula Dorigam *et al.*, 2017) should be computed for the peak egg mass period. These estimates help design the B1 feed to match the existing feeding plan.

Breeder 2 (B2) feed:
B2, introduced around 40 WOA if used, contains slightly lower protein, dLys, and more calcium. B2 is a good tool for controlling excess BW gain and delivering more calcium in older hens. B2 can provide more calories to older heavier hens if designed with 20 to 30 Kcal more energy/kg feed than B1.

Phase	Age (weeks)	Purpose	Desired outcome	Nutritional strategy
Starter	1 – 6	Develop optimum frame size. Rapid growth in the digestive system, immune system, and skeletal structure	Achieve four-week target BW with normal skeletal structure, healthy digestive system, and optimum feather development.	• Low-calorie, higher-protein feed with 0.95–1% dLys. Vitamin and mineral intakes should match ad libitum feed intake to prevent skeletal abnormalities. • A lack of compliance with the 4-week BW target and any skeletal structure abnormalities should drive nutritional changes. • Implement a good cocci control program to maintain flock uniformity.
Maintenance	7 – 12	Prevent excessive growth without sacrificing flock uniformity.	At 12 WOA, pullets should be on or slightly below BW target. No excess fleshing. A fleshing index* higher than 2 is not desirable.	• Low-calorie, low protein (14–14.5%) feed with 0.51–0.60% dLys. • Achieve target BW with planned feed allocation without sacrificing flock uniformity. • Lack of flock uniformity and difficulty complying with BW targets should drive nutritional changes.
Preparing for sexual maturity	13 – 21	Achieve steady BW gain with a gradual increase in fleshing index and labile body fat deposition.	Fleshing index should gradually increase to 3–3.5 by 21 WOA. >90% of pullets contain labile fat deposition around the pelvic bones.	• Feed calories, protein, and dLys could be the same as the previous phase. • BW, fleshing index*, and lack of fat deposition could lead to nutritional changes to reflect an increase in calories and a slight elevation in feed protein and dLys.
Managing sexual maturity	21 – 25	Achieve desired weekly BW gain, to facilitate optimum stimulation of ovaries. Avoid ovarian overstimulation and metabolic-related mortalities.	Achieve desired weekly BW gain with small increases in feed allocations. At 25 WOA, leave room for "egg production feeding". Promote optimum follicle recruitment as reflected by optimum "double yolk" pattern during the next phase.	• The same feed used in the previous phase could be used up to 23 WOA. • Feed allocation for the first week after photo-stimulation should only increase slightly to prevent ovarian overstimulation. • Maturing pullets should switch to B1 feed around 23–24 WOA (no later than 5% production). • Feed formulation changes should be driven by excessive hen mortality caused by metabolic disorders and overstimulation of the reproductive system (leading to excessive double-yolked eggs).
Flock management for optimum peak egg production	25 – 32	Reach maximum peak in egg production with optimum hen BW and competitive feed allocation.	Reach or exceed peak egg production with hen BW not significantly over target.	• Design feed as recommended, then change specifications, if necessary, based on data. • Increase feed calories if hens "run out" or are deprived of calories to produce maximu peak production. In this situation, hens continue to gain BW, but egg production rate does not climb and begins to fall. • Reduce feed protein and dLys content if hens gain BW rapidly and vice versa.
Post-peak feed management for egg production persistency	>32	Maintain high egg production persistency.	Maintain high egg production persistency.	• Design feeds to maintain high egg production persistence, and keep BW close to target. • Maintain optimum egg size with good eggshell quality. • Ensure weekly increase in egg weight matches breed standards.

BW = body weight; dLys = digestible lysine; *fleshing index = refer to breeder company management guides;
WOA = weeks of age; B1 = breeder 1 feed, B2 = breeder 2 feed.

Table 1. The purpose, desired outcomes, and nutritional strategy for each phase

In brief

Salmonella is one of the most important food safety concerns worldwide, and raw poultry products are one of the main sources of *Salmonella* in the human food chain.

The main challenge with controlling *Salmonella* is targeting all entry points in each poultry production system.

A multi-pronged strategy protects your flock and your brand reputation against *Salmonella* food safety concerns.

"Zero *Salmonella*" in poultry meat and eggs

A multi-pronged strategy to reach the goal

By Elle Chadwick, PhD, Global Poultry Marketing Manager, dsm-firmenich
Shelby Ramirez, PhD, Technical Manager Poultry Global, dsm-firmenich

Salmonella is one of the most important food safety and sanitation concerns worldwide, with the CDC estimating over one million illnesses reported each year. Poultry products are one of the main sources linked to *Salmonella* in the human food chain, in spite of the fact that the industry implements control strategies throughout production. When humans are infected, the short-term effect of *Salmonella* is foodborne illness, but the distrust in the food products that led to the illness can be felt long-term. For poultry producers, foodborne illness results in food waste, recalls, lost revenue and loss of brand reputation.

What does "Zero *Salmonella*" mean?

As poultry meat and eggs are two main agricultural goods traded globally, food inspection agencies are implementing stricter policies for *Salmonella*. The "zero *Salmonella*" claim is sought after but has caused debate around the world, with just a few programs able to manage a significant, continuous reduction of this organism in the food chain. Depending on the country, this means that samples are collected as early as the laying bird farms and as late as post-processing and analyzed for *Salmonella* on a yes (positive) or no (negative) basis. Having a negative result means that the level of *Salmonella* is not high enough on that sample to be detected at that time. The challenge with reaching "zero *Salmonella*" is that prevention and monitoring policies must be implemented throughout production, a tedious but necessary task.

Poultry and *Salmonella*: a common problem

Salmonella is regularly found in the poultry microbiome. There are over 2,500 variants (serotypes) associated with poultry, with very few causing illness in poultry and more causing illness in humans. When testing poultry flocks and food products for *Salmonella*, serotyping is important because it tells you if flocks contain *Salmonella* that can cause harm to humans.

Usually, *Salmonella* contamination starts with a bird consuming contaminated feed, debris or fecal material (*Chadwick*, 2017). *Salmonella* can colonize in multiple locations throughout the poultry gut and, if there is damage or stress to the gut, it can move into circulation and colonize in other internal organs (*Martha Pulido-Landínez*, 2019). It will compete with the native gut microbiota for colonization sites and food sources. Once colonized, it can replicate and move throughout the digestive tract, being found from crop to the ceca. The lining of the poultry gut is shed every few days, so *Salmonella* is shed in the feces to the rest of the flock. In laying hens raised in cages, there is concern with vertical transmission of *Salmonella* from the parent to the egg. In laying hens raised in cage-free/free-range systems as well as meat birds, vertical and horizontal transmission (between flock members) is of concern.

Ensuring all the *Salmonella* entry points throughout the production process--the feed and drinking water, breeding birds, the hatcheries, the broiler or laying hen farms and the processing facilities--are controlled, checked and regulated is necessary.

Salmonella in the feed and drinking water

Feed comprises 70% of poultry production costs, thus efficient and sustainable utilization of feed ingredients and related resources is paramount to have the lowest possible feed cost with the least feed material waste. *Salmonella* contamination risk increases due to ingredients coming from multiple locations, and cross contamination in feed can derive from crop harvest, feed processing, transportation, and storage (*Chadwick*, 2017). Monitoring feed ingredients in the poultry diet that are *Salmonella* carriers, like protein and vegetable sources, can help reduce the risk of contamination. Feedmill equipment must also be regularly cleaned to reduce cross contamination (*Martha Pulido-Landínez*, 2019).

Feed hygiene in combination with water sanitation practices can help control which bacteria are consumed by the flock. One of the most effective feed hygiene strategies, addition of formaldehyde, can no longer be used in multiple countries due to regulatory restrictions. Chlorination and acidification treatments have been used in water to reduce bacterial populations. Organic acids are typically used for both feed as well as drinking water, which act by damaging the *Salmonella* bacterial cell wall due to their antimicrobial activity, reducing the amount of *Salmonella* in the feed that can colonize in the bird's gut (*Hajati*, 2018).

Controlling *Salmonella* in breeding eggs and table eggs

The two contamination points in egg laying birds (laying hens and breeding hens)—the egg contents and the shell—can be controlled by reducing the amount of *Salmonella* in the hen's gut.

Internal egg contents become contaminated when *Salmonella* bacteria from the digestive tract move into circulation through the damaged intestinal epithelium and then colonize in the reproductive tract. Once in the reproductive tract, *Salmonella* is transferred to the egg contents through the vitelline membrane (*Gast et al*, 2005). *Salmonella* is also shed in the hen's feces, so contamination of the eggshell can occur if there is fecal material on the eggs.

The porous structure of the eggshell allows for the movement of *Salmonella* from the feces into the egg. This is more likely to happen if the eggshell is of poor quality. Dirty layer eggs bring *Salmonella* risk to the egg processing facilities while dirty breeder eggs bring risk to the hatcheries.

Control points for *Salmonella* in both types of eggs can be regulated through managing the hen's gut health and microbiome. If we can reduce gut colonization for internal egg contamination, and fecal shedding for external egg contamination, we can drastically reduce the likelihood of eggs carrying *Salmonella*.

Controlling *Salmonella* at the hatchery

Survey studies from China, Korea, Great Britain, and the Netherlands have shown that there can be a large variability in *Salmonella* detection at the hatchery, depending on sanitation practices (,*Van Der Fels-Klerx et al.*, 2008, *Ren et al*, 2016, *Ha et al.*, 2018, *Oaster et al.*, 2022) . Even with strict sanitation processes in place, there is still a risk of contamination. *Salmonella* has been known to increase the 'Exploders' – the eggs exploding during the incubation and hatching processes due to overgrowth of pathogenic bacteria such as *Salmonella*- resulting in killing the embryo. Furthermore, dust, debris, and fecal material released from the *Salmonella* contaminated eggs during the incubation and hatching processes, lead to the spread of contaminates to other chicks in the same incubator or hatcher (*Cason et al.*, 1994). Since chicks have an unestablished gut microbiota, *Salmonella* can easily travel to the gut for colonization sites and food with little competition.

With proper hatchery sanitation practices and the introduction of controlled competitive exclusion, we can reduce the risk of *Salmonella* in chicks before they go to the farm.

Controlling *Salmonella* in commercial broilers and laying hens

Broilers are most susceptible to *Salmonella* contamination and colonization in the first two weeks of life as their gut microbiota is naïve and in the process of getting established (*Butcher and Miles*, 2018). To outcompete *Salmonella*, the broiler gut needs consistent and continuous protection through grow-out with tools for competitive exclusion which can deprive *Salmonella* of places to colonize, as well as reducing the food sources available for *Salmonella* to colonize and proliferate. By protecting the health and integrity of the gut and improving nutrient utilization within the gut, less *Salmonella* can grow and replicate in that environment. This benefits the flock, with less spread of the pathogen between flock mates (horizontal transmission).

To control *Salmonella* in broiler and layers facilities, consistency is key. By reducing the *Salmonella* in the bird's gut, you can help reduce the pathogenic loads entering the processing facilities.

Controlling *Salmonella* in processing facilities

With the processing facilities being one of the last stops before poultry products go to market, the importance of processors to utilize existing, new, and additional measures to prevent contamination. Contact, temperature, and time must be monitored to reduce bacterial growth and contamination. After slaughter, the poultry food product and equipment can be cleaned using various antimicrobials through either air or water chilling. Air chilling consists of hanging the carcasses individually and allow rapid air movement to reduce the temperature of the product. This process reduces the risk of cross contamination since each carcass is chilled individually. Water chilling consists of submerging the carcasses in a chilled water current with an antimicrobial for a set amount of time. The preventative measures in water chilling include: chlorine (less common now with current legislation) and organic acids. The methodology of chilling used is dependent on the regulatory agency and consumer preference.

"With proper hatchery sanitation practices and the introduction of controlled competitive exclusion, we can reduce the risk of *Salmonella* in chicks before they go to the farm."

A comprehensive solution

Because of the potential for contamination all along the production process, achieving "Zero *Salmonella*" requires a comprehensive strategy:

- No matter the quality of the raw materials, it is strongly recommended to use a feed hygiene strategy that can reduce *Salmonella* contamination, like an organic acid. By applying Biotronic® to the feed, contaminant load going to poultry facilities can be reduced.

- Within the poultry gut, providing 'competitive exclusion' throughout the gut to deprive *Salmonella* of places to colonize as well as improving dietary nutrient utilization to also deprive *Salmonella* of the food source are key to prevent colonization, proliferation, and translocation to other organs. The combination of PoultryStar®, a synbiotic (prebiotic and probiotic) containing probiotic bacteria isolated from throughout the poultry's intestinal tract, along with Symphiome™, a precision glycan improving nutrient utilization through microbial protein metabolism. Since PoultryStar® contains gut bacteria from poultry, it can be given as early as the hatchery and throughout grow-out to ensure continuous protection. Symphiome™ removes the excess protein in the hindgut of the bird which acts as a food source for pathogens, like *Salmonella*, and can be added to all phases of the poultry diet.

- Intestinal integrity and microbial balance can both be altered with improper vitamin supplementation and the presence of mycotoxins. Providing proper vitamin levels through Optimum Vitamin Nutrition™ and controlling mycotoxins through MycoFix® reduces inflammation in the gut as well as microbial dysbiosis, reducing the incidence of pathogen colonization.

- dsm-firmenich's microbiome services measure both microbiome taxa composition and functionality which gives further insights into the microbiome including *Salmonella*.

Products and services can be used independently, but to reach the goal of a "zero *Salmonella*" claim, we recommend following this multi-point risk management plan. We at dsm-firmenich offer this comprehensive multi-point food safety solution, with the support of an end-to-end portfolio, that allows coverage throughout live production to reduce the opportunity for *Salmonella* to enter the food chain. This enhances the end product quality by reducing foodborne disease and food waste, while maintaining consumer trust.

"Since *PoultryStar®* contains gut bacteria from poultry, it can be given as early as the hatchery and throughout grow-out to ensure continuous protection."

*Not all products and services are available in every region

Improving calcium & phosphorous utilization in broilers

Calcium and phosphorus are the framework for bone and eggshell development, resulting in muscle growth and egg production - the essentials for poultry profitability.

By D. Korver, A. Maiorka, R. Sens, V. Fascina, R. Santos, and C. Lozano.

Calcium is necessary in the body for a wide range of functions including nerve transmission, muscle contraction and blood clotting. Normally, these functions demand relatively small amounts of Ca. The total Ca requirement is mostly driven by the need for bone growth and maintenance as well as by eggshell formation in layers and breeders. Blood Ca levels are strictly regulated. When these levels drop relative to the minimum blood level, the hormonal mechanisms increase Ca recovery from the kidney, Ca mobilization from the bone and the efficiency of Ca absorption from the diet. Conversely, when blood Ca levels are high, the hormonal mechanisms increase Ca excretion from the kidney, stimulate bone formation and downregulate the active Ca transport mediated by vitamin D from the gut.

In growing animals, Ca requirements largely reflect the need for bone growth and maintenance. Since bone growth is proportionately faster in young birds and it decreases with age, Ca requirements as a percentage of the diet tend to drop as broilers age. Normally, in broilers, Ca is required at a ratio of approximately 2:1 to available P. As long as this ratio is maintained, there will be a margin of Ca in the diet on which bone quality is optimized.

The role of Vitamin D

Vitamin D plays a critical role in Ca and P homeostasis in poultry, and it is unique among vitamins in that it can be synthesized in the skin of animals when it is exposed to ultraviolet light, i.e., sunlight. However, even in open barns, there is limited exposure to sunlight, thus, poultry generally require dietary supplementation with vitamin D.

Traditionally, vitamin D has been supplemented in poultry diets in its crystalline form as cholecalciferol, which is an inactive precursor of the form that the body is able to utilize. This form of vitamin D is absorbed in the digestive tract, and it is converted to an intermediate form, 25-hydroxycholecalciferol (25-OH vitamin D3 or 25-OHD) in the liver. This natural metabolite of vitamin D is the main source of vitamin D activity in the body, even in birds that have only received vitamin D in the diet.

The active form of vitamin D is 1,25 (OH)2 vitamin D3. The conversion of 25-OHD to the active form occurs in many organs, but mainly in the kidney. Because of its toxicity, it is also strictly regulated in the bird. 25-OHD is absorbed in the gut more efficiently than vitamin D because its absorption is less dependent on micelle-mediated absorption, thus overcoming the low absorption efficiency of fats and fat-soluble vitamins that occurs at an early age in young birds. On the other hand, in very young chicks and in birds whose liver function may be impaired (for example, due to mycotoxins or diseases), the conversion of vitamin D to its active form may be lower and, consequently, the absorption of Ca and P will be limited. This does not occur when the 25-OHD metabolite is supplemented because no metabolic process is necessary in the liver. Nowadays, this natural metabolite is commercially available as a dietary supplement (Hy-D®).

The absorption of Ca

The absorption of Ca in the digestive tract involves both active and passive mechanisms. When Ca demands are low and dietary Ca levels are high relative to the bird´s requirements, Ca is used mainly for paracellular transport that is not energy-dependent and occurs through the junctions between epithelial cells to absorb Ca from the intestine. On the other hand, when demands are high relative to the dietary Ca content, 25-OHD is converted in the kidney to the active form of vitamin D3 (1,25 (OH)2D3). This active form of vitamin D upregulates several mechanisms to increase the active transport of Ca through the intestinal cell itself (transcellular absorption).

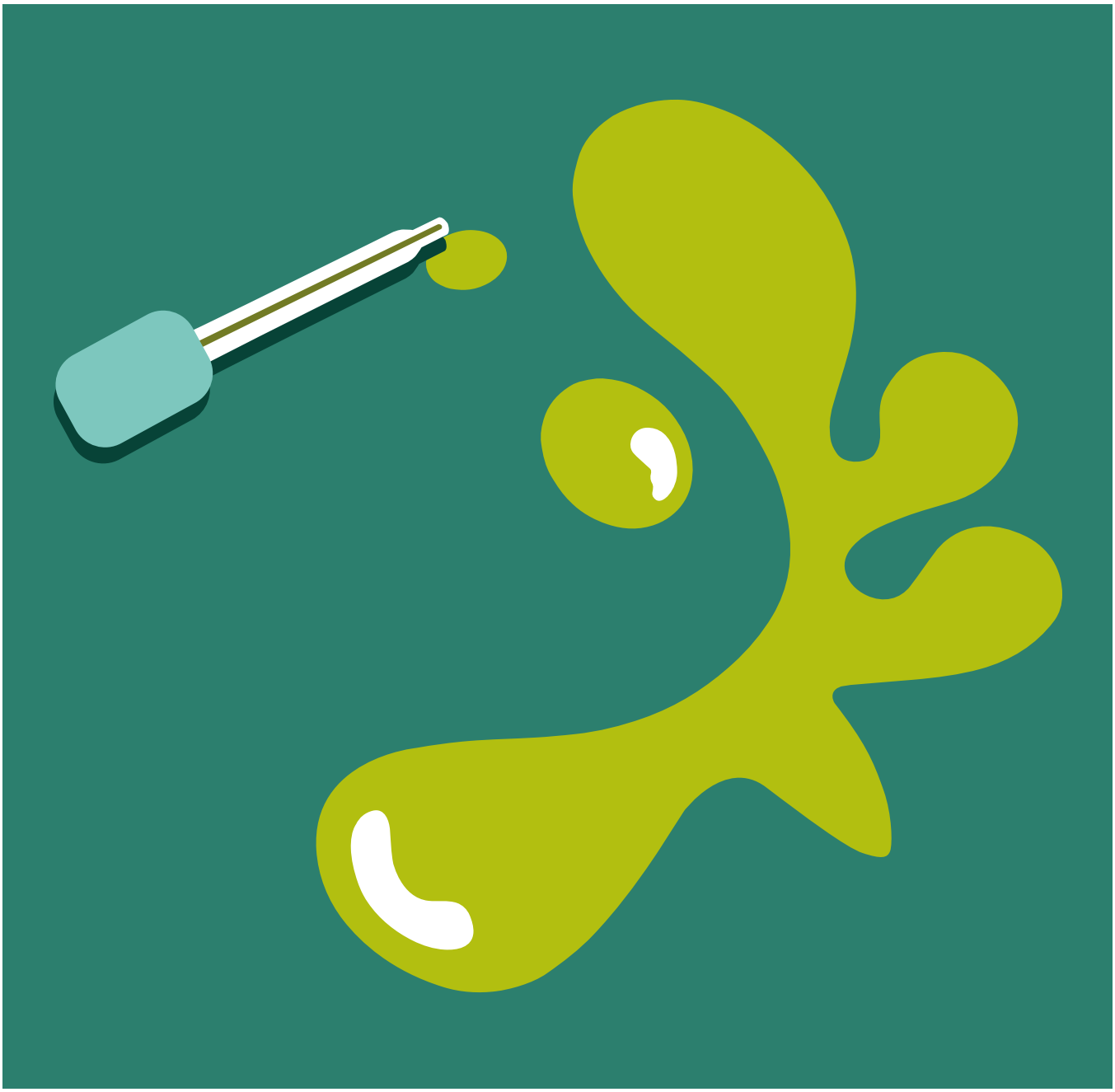
Phosphorous

Phosphorous, besides being a structural component of cell membranes, participates in several physiological processes, as muscle tissue formation, enzyme activation processes, osmotic maintenance, and the formation of the adenosine-triphosphate molecule. It is also crucial for the formation of collagen and skeletal mineralization. Phosphorous is one of the nutrients with the highest economic impact in the animal production industry, considering the animals' requirements and the cost involved in diet formulation. Phosphorous absorption can occur through two different pathways: sodium-dependent and sodium-independent. The sodium-dependent transport is not influenced by the Ca concentration present in the enterocyte membrane. Therefore, the transport of Ca and P appears to occur separately. On the other hand, the sodium-independent transport seems to be related to the amount of Ca present. Thus, the Ca:P ratio influences phosphorus absorption through this pathway.

“Phosphorous is one of the nutrients with the highest economic impact in the animal production industry.”

Transport

It is well known that after feed intake, the rise in P concentration favors paracellular transport. However, transcellular transport, which involves energy expenditure, is stimulated by the presence of vitamin D, and it occurs through sodium-dependent co-transporters (type I, II and III). The type II Na-P co-transporters (IIa, IIb and IIc) seem to more related with the transcellular transport of P in birds. Another important factor in the absorption process is the structural form in which P is found in the intestinal lumen. The main form of phosphorous reserves in plants is phytin, solubilized in the proventriculus and the gizzard in a pH range between 2.5 and 3.0. It is called phytic acid, and it is free and reactive. However, with the gradual increase in pH as the feed reaches the posterior segments of the GI tract, between approximately 5.0 to 6.0, the precipitation of phytic acid and its binding to other minerals and amino acids, in addition to phosphorous, are favored, making them unavailable to monogastric animals. To mitigate the negative effects of the presence of phytic acid in the GI tract, exogenous phytase is widely used nowadays in animal production, with the purpose of hydrolyzing phytic phosphorous and releasing the nutrients trapped in the molecule, thus favoring their absorption and that of other compounds in the diet.



The benefits of using phytases

Phytases are a diverse group of enzymes covering a range of sizes, structures and catalytic mechanisms. The reaction promoted by the phytase is the dephosphorylation of the myo-inositol-1,2,3,4,5,6-hexakiphosphate molecule, characterized by the removal one by one of the phosphate groups attached to the myo-inositol ring. The following are the main benefits of using phytase: reducing the use of inorganic phosphates in the diet, by increasing the availability of phytic phosphorous from plant ingredients; reducing the antinutritional factors of phytic acid, by lowering the endogenous losses and favoring the utilization of minerals, amino acids and energy. An increase in the availability of P and other nutrients also plays an important role in terms of the environment, since reducing the excretion of these elements into the environment is extremely important, especially in regions where animal production is highly concentrated. Therefore, the effective use of phytase can reduce the need for both Ca and available P supplementation.

Adding 25-OHD to the diet

Along with higher concentrations of circulating Ca and P and increased blood levels of 25-OHD (as assessed by the DBS test), improvements in meat yield have also been reported with the use of 25-OHD in broiler diets. Many cell types have vitamin D receptors (VDR) and the binding of active vitamin D to these receptors leads to an altered gene expression in several tissues. Thus, supplying 25-OHD as a partial or total replacement of vitamin D increases meat yield (mainly breast meat) due to the upregulation of the vitamin D receptors in the breast muscle cells, as well as of the genetic control factors of muscle protein synthesis. Many types of immune cells also express the vitamin D receptor. Adding 25-OHD to the diet protects broiler growth from the effects of systemic inflammation. This protective effect has been associated with a decrease in Interleukin 1, which is an important pro-inflammatory cytokine that causes decreased appetite, higher metabolic rates and the use of skeletal muscle for the protein synthesis of the immune response.

Several studies have also shown that broilers supplemented with 25-OHD have a higher ratio of intestinal villus height to crypt depth, compared to broilers supplemented solely with vitamin D. This seems to indicate that the surface area of intestinal absorption is maintained or is greater, while the rate of intestinal cell turnover is lower. Therefore, maintaining intestinal digestive efficiency with reduced metabolic cost (due to lower cell turnover) and, in turn, a greater area of nutrient absorption, may contribute to the increase in feed efficiency often observed when birds are supplemented with 25-OHD.

In conclusion

Hy-D® supplementation can partially or completely replace vitamin D in poultry diets. Additionally, to fulfill the basic functions of vitamin D, 25-OHD has an impact greater than vitamin D on several metabolic systems, including the intestinal, skeletal, muscular, immune and reproductive systems. It has also been fully demonstrated that phytases decrease the requirement for both Ca and available P supplementation in poultry diets. RONOZYME® HiPhos and HiPhorius™ have exceptional phytic acid degradation, leading to greater availability of dietary P and less P excreted into the environment. Therefore, a combination of feed additives that favor the metabolism and the availability of minerals, diminish their effect on the environment and reduce the cost of the diet, will undoubtedly be an adequate strategy for modern broilers.

“...a combination of feed additives that favor the metabolism and the availability of minerals, diminish their effect on the environment and reduce the cost of the diet, will undoubtedly be an adequate strategy for modern broilers.”

Colophon

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A Q&A with Christie Chavis

Name
Christie Chavis

Title
Head of Marketing, Animal Nutrition & Health

Company name:
dsm-firmenich

Location
Kaiseraugst, Switzerland

Where you were born and/or grew up:
Rockville, Indiana, USA

First job:

Rockville Feed Store where I did the monthly invoicing, some feed deliveries and worked in the store.

Was your path to your current role a linear one?

No – not at all! It was very serendipitous and I followed my heart and jumped at a lot of opportunities along the way. Every experience led me to where I am today, building on each other and building a network and community of great professional relationships.

What was the best piece of advice you ever received?

The one thing that you can't get back is time. Thus, make the most of every situation you are facing and don't waste time in roles and projects that you are not passionate about.

What advice do you wish you'd received? Or: What advice would you give someone just starting out in your field?

The advice I give to others is the same that I had early on which is super practical and simple at the end of the day:

1. Your name will be your brand... what will it stand for?
2. Leave everything you touch in better shape than you found it.
3. If you make a promise keep it.
4. Know your ethics and when to draw the line.
5. Live every day with courage.

Favorite podcasts:

Doctor's Farmacy as it is focused on optimizing health, wellness and the importance of regenerative agriculture.

Favorite book and/or what are you currently reading:

Business: *Never Split the Difference* by Chris Voss. It is a book about negotiations yet I find it very helpful for communications in general.

Pleasure: I'm currently reading *The Island* and am quite interested in reading Greek mythology after a trip to Greece.

What have you learned about leadership or about yourself from these last few years of coronavirus?

Do not underestimate the need and frequency for personal connections and "regular" conversations. So much of the pandemic time we were living from one video meeting to another and seldom taking the time to just connect as individuals.

Are there any apps, gadgets or tools that you can't live without?

I love to experiment with different tools and gadgets for improving my health. I can't live without my weighted blanket...25 pounds. It completely changed my sleep quality. I am also loving a meditation app and wearing a continuous glucose monitor.

Do you have any "life hacks" for productivity, efficiency or work-life balance?

Get a dog. Walking my dog every morning and night is a non-negotiable in exercise, taking a break and being in nature. This is the time when I reflect, think and plan my day and next steps. No matter the weather, my dog needs to go out so this is a 2x daily commitment in ensuring that I have a bit of balance and time for reflection.

How do you take a break and relax?

Relaxing looks different for everyone. For me, taking a break is all focused on my kids. Time with them and watching them in their sports is super special.

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