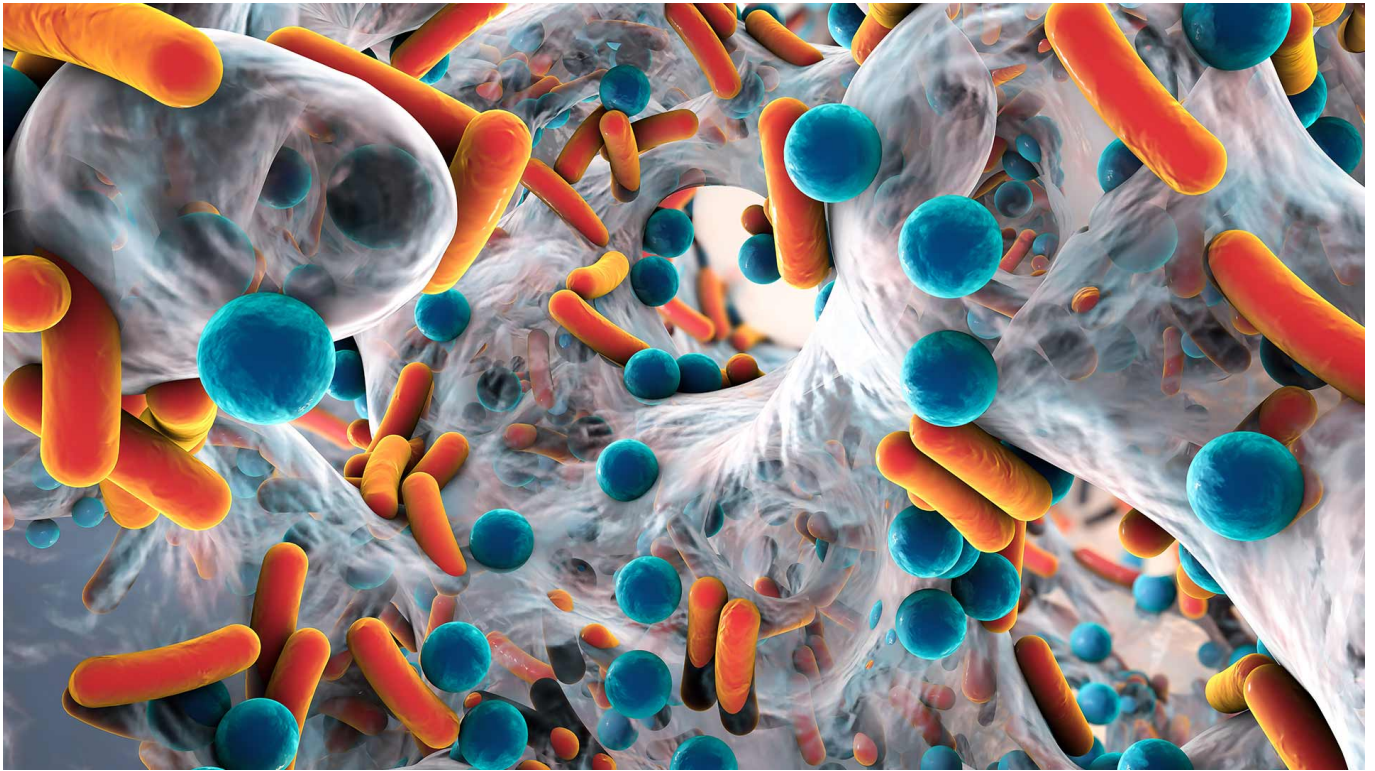


# Antibiotic reduction: The increased importance of high-level biosecurity



Biosecurity is the foundation for all disease prevention programs (Dewulf, et al., 2018), and one of the most important points in antibiotic reduction scenarios. It includes the combination of all measures taken to reduce the risk of introduction and spread of diseases. It is based on the prevention of and protection against infectious agents by understating the disease transmission processes.

The application of consistently high standards of biosecurity can substantially contribute to the [reduction of antimicrobial resistance](#), not only by preventing the introduction of resistance genes into the farm but also by lowering the need to use antimicrobials (Davies & Wales, 2019).

## Lower use of antimicrobials with higher biosecurity

Several studies and assessments relate that high farm biosecurity status and/or improvements in biosecurity lead to [reduced antimicrobial use](#) (Laanen, et al., 2013, Gelaude, et al., 2014, Postma, et al., 2016, Collineau, et al., 2017 and Collineau, et al., 2017a). Laanen, Postma, and Collineau studied the profile of swine farmers in different European countries, finding a relation between the high level of internal biosecurity, efficient control of infectious diseases, and reduced need for antimicrobials.

Reports on reduction on antibiotic use due to farm interventions are also available. Gelaude, et al. (2014), evaluated data from several Belgian broiler farms, finding a reduction of antimicrobial use by almost 30% within a year when biosecurity and other farm issues were improved. Collineau et al. (2017) studied pig farms in Belgium, France, Germany, and Sweden, in which the use of antibiotics was reduced on average by 47% across all farms. The researches observed that farms with the most strict biosecurity protocols,

higher compliance, and who also took a multidisciplinary approach (making other changes, e.g. in management and nutrition), achieved a greater reduction of antibiotic use.

## Biosecurity interventions pay off

Of course, the interventions necessary to achieve an increased level of biosecurity carry some costs. However, the interventions have proven to also improve productivity. Especially if taken with other measures such as improved management of newborn animals and nutritional improvements. The same studies which report that biosecurity improvements decrease antibiotics use also report an improvement in animal performance. In the case of broilers, Laanen (2013) found a reduction of 0.5 percentual points in mortality and one point in FCR; and Collineau (2017) reported a reduction in mortality in pigs during both the pre-weaning and fattening period of 0.7 and 0.9 percentual points, respectively.

## Execution

Although biosecurity improvements and other interventions necessary for [antibiotic reduction](#) programs are well known, continuous compliance of these interventions is often low and difficult. The implementation, application, and execution of any biosecurity program involve adopting a set of attitudes and behaviors to reduce the risk of entrance and spread of disease in all activities involving animal production or animal care. Measures should not be constraints but part of a process aimed to improve health of animals and people, and a piece of the multidisciplinary approach to reduce antibiotics and improve performance.

## Designing effective biosecurity programs: consider five principles

When designing or evaluating biosecurity programs, we can identify five principles that need to be applied (Dewulf, et al., 2018). These principles set the ground for considering and evaluating biosecurity interventions:

### 1. Separation: Know your enemy, but don't keep it close

It is vital to have a good definition of the perimeter of the farm, a separation between high and low-risk animals, and dirty and clean internal areas on the farm. This avoids not only the entrance but the spread of disease, as possible sources of infection (e.g. animals being introduced in the herd and wild birds) cannot reach the sensitive population.

### 2. Reduction: Weaken your enemy, so it doesn't spread

The goal of the biosecurity measures is to keep infection pressure beneath the level which allows the natural immunity of the animals to cope with the infections (Dewulf, et al., 2018). Lowering the pressure of infection e.g. by an effective cleaning and disinfection program, by the reduction of the stocking density, and by changing footwear when entering a production house.

### 3. Focus: Hunt the elephant in the room, shoo the butterflies

In each production unit, some pathogens can be identified as of high economic importance due to their harm and frequency. For each of these, it is even more important, to understand the likely routes of introduction into a farm and how it can spread within it. Taking into consideration that not all disease transmission routes are equally significant, the design of the biosecurity program should focus first on high-risk pathogens and transmission routes, and only subsequently on the ones lower-risk (Dewulf, et al., 2018).

### 4. Repetition: When the danger is frequent, the probability of injury is increased

In addition to the probability of pathogen transmission via the different transmission routes, the frequency of occurrence of the transmission route is also highly significant when evaluating a risk (Alarcon, et al., 2013). When designing biosecurity programs, risky actions such as veterinary visits, if repeated regularly must be considered with a higher risk.

### 5. Scaling: In the multitude, it is easy to disguise

The risks related to disease introduction and spread are much more important in big farms (Dorea, et al., 2010); more animals may be infected and maintain the infection cycle, also large flocks/herds increase the infection pressure and increase the risk by contact with external elements such as feed, visitors, etc.

## Can we still improve our biosecurity?

Almost 100% of poultry and swine operations already have a nominal biosecurity program, but not in all cases is it fully effective. BioCheck UGent, a standardized biosecurity questionnaire applied in swine and broiler farms worldwide, shows an average of 65% and 68% in conformity, respectively, from more than 3000 farms between both species (UGent, 2020). Therefore, opportunities to improve can be found in farms globally, and they pay off.

**To find these opportunities, consider three situations you need to know:**

1. **Know your menace:** Identify and prioritize the disease agents of greatest concern for your production system by applying the principles of **focus** and **repetition**. Consider the size of the facility when evaluating risks applying the **scaling**
2. **Know your place:** Conduct an assessment of the facility. A starting point is to define the *status quo*. For that, operation-existing questionnaires or audits can be used. However, the “new eyes principle” should be applied and an external questionnaire such as BioCheck UGent ([biocheck.ugent.be](https://biocheck.ugent.be)) is recommended. The questionnaire will help you identify gaps in your **biosecurity plan** as well as **processes** that may be allowing pathogens to enter or move from one location to another, and measures that can be implemented applying the principles of **separation** and **reduction**.
3. **Know your processes:** Implement processes and procedures that apply the biosecurity principles and help to eliminate, prevent, or minimize the potential of disease. A deep evaluation of the daily farm processes will aid in risk mitigation, considering, among others, movement of personnel, equipment, and visitors, the entrance of pets, pests and vermin, dealing with deliveries and handling of mortality and used litter.

# Compliance – The weak link in biosecurity programs

Achieving systematic compliance of biosecurity protocols on a farm is a complex, interactive, and continuous process influenced by several factors (Delabbio, 2006) and an ongoing challenge for animal production facilities (Dewulf, et al., 2018). Thus, it is clear that the biosecurity plan can only be effective if everyone on the operation follows it constantly, i.e. if everyone performs in **compliance**.

Compliance can be defined as the extent to which a person's behavior coincides with the established rules. Thus, compliance with biosecurity practices should become part of the culture of the facility. Poor compliance in relation with biosecurity can be connected to:

- Lack of knowledge or understanding of the biosecurity protocols (Alarcon, et al., 2013; Cui & Liu, 2016; Delpont, et al., 2020)
- Lack of consequences for non-compliance (Racicot, et al., 2012a)
- A company culture of inconsistent or low application of biosecurity protocols (Dorea, et al., 2010)

In general terms, compliance with biosecurity procedures has been found to be incomplete in different studies (Delpont, et al., 2020; Dorea, et al., 2010; Gelaude, et al., 2014; Limbergen, et al., 2017). In one study (Racicot, et al., 2011) used hidden cameras, to assess biosecurity compliance in Quebec, Canada and found 44 different biosecurity fails made by 114 individuals (farm workers and visitors) in the participating poultry farms, over the course of 4 weeks; in average four mistakes were made per visit. The most frequent mistakes were ignoring the delimitation between dirty and clean areas, not changing boots, and not washing hands at the entrance of the barns; these three mistakes were committed in more than 60% of the occasions, regardless of being farm employees or visitors. These are frequent breaches not only of those farms in Quebec but found frequently in many animal production units around the world and have a high probability of causing the entrance and spread of pathogens.

## How to create a high biosecurity culture: start now!

Creating, applying, and maintaining a biosecurity culture is the most effective way to make sure that compliance of the biosecurity program and procedures is high on the farm. Decreasing, therefore, the probability of entrance and spread of pathogens, reducing the use of antimicrobials, and maintaining animal health. Some actions are recommended in order to achieve a high biosecurity culture:

### 1. Name an accountable person

Every operation should have a biosecurity coordinator who is accountable for developing, implementing, and maintaining the biosecurity program.

This important position should be appointed having in mind that certain personality traits may facilitate performance and execution of the labor (Delabbio, 2006; Racicot, et al., 2012; Laanen, et al., 2014; Delpont, et al., 2020) such as responsibility, orientation to action, and being able to handle complexity. Additionally, expertise – years working in the industry – and orientation to learn are strategic (Racicot, et al., 2012).

### 2. Set the environment

When the farm layout is not facilitating biosecurity, compliance is low (Delabbio, 2006), thus the workspace should facilitate biosecurity workflows and at the same time make them hard to ignore (Racicot, et al., 2011).

### 3. Allow participation

It is important to mention that not only the management and the biosecurity coordinator are responsible for designing and improving biosecurity procedures. Biosecurity practices must be owned by all the farm workers and should be the social norm.

The annual or biannual revision of biosecurity measures should be done together with the farm staff. This not only serves the purpose of assessing compliance but also allows the personnel to suggest measures addressing existing -often overlooked- gaps, and to be frank about procedures that are not followed and the reasons for it. At the same time, participation increases accountability and responsibility for the biosecurity program.

### 4. Train for learning

Don't take knowledge for granted. Even when a person has experience in farm work and has been working in the industry for several years, their understanding and comprehension around biosecurity may have gaps.

People are more likely to do something when they see evidence of the activity's benefit. Therefore, if workers are told about the effectiveness of the practices, showing the benefits of biosecurity and analyzing the consequences of non-compliance, they are most likely to follow the procedures (Dewulf, et al., 2018). Knowledge of disease threats and symptoms also improves on-farm biosecurity (Dorea, et al., 2010), thus workers should recognize the first symptoms of disease in animals and act upon them.

Discussion of 'What if...?' scenarios to gain an understanding of the key aspects of farm biosecurity should be held on a regular basis. Workers should see examples of the benefits of compliance – and risks of noncompliance – as part of their training.

### 5. Lead by example

A high biosecurity culture requires everyone to comply regardless of status.

Personnel practice of biosecurity procedures is not only affected by the availability of resources and training, but also by the position that management takes on biosecurity and the feedback provided. The management and owners must transmit a message of commitment to the farm personnel, owning and following biosecurity practices, procedures and protocols, giving positive and negative feedback on the personnel's compliance, supplying information on farm performance and relating it with biosecurity compliance and ensuring adequate resources for the practice of biosecurity (Delabbio, 2006).

When necessary, management also should enforce personnel compliance by disciplinary measures, firings, and creating awareness about the consequences of disease incidence. Nevertheless, the recognition of workers' contribution to animal health performance also has a positive impact on biosecurity compliance (Dorea, et al., 2010).

## The bottom line

Biosecurity is necessary for disease prevention in any animal production system. Actions and interventions that prevent the entrance and spread of disease in a production unit have a pay-off as they often lead to performance improvements and lower antimicrobial use. Maintaining a successful production unit requires a multidisciplinary approach in which [biosecurity compliance](#) needs to be taken seriously and also actions to improve in other areas such as management, health, and nutrition.

By **Marisabel Caballero**, Global Technical Manager Poultry, EW Nutrition.

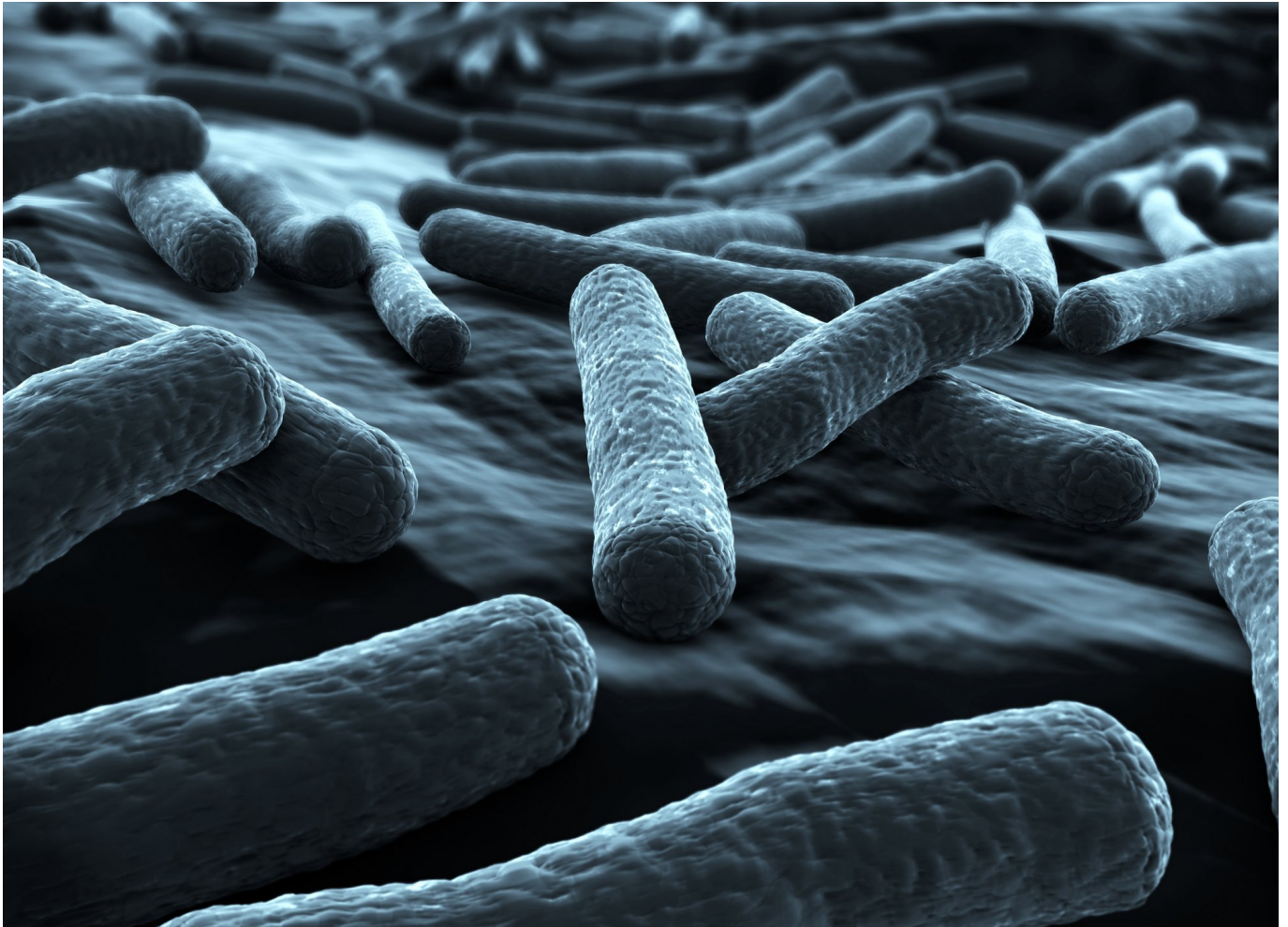


## References

- Alarcon, P., Wieland, B., Pereira, A. L. & Dewberry, C., 2013. Pig Farmer's perceptions, attitudes, influences, and management of information in the decision-making process for disease control. *Preventive Veterinary Medicine*, 116(3).
- Collineau, L. et al., 2017. Profile of pig farms combining high performance and low antimicrobial usage within four European countries. *Veterinary Record*, Volume 181.
- Collineau, L. et al., 2017a. Herd-specific interventions to reduce antimicrobial usage in pig production without jeopardizing technical and economic performance. *Preventive Veterinary Medicine*.
- Cui, B. & Liu, Z. P., 2016. Determinants of Knowledge and Biosecurity Preventive Behaviors for Highly Pathogenic Avian Influenza Risk Among Chinese Poultry Farmers. *Avian Diseases*, 60(2).
- Davies, R. & Wales, A., 2019. Antimicrobial Resistance on Farms: A Review Including Biosecurity and the Potential Role of Disinfectants in Resistance Selection. *Comprehensive Reviews in Food Science and Food Safety*.
- de Gussem, M. et al., 2016. *Broiler Signals*. First ed. Zutphen: Roodbont Publishers.
- Delabbio, J., 2006. How farmworkers learn to use and practice biosecurity. *Journal of Extension*, 44(6).
- Delpont, M. et al., 2020. Determinants of biosecurity practices in French duck farms after an H5N8 Pathogenic Avian Influenza epidemic: The effect of farmer knowledge, attitudes and personality traits. *Transboundary and Emerging Diseases*.
- Dewulf, J. et al., 2018. *Biosecurity in animal production and veterinary medicine*. First ed. Den Haag: Acco Nederland.
- Dorea, F., Berghaus, R., Hofacre, C. & Cole, D., 2010. Biosecurity protocols and practices adopted by growers on commercial poultry farms in Georgia USA. *Avian Diseases*, 54(3).
- Gelaude, P. et al., 2014. Biocheck.UGent: A quantitative tool to measure biosecurity at broiler farms and the relationship with technical performances and antimicrobial use. *Poultry Science*.
- Laanen, M. et al., 2014. Pig, cattle, and poultry farmers with a known interest in research have comparable perspectives on disease prevention and on-farm biosecurity. *Preventive Veterinary Medicine*.
- Laanen, M. et al., 2013. Relationship between biosecurity and production/antimicrobial treatment characteristics in pig herds. *The Veterinary Journal*, 198(2).
- Limbergen, T. et al., 2017. Scoring biosecurity in European conventional broiler production. *Poultry Science*.
- Postma, M. et al., 2016. Evaluation of the relationship between the biosecurity status, production parameters, herd characteristics, and antimicrobial usage in farrow-to-finish pig production in four EU countries. *Porcine Health Management*.
- Racicot, M., Venne, D., Durivage, A. & Vaillancourt, J.-P., 2011. Description of 44 biosecurity errors while entering and exiting poultry barns based on video surveillance in Quebec, Canada. *Preventive veterinary medicine*, Volume 100.
- Racicot, M., Venne, D., Durivage, A. & Vaillancourt, J.-P., 2012a. Evaluation of strategies to enhance biosecurity compliance on poultry farms in Quebec: Effects of audits and cameras. *Preventive veterinary medicine*, Volume 103.
- Racicot, M., Venne, D., Durivage, A. & Vaillancourt, J.-P., 2012. Evaluation of the relationship between personality traits, experience, education, and biosecurity compliance on poultry farms in Quebec, Canada. *Preventive veterinary medicine*, Volume 103.
- UGent, b., 2020. *biocheck UGent*. [Online]  
Available at: [www.biocheck.ugent.be](http://www.biocheck.ugent.be)

---

# Antibiotic reduction: the key role of biosecurity



Biosecurity is the foundation for disease prevention. It includes all measures to reduce the risk of introduction and spread of infectious agents, using our knowledge of disease transmission processes.

Biosecurity is all the more important in antibiotic reduction scenarios: consistently high biosecurity standards can contribute substantially to the [reduction of antimicrobial resistance](#), by preventing the introduction of resistance genes to the farm, and also by lowering the need for antimicrobials.

## Higher biosecurity, lower use of antimicrobials

Laanen et al. (2013) studied the profile of swine farmers across Europe, finding a relation between a high level of internal biosecurity, an efficient control of infectious diseases, and a reduced need for antimicrobials.

In another study, Gelaude et al. (2014) examined Belgian broiler farms, concluding that antimicrobial use

could be reduced by almost 30% when biosecurity and other farm issues were improved within a year. Collineau et al. (2017) studied swine farms in Belgium, France, Germany and Sweden. On average, antimicrobial use dropped by 47% – but farms with higher biosecurity compliance and a holistic approach (e.g. management and nutrition changes) needed even fewer antimicrobials.

## Interventions pay off

Of course, the interventions necessary to achieve an increased level of biosecurity carry some costs. However, such interventions, especially if combined with better management of newborn animals and nutritional improvements, also strengthen productivity.

The same studies, which report that biosecurity improvements decrease antimicrobial use, also report stronger animal performance. For broilers, Laanen et al. (2013) found a reduction of 0.5 percentage points in mortality and one point in FCR. For pigs, Collineau et al. (2017) found an improvement during both the pre-weaning and the fattening period of 0.7 and 0.9 percentage points, respectively.

## Execution is a challenge

Biosecurity is considered the cheapest and most effective intervention in antibiotic reduction programs, but compliance is often difficult to achieve and thus low. It sounds simple: stop the introduction and spread of diseases.

However, in practice, this involves adopting a new set of attitudes and behaviors across all animal production and care activities. Measures should not be constraints, but part of a holistic process to improve the health of animals and people, to reduce antibiotics and boost performance.

## Best practices

If you want to design a biosecurity program or improve an existing one, consider these three factors:

1. **Know your menace**  
Identify and prioritize the disease agents of **greatest concern** to the facility, focusing on the processes that carry a risk of pathogen entrance and spread, and are frequently **repeated**. Additionally, consider the **size** of the facility – more animals means higher risk.
2. **Know your place**  
Define the *status quo*, ideally using external questionnaires or audits (e.g. [BioCheck UGent](#)). This helps you identify and **gaps** in your biosecurity plan. **Measures** need to be based on the principles of **separation** (between high and low-risk animals and areas) and **reduction** (lower the infection pressure).
3. **Know your processes**  
An exhaustive evaluation of the **daily farm practices** – e.g. the movement of personnel, equipment and visitors, and or used litter management – will help you find **weak spots** so you can eliminate, prevent, or minimize the **potential** of disease.

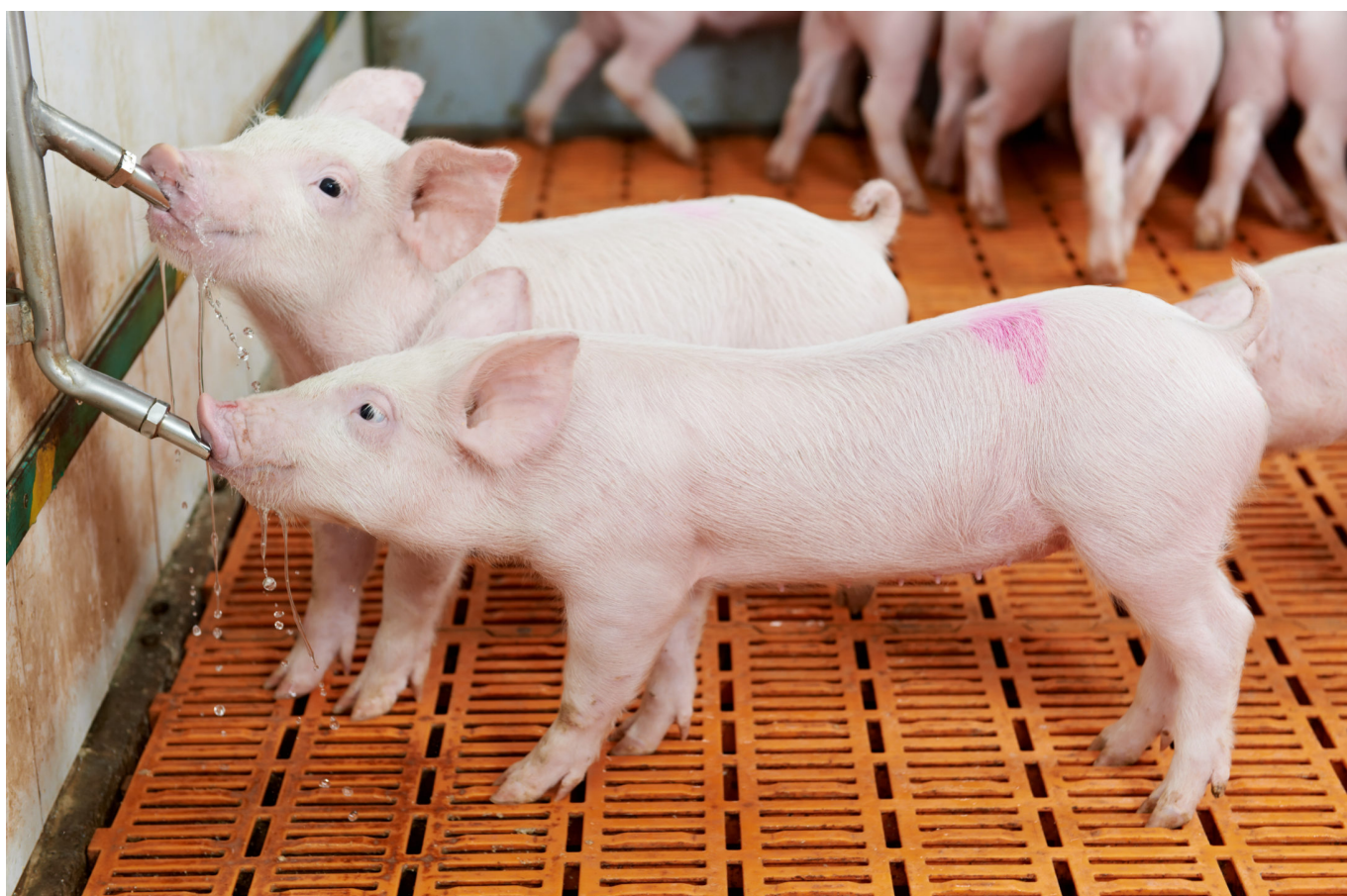
## The bottom line

Biosecurity measures are the basis for disease prevention in any profitable animal production system. Preventing the entrance and spread of disease pays off through performance improvements and lower antimicrobial use. Taking this to the next level, where biosecurity compliance complements improvements in management, health, and nutrition, sets your production up for long-term success.

*By Marisabel Caballero and Fellipe Freitas Barbosa*



# 5 key facts pig producers need to know about the EU's ZnO ban



We all know the headlines, “European Commission adopts ZnO ban” or “Zinc oxide to be phased out at EU level by 2022”. Clearly, EU legislation has far-reaching consequences for European pig producers – but in the jungle of acronyms and legalistic jargon, it’s not always clear which institution gets to decide what and why. Here are five key facts that help pig producers make sense of the EU’s zinc oxide ban.

## 1. Zinc oxide can only be used as a feed additive (low dosage)

Pigs require zinc to maintain various metabolic functions, hence it is included in their diet as a feed additive. This use will not be banned: ZnO is included as a source of zinc in the so-called [register of feed additives](#), which applies to the whole EU. The European Commission decides which products are included in the register based on the opinions of the European Food Safety Authority (EFSA), which also advises the Commission on topics like animal welfare and African swine fever. The EFSA currently suggests that a total level of 150ppm meets the animals’ physiological needs for zinc. The European Commission has turned

this recommendation into law, hence [150ppm is the legal limit](#) for zinc supplementation for piglets.

## 2. The EU sets common rules for veterinary medicinal products

ZnO-based products to treat post-weaning diarrhea in piglets, on the other hand, contain pharmacological doses of zinc oxide. A commonly administered dosage is 100mg per kg body weight per day for 14 consecutive days, amounting to 2500ppm zinc in the feed. These products are classified as veterinary medicinal products (VMPs) and are thus covered by [Directive 2001/82/EC](#) on medicinal products for veterinary use and by [Regulation \(EC\) No 726/2004](#). These pieces of legislation set out the EU's rules for the production, distribution, and authorizations of VMPs, and they establish the European Medicines Agency (EMA). Just as the EFSA advises the European Commission on feed additives, they turn to the EMA regarding VMPs.

### What is the difference between a “regulation” and a “directive”?

Regulations automatically apply to all EU countries, without needing to be transposed into national law. A directive requires EU members to achieve certain objectives – and to transpose them into national law – but lets them to choose how to do so, as long as they meet a set deadline.

### *Zinc oxide – two different uses, two different situations*

	ZnO as a feed additive	ZnO as a veterinary medicinal product (VMP)
EU agency	European Food Safety Authority (EFSA)	European Medicines Agency (EMA)
Legislation	Regulation (EC) No 1831/2003 on additives for use in animal nutrition	Directive 2001/82/EC on veterinary medicinal products + Regulation (EC) No 726/2004 Note: by 2022 these two will be replaced by the new Regulation (EU) 2019/6
Levels	Max. total 150ppm of zinc (from ZnO and other sources)	Normal dosage ca. 2500ppm
Ban?	No! There is no indication at the moment that zinc oxide will be banned as a feed additive.	<b>Yes!</b> Marketing authorizations for VMPs containing zinc oxide will be withdrawn across EU by June 2022.

## 3. ZnO products licenses are a national topic – but subject to EU scrutiny

One of EMA's key topics are marketing authorizations: VMPs can only be sold and traded in the EU if they have received a marketing authorization, which is basically a license. Depending on the type of VMP and on when it was first released, the marketing authorization is either issued by the EMA or by national

authorities. Veterinary medicines containing zinc oxide are (or rather were) within the remit of national authorization procedures. However, national authorities are supposed to turn to the EMA's [Committee for Medicinal Products for Veterinary Use \(CVMP\)](#) if they have any issues with an application that is submitted to them. This is what happened in the case of zinc oxide.

## 4. France and the Netherlands initiated the review of zinc oxide

A European company in the feed industry had applied for marketing authorization for its ZnO-based medicated feeding stuff for piglets in the United Kingdom, hoping for a so-called decentralized authorization procedure to take place. This procedure would mean that the marketing authorization issued in the UK would also be valid in other EU countries. However, France and the Netherlands objected to this on the grounds of environmental concerns. Initially, the CVMP ruled that the marketing authorization could be granted, but France and the Netherlands persisted. In a second round, they raised doubts about the efficacy of risk mitigation measures and the added [issue of antimicrobial resistance](#). This time, [they were successful](#).

## 5. Bottom line: ZnO products will no longer get a marketing authorization

In March 2017, the CVMP concluded that zinc oxide's benefits of preventing diarrhea do not outweigh the risks to the environment. Therefore the panel recommended that national authorities withdraw existing marketing authorizations for zinc oxide-based VMPs and that they no longer grant new authorizations. Shortly after that, on 26 June 2017, [the European Commission adopted the CVMP's recommendation](#), which means that all EU countries have to implement it. This decision also says that countries may defer withdrawing the marketing authorizations if they think that the lack of available alternatives and necessary changes in farming practices put too much pressure on their pig sectors. They can only defer for five years though; hence, the decision must be implemented no later than 26 June 2022.

### How do you say "ZnO ban" in EU terms?

The withdrawal of marketing authorizations for veterinary medicinal products containing zinc oxide to be administered orally to food-producing species.

Today we stand at the half-way point before the ban of VMP ZnO as a veterinary medicinal product kicks in across the EU. Hence the search is on for effective strategies to control post-weaning diarrhea: without zinc but through continuous improvements in management and feed practices, as well as the support of targeted, functional feed additives.

By Technical Team, EW Nutrition  
Article available in [german](#), [dutch](#) and [spanish](#).

---



# Challenging times for broilers? Phytomolecules, not antibiotics, are the answer



*by **Ajay Bhojar**, Global Technical Manager, EW Nutrition*

Anyone working with today's fast-growing broiler chicken knows that it is a sensitive creature – and so is its gut health. Thanks to continuous improvements in terms of [genetics and breeding](#), nutrition and feeding, as well as general management strategies, broiler production has tremendously upped performance and efficiency over the past decades. It is estimated that, between 1957 and 2005, the [broiler growth rate increased by over 400%, while the feed conversion ratio dropped by 50%](#).

These impressive improvements, however, have come at the cost of intense pressure on the birds' digestive system, which needs to process large quantities of feed in little time. To achieve optimal growth, a broiler's [gastrointestinal tract \(GIT\)](#) needs to be in perfect health, all the time. Unsurprisingly, enteric



diseases such as [necrotic enteritis](#), which severely damages the intestinal mucosa, hamper the intestines' capacity to absorb nutrients and induce an inflammatory immune response.

## The modern broiler's gut - a high-performing, but sensitive system

However, in a system as high performing as the modern broiler's GIT, much less can lead to problems. From when they are day-old chicks up to slaughter, broilers go through several challenging phases during which they are more likely to show impaired gut functionality, e.g. after vaccinations or feed changes. [Good management practices go a long way towards eliminating unnecessary stressors](#) for the animals, but some challenging periods are unavoidable.

The transition from starter to grower diets is a classic situation when nutrients are very likely to not be well digested and build up in the gut, fueling the proliferation of harmful microbes. Immunosuppressive stress in combination with an immature intestinal microflora results in disturbances to the bacterial microbiota. At "best", this entails temporarily reduce nutrient absorption, in the worst case the birds will suffer serious intestinal diseases.

## Phytomolecules - the intelligent alternative to antibiotics

To safeguard performance during stressful periods, poultry producers need to anticipate them and proactively provide effective gut health support. For many years, this support came in the form of antibiotic growth promoters (AGP): administered prophylactically, they were effective at keeping harmful enteric bacteria in check. However, due to grave concerns about the [development of antimicrobial resistance](#), non-therapeutic antibiotics use has been banned in many countries. Alternatives need to focus on improving feed digestibility and strengthening gut health, attacking the root causes of why the intestinal microflora would become unbalanced in the first place.

Phytomolecules are secondary metabolites active in the defense mechanisms of plants. Studies have found that certain phytomolecules [stimulate digestive enzyme activities](#) and stabilize the gut microflora, "leading to improved feed utilization and less exposure to growth-depressing disorders associated with digestion and metabolism" (Zhai et al., 2018). With other trials showing [positive effects on broilers' growth performance and feed conversion](#), the research indicates that phytomolecules might also specifically support chickens during challenging phases.

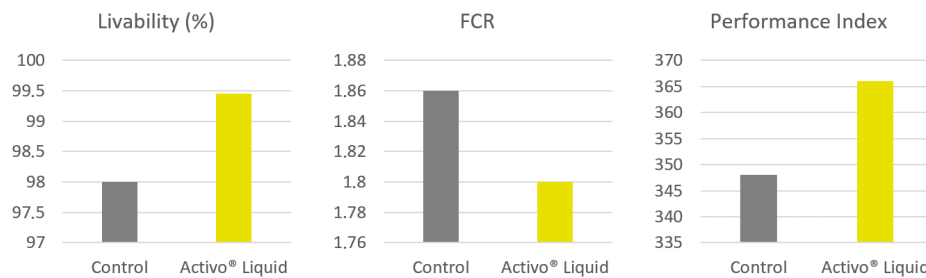
## The effect of phytomolecules on broilers during a challenging phase

A study was conducted over a period of 49 days on a commercial broiler farm of an AGP-free integration operation in Japan. The farm reported gut health challenges in the second and third week of the fattening period due to vaccinations and changes to the animals' diets. The trial included 15504 Ross 308 broilers, divided into two groups. The negative control group included a total of 7242 birds, kept in another house.

All the birds were fed the standard feed of the farm. The trial group (8262 birds) received Activo Liquid, which contains a synergistic combination of phytomolecules, administered directly through the drinking water. Activo Liquid was given at an inclusion rate of 200ml per 1000L of water (3.3 US fl oz per gallon of stock solution, diluted at 1:128), from day 8 until day 25, for 8 hours a day.

The results are summarized in Figure 1:

*Figure 1: Improved broiler performance for Activo Liquid group (day 49)*



The Activo Liquid group clearly showed performance improvements compared to the control group. Livability augmented by 1.5%, while the feed conversion rate improved by 3.2%. This resulted in a more than 5% higher score in terms of the performance index.

## Challenging times? Tackle them using phytomolecules

Poultry producers take great care to eliminate unnecessary sources of stress for their birds. Nonetheless, during their lifecycle, broiler chickens face challenging periods during which the balance of the intestinal microflora can easily become disturbed, with consequences ranging from decreased nutrient absorption to full-blown enteric disease.

The trial reviewed here showed that, after receiving Activo Liquid, broilers raised without AGPs showed encouraging performance improvements during a challenging phase of feed changes and vaccinations. Likely thanks to the activation of digestive enzymes and a stabilization of the gut flora, the broilers showed improved livability and feed conversion, thus delivering a much more robust performance during a critical phase of their lives. In times where the non-therapeutic use of antibiotics is no longer an option, phytomolecules allow poultry farmers to effectively support their animals during challenging times.

## References

Photo Source: [Aviagen](#)

[Adedokun, Sunday A., and Opeyemi C. Olojede. "Optimizing Gastrointestinal Integrity in Poultry: The Role of Nutrients and Feed Additives." \*Frontiers in Veterinary Science\* 5 \(January 31, 2019\): 348.](#)

[Jamroz, D., T. Wiertelicki, M. Houszka, and C. Kamel. "Influence of Diet Type on the Inclusion of Plant Origin Active Substances on Morphological and Histochemical Characteristics of the Stomach and Jejunum Walls in Chicken." \*Journal of Animal Physiology and Animal Nutrition\* 90, no. 5-6 \(March 23, 2006\): 255-68.](#)

[Tavárez, Marcos A., and Fausto Solis De Los Santos. "Impact of Genetics and Breeding on Broiler Production Performance: a Look into the Past, Present, and Future of the Industry." \*Animal Frontiers\* 6, no. 4 \(October 1, 2016\): 37-41.](#)

[Zhai, Hengxiao, Hong Liu, Shikui Wang, Jinlong Wu, and Anna-Maria Klünter. "Potential of Essential Oils for Poultry and Pigs." \*Animal Nutrition\* 4, no. 2 \(June 2018\): 179-86.](#)

[Zuidhof, M. J., B. L. Schneider, V. L. Carney, D. R. Korver, and F. E. Robinson. "Growth, Efficiency, and Yield of Commercial Broilers from 1957, 1978, and 2005." \*Poultry Science\* 93, no. 12 \(December 2014\): 2970-82.](#)

# Want antibiotic-free broilers?

## Raise low-AB breeders



Strong demand by consumers; restaurant chains and wholesalers for antibiotic-free (ABF) meat; the threat of [antimicrobial resistance](#); and stringent regulations on the use of antibiotics – there are many good reasons for poultry producers to strive for antibiotic-free production systems. Crucially, to successfully produce poultry meat without antibiotics requires a paradigm shift that starts right at the parent stock level, with the antibiotic-free production of hatching eggs.

## Broiler breeders' gut health is linked to progeny's performance

Broiler breeders' performance is measured in terms of how many saleable day old chicks (DOCs) per hen they produce. However, within a sustainable ABF production system (also known as No Antibiotics Ever or NAE), this parameter is not seen in isolation. Breeder hens' nutritional and health status not only affect the number of DOCs they can produce, but also the transfer of nutrients, antibodies, microbiota and even contaminants, e.g. mycotoxins, to the egg – and therefore, their progeny's long-term health and performance.

This starts with egg formation, which requires several metabolic processes in the hen to function perfectly.

If the hen's intestinal integrity is compromised, for example due to mycotoxins, she will absorb fewer nutrients, which in turn affects egg formation. [Mycotoxicosis has particularly insidious effects for egg formation](#) as it can damage the liver whose biosynthetic activities strongly impact on the egg's internal (yolk) and external (eggshell) quality.

Chick embryos depend on the [maternal antibodies and nutrients deposited in the yolk](#), including vitamin D3, carotenoids, and fatty acids, to develop normally. Eggshell quality, among other things, affects the embryo's access to oxygen, which is especially important when it develops body tissues.

Hens' ability to form healthy eggs depends on their diet and health. Research indicates that, via the impact on egg formation, broiler breeders' feeding program quantifiably influences their progeny's [immune system](#) and [intestinal health](#). There is indeed a direct relationship between parent and offspring's gut health because [the chick's microbiome is in part also inherited from the hen](#). The impact on DOC quality is thus one of many dimensions to consider when calibrating one's broiler breeders feeding approach.

## The challenge of feeding an ABF broiler breeder

Just as their offspring, breeder hens are genetically predisposed for rapid growth and muscle development. From rearing right through to the laying period, poultry nutritionists need to carefully balance their diets and moderate weight gain in order for hens to reach their reproductive potential.

Different stages of a breeder's life cycle come with different objectives – for example, good flock uniformity in the rearing period versus egg size and hatchability in the laying phase – and thus different requirements in terms of calories, amino acids, vitamins, and minerals. What remains constant is that the actual nutrient intake depends on intestinal health, determining both the breeders' performance and, via the impact on egg characteristics, its progeny's performance.

The [feeding regimes adopted to avoid hens becoming overweight can have a negative effect on their gut flora](#). Without antibiotics as a tool to maintain or recover optimal gut function, even mild intestinal disorders can quickly become chronic impairments that negatively impact breeders' productivity. In ABF production systems, intestinal health therefore needs to be a central focus for the feeding strategy.

## Can phytomolecules improve broiler breeders' performance?

Among the plethora of feed additives, phytomolecules, or secondary plant compounds, stand out as a class of active ingredients that may help to improve gut health and thereby reduce the use of antibiotics. Synthesized by plants as a defense mechanism against pathogens, phytomolecules combine digestive, antimicrobial and antioxidant properties.

Some studies have shown that [phytomolecules-based products](#) can increase broilers' body weight gain and improve laying hens' laying rate, egg mass and egg weight. Both broilers and laying hens responded to the inclusion of phytomolecules in their diet with inclusion rate-dependent improvements in feed conversion. To evaluate if phytomolecules could similarly improve broiler breeders' performance, two trials were conducted.

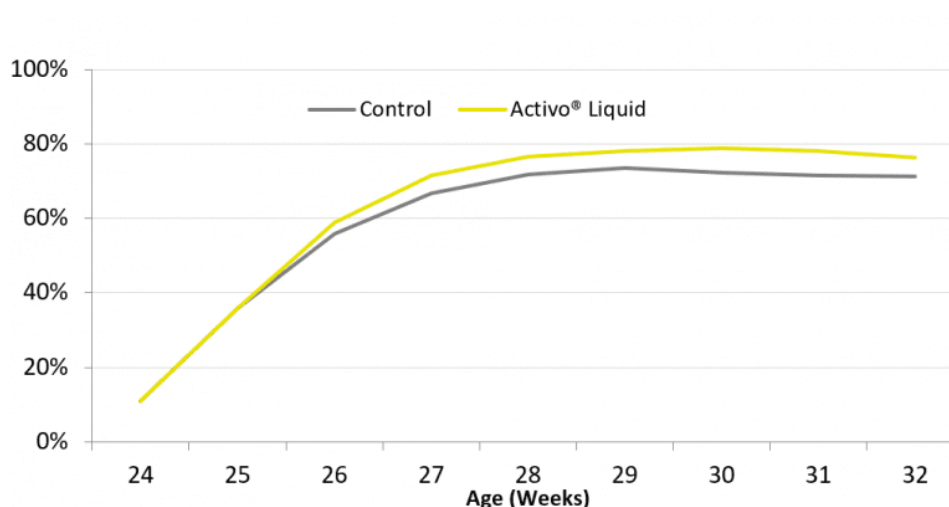
### Study I: Effect of phytomolecules on laying performance during peak production

The first study was set up on a farm in Thailand. In total, 40000 Cobb broiler breeders (85% female, 15% male) were divided into two groups with 8500 hens (one house) in the control and 25500 (three houses) in the trial group. Both groups were fed standard feed. The trial group additionally received a phytomolecules-based liquid complementary feed (Activo Liquid, EW Nutrition GmbH) via the waterline from week 24 to week 32 at a rate of 200ml/1000L during 5 days per week.

Activo Liquid was found to have a positive influence on laying performance (Figure 1). The average laying



rate increased by 7.2% during the trial period, resulting in almost 3 additional hatching eggs per hen housed. A further indication of the beneficial influence that this particular combination of phytomolecules had on gut health was a 0.2% lower mortality.



**Figure 1: Laying rate (%) of breeder hens during first 9 weeks of production**

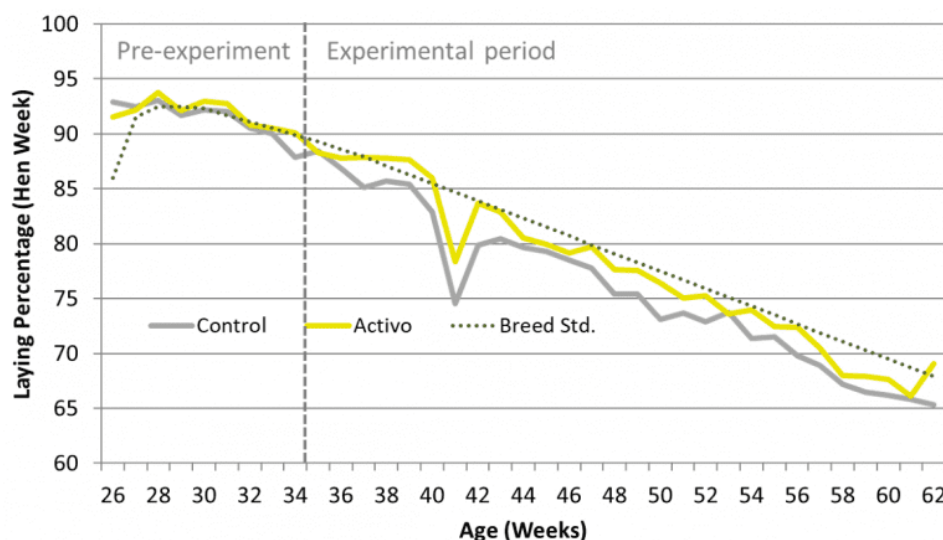
## **Study II: Effect of phytomolecules on laying performance after peak production**

For a second study, conducted in the Czech Republic, 800 female and 80 male Hubbard breeders (JA57 and M77, respectively) were divided into 2 groups with 5 replicate pens and 80 female and 8 male breeders per pen. The experiment started after the peak-production period, at 34 weeks of age and ended at 62 weeks of age. All animals received a standard mash diet. For one group a phytogenic premix (Activo, EW Nutrition GmbH) was added to the diet at a rate of 100g/MT.

The results indicate that Activo helped maintain the breeder hens' egg laying performance close to the breed's genetic potential (Figure 2). In the course of the experiment, Activo supplemented birds produced 3.6 more eggs than control birds, while consuming a similar amount of feed. As a result, feed consumption per egg produced was lower for birds receiving phytomolecules than for the control birds (169.9 versus 173.6g/d, respectively).

As hatchability was not influenced by the dietary treatment in this study ( $P > 0.5$ ), the 3.6 extra eggs resulted in 2.9 extra day old chicks per hen produced, during the post-peak period alone.

The microencapsulated, selected phytomolecules contained in Activo are likely to have improved gut health and feed digestibility, and thereby enhanced the animals' feed efficiency.



**Figure 2: Laying rate (%) of breeder hens week 35 till 62**

## Chicken or egg? Antibiotic-free poultry production looks at the bigger picture

To successfully produce antibiotic-free poultry meat requires a systematic re-think of each component of the production process. Broiler breeders' lay the foundation for their progeny's health and performance via the egg. Breeder hens need to be in optimal health to consistently deliver optimal eggs. Without recourse to antibiotics for maintaining or recovering intestinal functionality, an effective ABF production needs to make gut health central to its feeding approach.

The trials reviewed demonstrate that selected phytomolecules quantifiably boost breeders' laying performance, increasing the number of hatching eggs and DOCs, while reducing mortality and feed consumption per egg produced. As part of an intelligent antibiotic reduction strategy, the right phytogenic products can be potent tools to help poultry producers achieve their NAE objectives.

by T. van Gerwe, Global Technical Director, and M. Caballero, Global Technical Manager Poultry, EW Nutrition

## References

Calini, F., and F. Sirri. "Breeder Nutrition and Offspring Performance." *Revista Brasileira De Ciência Avícola* 9, no. 2 (2007): 77-83. doi:10.1590/s1516-635x2007000200001.

Ding, Jinmei, Ronghua Dai, Lingyu Yang, Chuan He, Ke Xu, Shuyun Liu, Wenjing Zhao, et al. "Inheritance and Establishment of Gut Microbiota in Chickens." *Frontiers in Microbiology* 8 (October 10, 2017): 1967.

Kuttappan, Vivek A., Eduardo A. Vicuña, Juan D. Latorre, Amanda D. Wolfenden, Guillermo I. Téllez, Billy M. Hargis, and Lisa R. Bielke. "Evaluation of Gastrointestinal Leakage in Multiple Enteric Inflammation Models in Chickens." *Frontiers in Veterinary Science* 2 (December 14, 2015): 66.

Moraes, Vera M. B., Edgar O. Oviedo-Rondón, Nadja S. M. Leandro, Michael J. Wineland, Ramon D. Malheiros, and Pamela Eusebio-Balcazar. "Broiler Breeder Trace Mineral Nutrition and Feeding Practices on Embryo Progeny Development." *Avian Biology Research* 4, no. 3 (2011): 122-32.

Oviedo-Rondon, Edgar O., Nadja S. M. Leandro, Rizwana Ali, Matthew Koci, Vera M. B. Moraes, and John Brake. "Broiler Breeder Feeding Programs and Trace Minerals on Maternal Antibody Transfer and Broiler

# Phytomolecules: A tool against antibiotic-resistant *E. coli*



## Diseases caused by *E. coli* entail use of antibiotics in animal production

*E. coli* infections are a major problem in pig production. Especially young animals with an incompletely developed immune system are often unable to cope with the cavalcade of pathogens. In poultry, *E. coli* are responsible for oedema, but also for [respiratory diseases](#). In young piglets, *E. coli* cause diarrhoea, oedema, endotoxic shock and death. In order to cure the animals, antibiotics often must be applied. Besides this curative application, antibiotics were and in many countries still are used prophylactically and as growth promoters.

The excessive use of antibiotics, however, leads to the [occurrence of antimicrobial resistance](#) (AMR): due to mutations, resistance genes are created which enable enterobacteria such as *Salmonella*, *Klebsiella* and *E. coli* to produce enzymes ( $\beta$ -lactamases) in order to withstand  $\beta$ -lactam antibiotics. In case of an antibiotic treatment, the resistant bacteria survive whereas the other bacteria die.

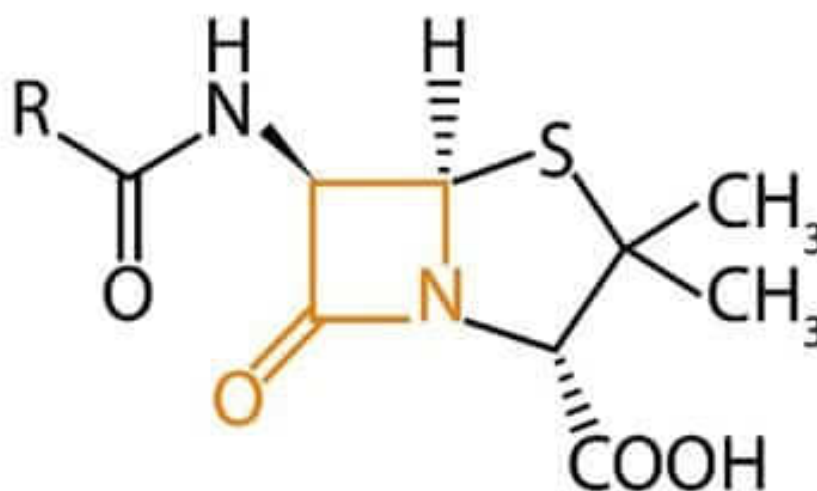
The major problem here is that these resistance genes can be transferred to other bacteria. Harmless

bacteria can thus transfer resistance genes to dangerous pathogens, which then cannot be combatted with antibiotics anymore. In this article we explore in detail how AMR happens and how phytomolecules, which have antimicrobial properties, could be a key tool to reduce the need for antibiotics in animal production.

## How $\beta$ -lactam antibiotics work

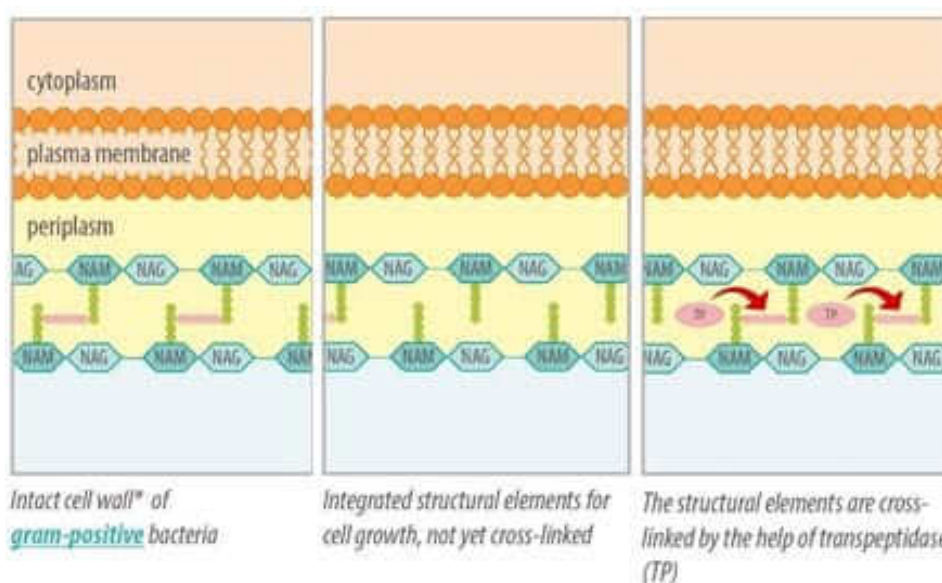
The group of  $\beta$ -lactam antibiotics consists of penicillins, cephalosporins, monobactams, and carbapenems. These antibiotics are characterised by their lactam ring (Figure 1).

Figure 1: An antibiotic with a  $\beta$ -lactam ring (in orange)



If bacteria are growing, the cell wall also has to grow. For this purpose existing conjunctions are cracked and new components are inserted. In order for the cell wall to remain a solid barrier, the new components must be interconnected by crosslinks. For the creation of these crosslinks an enzyme is essential, the transpeptidase (figure 2).

Figure 2: building up a stable cell wall with the help of transpeptidase

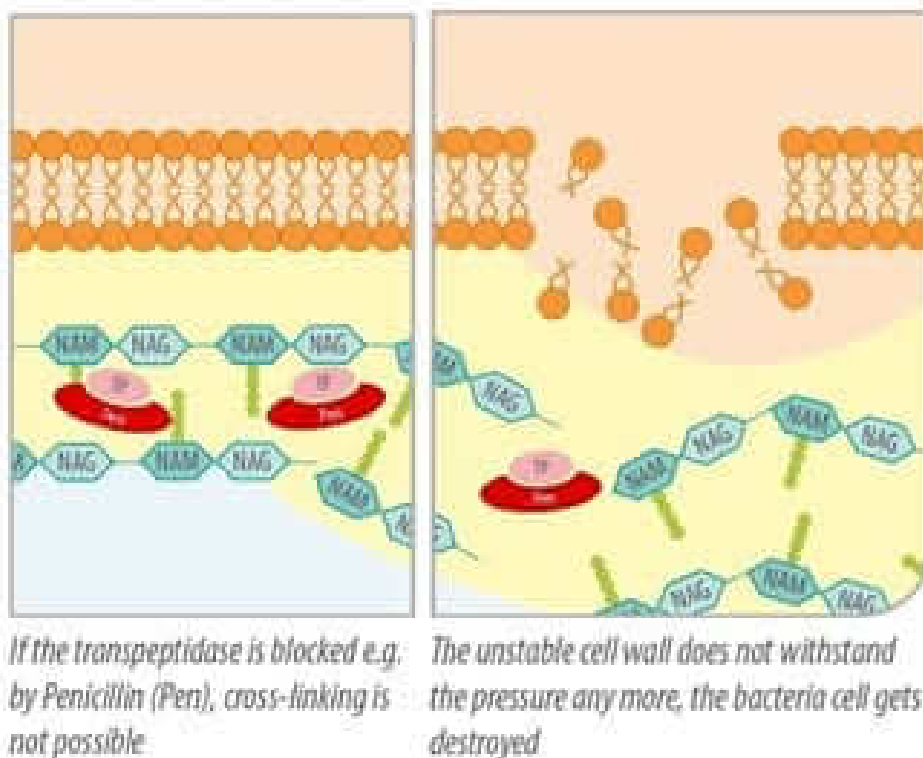


Due to their structure,  $\beta$ -lactam-antibiotics also fit as binding partner for transpeptidase. They bind to the enzyme and block it (Kohanski et al., 2010). The crosslinks cannot be created and the stabilization of the cell wall is prevented. Disturbance of cell wall stability leads to the death of the bacterial cell, hence  $\beta$ -



lactam antibiotics act bactericidal.

Figure 3: blocked by  $\beta$ -lactam antibiotics, transpeptidase cannot serve as enzyme for building the cell wall



## The challenge: *E. coli* producing $\beta$ -lactamases

Resistant bacteria, which are able to produce  $\beta$ -lactamases – enzymes that destroy the  $\beta$ -lactam ring – prevent their own destruction. Divers point mutations within the  $\beta$ -lactamase genes lead to the occurrence of “extended-spectrum-beta-lactamases” (ESBL). ESBL are able to inactivate most of the  $\beta$ -Lactam-antibiotics.

Another mutation leads to so-called AmpC (aminopenicillin and cephalosporin)  $\beta$ -lactamases. They enable the *E. coli* to express a resistance against penicillins, cephalosporins of the second and third generation as well as against cephamycins.

## Phytomolecules – an alternative?

One approach to reduce the use of antibiotics is the utilization of phytomolecules. These secondary metabolites are produced by plants to protect themselves from moulds, yeasts, bacteria and other harmful organisms.

The use of plants and their extracts in human and veterinary medicine is well-established for centuries. Besides digestive and antioxidant characteristics they are well known for their bacteriostatic and bactericidal effects.

Consisting of a high number of chemical compounds, they attack at diverse points and their antimicrobial effect is not caused by only one single specific mechanism. This is crucial because it is therefore very unlikely that bacteria can develop resistances to phytomolecules like they do to antibiotics.

## How phytomolecules work

Mostly, phytomolecules act at the cell wall and the cytoplasm membrane level. Sometimes they change the whole morphology of the cell. This mode of action has been studied extensively for thymol and

carvacrol, the major components of the oils of thyme and oregano.

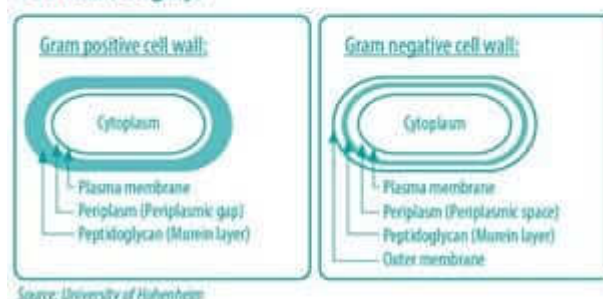
They are able to incorporate into the bacterial membrane and to disrupt its integrity. This increases the permeability of the cell membrane for ions and other small molecules such as the energy carrier ATP (Adenosin-tri-phosphate). It leads to the decrease of the electrochemical gradient above the cell membrane and to the loss of energy equivalents of the cell.

### A special challenge: gram-negative bacteria

Gram-negative bacteria such as *E. coli* and *Salmonella* pose a special challenge. The presence of lipopolysaccharides in the outer membrane (OM) provides the gram-negative bacteria with a hydrophilic surface ([Nikaido, 2003](#); [Nazarro et al., 2013](#)) (see also blue infobox).

**Gram-positive bacteria and gram-negative bacteria:**  
Bacteria differ in the construction of their cell walls. The Danish bacteriologist Hans Christian Gram (1853–1938) developed a colouring method to differentiate the bacteria. It is not possible to assign all bacteria to both groups. There are also gram-variable and gram-indefinite species.

#### Cell wall (roughly):



The cell wall therefore only allows the passage of small hydrophilic solutes and is a barrier against macromolecules and hydrophobic compounds such as hydrophobic antibiotics and toxic drugs. The bypassing of the OM therefore is a prerequisite for any solute to exert bactericidal activity toward gram-negative bacteria (Helander et al., 1998).

Based on their trial results Helander et al. (1998) (1998) concluded that trans-cinnamaldehyde and partly also thymol and carvacrol gain access to the periplasm and to the deeper parts of the cell. Nikaido (1996) also concluded that OM-traversing porin proteins allow the penetration of lipophilic probes at significant rates.

## Evaluating phytomolecules I - in vitro trial, Scotland

A trial conducted in Scotland evaluated the effects of Activo Liquid, a mixture of selected phytomolecules and citric acid, on ESBL-producing *E. coli* as well as on *E. coli* that generate AmpC.

### Material and methods

For the trial two strains for each group were isolated from the field, a non-resistant strain of *E. coli* served as control. Suspensions of the strains with  $1 \times 10^4$  CFU/ml were incubated for 6-7 h at 37°C (98.6°F) together with diverse concentrations of Activo Liquid or with cefotaxime, a cephalosporin. The cefotaxime group served as a control for differentiating resistant and non-resistant *E. coli*.

The suspensions were put on LB agar plates and bacteria colonies were counted after further 18-22h incubation at 37°C.

### Results

The antimicrobial efficacy of the blend of phytomolecules depended on the concentration at which they were used (see table 1). A bacteriostatic effect could be shown at dilutions up to 0.1 %, a bactericidal effect at higher concentrations.

Table 1: Effect of phytomolecules against resistant *E. coli* producing ESBL and AmpC in poultry

Poultry Microbiology Laboratory, Edinburgh, Scotland	Cefotaxime	Phytomolecules (Activo® Liquid)			
	30 µg / ml	0.1 %	0.2 %	0.4 %	0.5 %
<i>E. coli</i> ESBL 1 (Poultry)	-	+	++	++	++
<i>E. coli</i> ESBL 2 (Poultry)	-	+	++	++	++
<i>E. coli</i> AmpC 1 (Poultry)	-	+	++	++	++
<i>E. coli</i> AmpC 2 (Poultry)	-	++	++	++	++
<i>E. coli</i> non-resistant	+	+	++	++	++
- no effect + growth inhibiting (bacteriostatic) ++ bactericidal					

## Evaluating phytomolecules II - in vitro trial, Germany

A further trial was conducted in Germany (Vaxxinova, Münster), confirming the preceding results.

### Material and methods

Four ESBL producing *E. coli* all isolated from farms and a non-resistant reference strain as control were tested concerning their sensitivity against Activo Liquid. Every bacteria strain (Conc.:  $1 \times 10^4$  CFU/ml) was subjected to a bacterial inhibition assay in an appropriate medium at 37°C for 6-7 hours.

### Results

In this trial Activo Liquid also showed a dose-dependent efficacy, with no or just a bacteriostatic effect up to a concentration of 0.1 %, but bactericidal effects at a concentration of  $\geq 0.2$  % (table 2).

Table 2: Effect of phytomolecules against resistant ESBL producing *E. coli* in pig and in poultry

Vaxxinova GmbH, Münster	Phytomolecules (Activo® Liquid)			
	0.1 %	0.2 %	0.4 %	1 %
<i>E. coli</i> ATCC25922	+	++	++	++
<i>E. coli</i> ESBL 1 (Pig)	-	++	++	++
<i>E. coli</i> ESBL 2 (Pig)	+	++	++	++
<i>E. coli</i> ESBL 3 (Poultry)	+	++	++	++
<i>E. coli</i> ESBL 4 (Poultry)	-	++	++	++
- no effect + growth inhibiting (bacteriostatic) ++ bactericidal				

## Phytomolecules: a promising outlook

*E. coli* infections have devastating effects on animals, from diarrhea to edema, enterotoxic shock and even death. Antibiotic treatments have long been the only practicable answer. However, their excessive use– for instance, the metaphylactic application to thousands of animals in a flock– has led to the development of resistant strains. There is evidence that a reduction of antibiotic use reduces the occurrence of resistances ([Dutil et al., 2010](#)).

The results of the two in vitro trials in Scotland and Germany demonstrate the bactericidal effects of [phytomolecules](#) on *E. coli* that produce ESBL and AmpC. Using phytomolecules could thus reduce the use of antibiotics and therefore also the occurrence of AMR.

While it is theoretically possible for bacteria to also become resistant against phytomolecules, the probability of this happening is very low: unlike antibiotics, phytomolecules contain hundreds of chemical components with different modes of action. This makes it exceedingly difficult for bacteria to adapt and develop resistance. To tackle the problem of antibiotic-resistant *E. coli*, antimicrobial phytomolecules therefore offer a promising, sustainable and long-term solution.

By Dr. Inge Heinzl, Editor, EW Nutrition

---

### Literature

Dutil, Lucie, Rebecca Irwin, Rita Finley, Lai King Ng, Brent Avery, Patrick Boerlin, Anne-Marie Bourgault, Linda Cole, Danielle Daignault, Andrea Desruisseau, Walter Demczuk, Linda Hoang, Greg B. Horsman, Johanne Ismail, Frances Jamieson, Anne Maki, Ana Pacagnella, and Dylan R. Pillai. 2010. "Ceftiofur Resistance in *Salmonella enterica* Serovar Heidelberg from Chicken Meat and Humans, Canada." *Emerg Infect Dis* 16 (1): 48-54.

Helander, Ilkka M., Hanna-Leena Alakomi, Kyösti Latva-Kala, Tiina Mattila-Sandholm, Irene Pol, Eddy J. Smid, Leon G. M. Gorris, and Atte von Wright. 1998. "Characterization of the Action of Selected Essential Oil Components on Gram-Negative Bacteria." *J. Agric. Food Chem* 46: 3590-595.

Kohanski, Michael A., Daniel J. Dwyer, and James J. Collins. 2010. "How Antibiotics Kill Bacteria: From Targets to Networks." *Nature Reviews* 8: 423-435.

Nazarro, Filomena, Florinda Fratianni, Laura De Martino, Raffaele Coppola, and Vincenzo De Feo. 2013. "Effect of Essential Oils on Pathogenic Bacteria." *Pharmaceuticals* 6 (12): 1451-1474.

Nikaido, Hiroshi "Molecular Basis of Bacterial Outer Membrane Permeability Revisited. 2003. " *Microbiology and Molecular Biology Reviews*, 67 (4): 593-656.

Rodriguez, Tori. 2015 "Essential Oils Might Be the New Antibiotics." *The Atlantic*.

<http://www.theatlantic.com/health/archive/2015/01/the-new-antibiotics-might-be-essential-oils/384247/>

Rüben, Christiane. 2009. "Antimikrobielle Wirksamkeit von chemischen Einzelkomponenten ätherischer Öle gegenüber ausgewählten Lebensmittelverderbniserregern". PhD diss, TeHo Hannover.



---

# Phytomolecules: Boosting Poultry Performance without Antibiotics



Antimicrobial resistance (AMR) is a major threat to global public health. It is largely caused by the overuse of antibiotics in human medicine and agriculture. In intensive poultry production most antibiotics are used as antimicrobial growth promoters and/or used as prophylactic and metaphylactic treatments to healthy animals. Reducing such antibiotic interventions is crucial to lowering the incidence of AMR. However, antibiotic reduction often results in undesirable performance losses. Hence alternative solutions are needed to boost poultry performance. Phytomolecules have antimicrobial, digestive, anti-inflammatory and

antioxidant properties, which could make them key to closing the performance gap.

## Poultry performance depends on intestinal health

Poultry performance is to a large extent a function of intestinal health. The intestines process nutrients, electrolytes and water, produce mucin, secrete immunoglobulins and create a barrier against antigens and pathogens.

In addition, it is an important component of the body's immune defense system. The intestine has to identify pathogens and reject them, but also has to tolerate harmless and beneficial microorganisms. If the intestines do not function properly this can lead to food intolerance, dysbiosis, infections and diseases. All of these are detrimental to feed conversion and therefore also to animal performance.

Antibiotics reduce the number of microorganisms in the intestinal tract. From a performance point of view this has two benefits: first, the number of pathogens is reduced and therefore also the likelihood of diseases; second, bacteria are eliminated as competitors for the available nutrients. However, the overuse of antibiotics not only engenders AMR: antibiotics also eliminate probiotic bacteria, which negatively impacts the digestive tracts' microflora.

Products to boost poultry performance may be added to their feed or water. They range from pre- and probiotics to medium chain fatty acids and organic acids to plant extracts or phytomolecules. Especially the latter have the potential to substantially reduce the use of antibiotics in poultry farming.

## Phytomolecules are promising tools for antibiotic reduction

Plants produce phytomolecules to fend off pathogens such as moulds, yeasts and bacteria. Their antimicrobial effect is achieved through a variety of complex mechanisms. Terpenoids and phenols, for example, disturb or destroy the pathogens' cell wall. Other phytomolecules inhibit their growth by influencing their genetic material. Studies on broilers show that certain phytomolecules reduce the adhesion of pathogens such as to the wall of the intestine. Carvacrol and thymol were found to be effective against different species of *Salmonella* and *Clostridium perfringens*.

There is even evidence that secondary plant compounds also possess antimicrobial characteristics against antibiotic resistant pathogens. In-vitro trials with cinnamon oil, for example, showed antimicrobial effects against methicillin resistant *Staphylococcus aureus*, as well as against multiresistant *E. coli*, *Klebsiella pneumoniae* and *Candida albicans*.

Importantly, there are no known cases to date of bacteria developing resistances to phytomolecules. Moreover, phytomolecules increase the production and activity of digestive enzymes, they suppress the metabolism of pro-inflammatory prostaglandins and they act as antioxidants. Their properties thus make them a promising alternative to the non-therapeutic use of antibiotics.

## Study design and results

In order to evaluate the effect of phytomolecules on poultry performance, multiple feeding studies were conducted on broilers and laying hens. They were given a phytogenic premix ([Activo](#), EW Nutrition GmbH) that contains standardized amounts of selected phytomolecules.

To achieve thermal stability during the feed processing and a targeted release in the birds' [gastrointestinal tract](#), the product is microencapsulated. For each , the studies evaluated both the tolerance of the premix and the efficacy of different dosages.

### **Study I: Evaluation of the dose dependent efficacy and tolerance of Activo for broilers**

Animals: 400 broilers; age: 1-35 days of age

Feed: Basal starter and grower diets

Treatments:

- No supplement (negative control)
- 100 mg of Activo /kg of feed
- 1.000 mg of Activo /kg of feed
- 10.000 mg of Activo /kg of feed

Parameters: weight gain, feed intake, feed conversion ratio, health status, and blood parameters

**Results:** The trial group given the diet supplemented with 100 mg/kg [Activo](#) showed significant improvements in body weight gain during the starter period (+4%) compared to the control group. Additional significant improvements in feed conversion ratio (FCR) in the growing period (+4%) resulted in an overall improvement in FCR of 3%. At a 1.000 mg/kg supplementation, a significant improvement in FCR of 6% was observed over the entire feeding period. Hematological parameters were within the reference range of healthy birds when feeding up to 10,000 Activo/ kg of feed.

### ***Study II: Evaluation of the dose depending efficacy and tolerance of Activo for laying hens***

Animals: 200 hens; age: 20 to 43 weeks

Feed: basal diet for laying hens

Treatments:

- No supplement (negative control)

- 100 mg of Activo/ kg of feed

- 250 mg of Activo/ kg of feed

- 500 mg of Activo/ kg of feed

- 5.000 mg of Activo/ kg of feed

Parameters: weight gain, feed intake, feed conversion ratio, health status, and blood parameters

**Results:** Inclusion levels from 100 mg/kg of Activo onwards improved laying performance, egg mass and egg weight and reduced FCR compared to the control group. Results recorded for hematological parameters were within the reference range of healthy birds when feeding up to 5.000 mg Activo/ kg of feed.

### ***Study III: Evaluation of the dose-dependent effects of Activo for coccidiosis vaccinated broilers***

Animals: 960 broiler chickens; age: 42 days

Feed: Standard starter and finisher feed

Treatments:

- No supplement (negative control)

- 50 g of Activo /US ton of feed

- 100 g of Activo /US ton of feed

- 150 g of Activo /US ton of feed

- 200 g of Activo /US ton of feed

- 250 g of Activo /US ton of feed

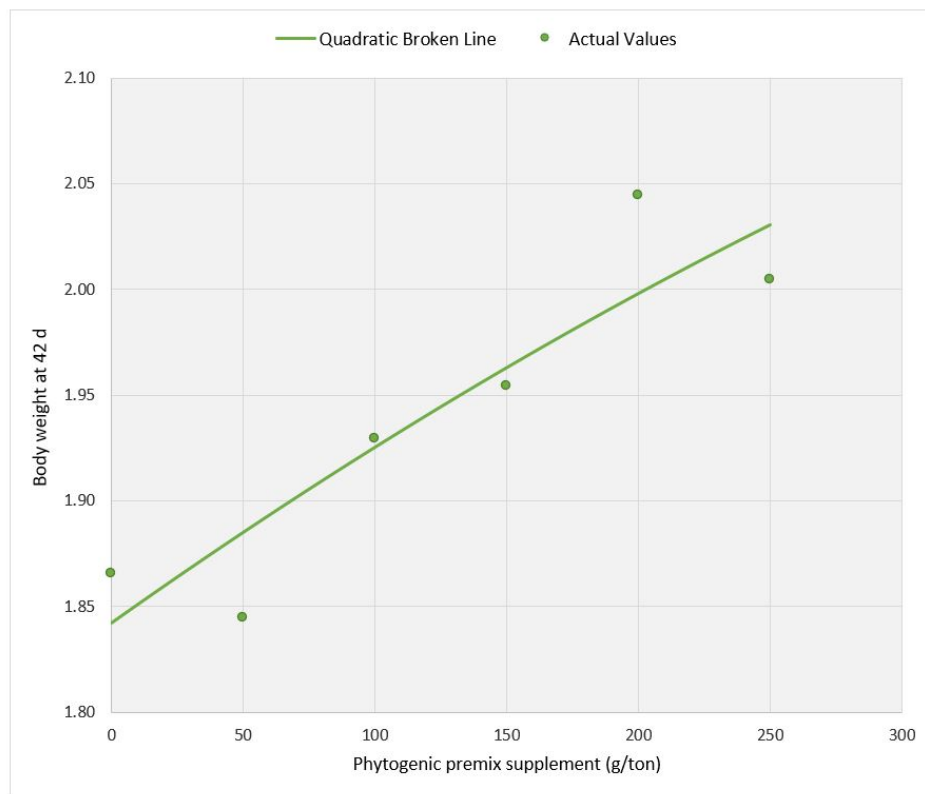
- Antibiotic growth promoter (AGP)(positive control)

Parameters: weight gain, feed efficiency

Specific: In order to represent field conditions, the birds were challenged with used, homogenized litter.

**Results:** A clear dose response for both body weight gain and feed efficiency was observed (see Figure 1): the more phytogenic premix given, the better the birds' performance. The group with 200g of Activo /US ton of feed showed similar performance levels than the positive control group supplemented with AGP.

*Figure 1: Dose-dependent effects of for coccidiosis vaccinated broilers*



#### **Study IV: Evaluation of the dose-dependent effects of Activo for laying hens**

Animals: 40 hens; age: week 20 to 43

Feed: basal diet for laying hens

Treatments:

- No supplement (negative control)
- 100 mg of Activo/ kg of feed
- 250 mg of Activo/ kg of feed
- 500 mg of Activo/ kg of feed
- 5.000 mg of Activo/ kg of feed

Parameters: weight gain, feed intake, egg production, feed conversion ratio, health status

Duration: 168 days of feeding period

**Results:** The laying hens showed a higher laying rate when fed with a higher concentration of phytomolecules (Figure 2). Similarly improved results were observed for the feed efficiency. The more phytogetic premix added to their diet the better feed efficiency (Figure 3).

*Figure 2: Dose-dependent effects of Activo on laying rate in laying hens*



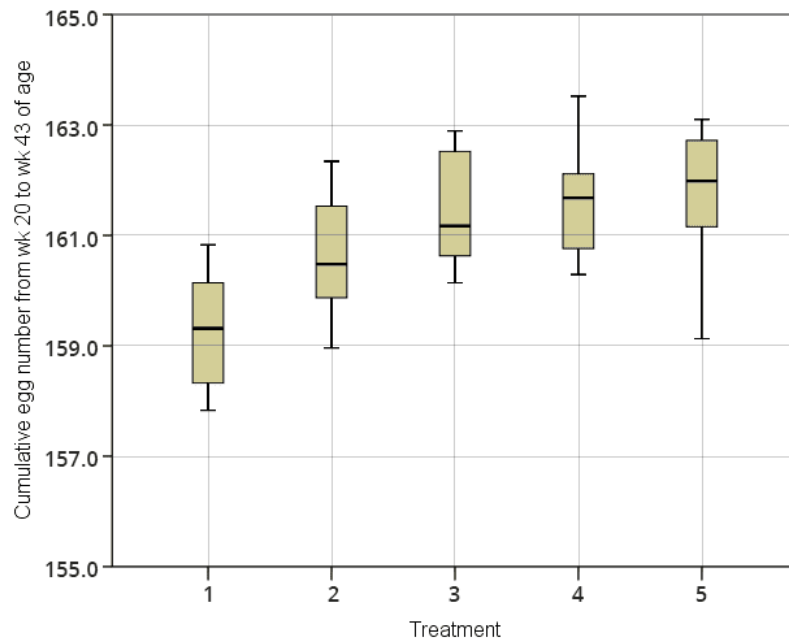
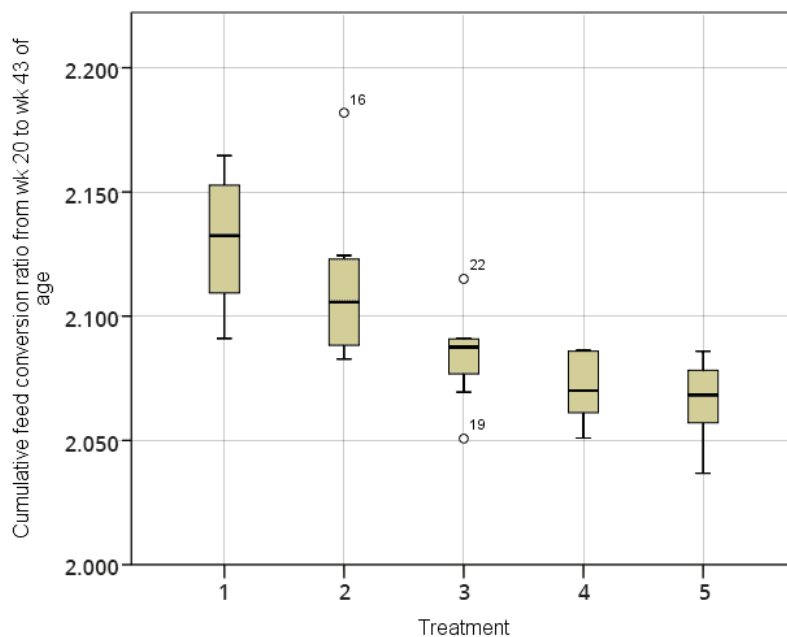


Figure 3: Dose-dependent effects of Activo on feed efficiency in laying hens



In conclusion, all four studies indicate that the inclusion of phytomolecules in broilers' and laying hens' diet improves their performance. Increasing levels of a phytogenic premix (Activo) significantly increased the production parameters for both groups. These improvements might bring performance in antibiotic-free [poultry production](#) on par with previous performance figures achieved with antimicrobial growth promoters.

The studies also showed that microencapsulated phytogenic premixes are safe when used in dose ranges recommended by the suppliers. No negative effects on animal health could be observed even at a 100 fold / 50 fold of the recommended inclusion rate in diets for broiler or laying hens, respectively. Thanks to their positive influence on intestinal health, phytomolecules thus boost poultry performance in a safe and effective way.

By Technical Team, EW Nutrition

## Literature

[Alanis, Alfonso J. "Resistance to Antibiotics: Are We in the Post-Antibiotic Era?" Archives of Medical Research 36, no. 6 \(October 08, 2005\): 697-705. doi:10.1016/j.arcmed.2005.06.009.](#)

[Borda-Molina, Daniel, Jana Seifert, and Amélia Camarinha-Silva. "Current Perspectives of the Chicken Gastrointestinal Tract and Its Microbiome." Computational and Structural Biotechnology Journal 16 \(March 15, 2018\): 131-39. doi:10.1016/j.csbj.2018.03.002.](#)

[Diaz-Sanchez, Sandra, Doris Dsouza, Debrabrata Biswas, and Irene Hanning. "Botanical Alternatives to Antibiotics for Use in Organic Poultry Production." Poultry Science 94, no. 6 \(June 2015\): 1419-430. doi:10.3382/ps/pev014.](#)

[Du, Encun, Weiwei Wang, Liping Gan, Zhui Li, Shuangshuang Guo, and Yuming Guo. "Effects of Thymol and Carvacrol Supplementation on Intestinal Integrity and Immune Responses of Broiler Chickens Challenged with Clostridium Perfringens." Journal of Animal Science and Biotechnology 7, no. 19 \(March 22, 2016\). doi:10.1186/s40104-016-0079-7.](#)

[Gao, Pengfei, Chen Ma, Zheng Sun, Lifeng Wang, Shi Huang, Xiaoquan Su, Jian Xu, and Heping Zhang. "Feed-additive Probiotics Accelerate Yet Antibiotics Delay Intestinal Microbiota Maturation in Broiler Chicken." Microbiome 5, no. 1 \(August 03, 2017\). doi:10.1186/s40168-017-0315-1.](#)

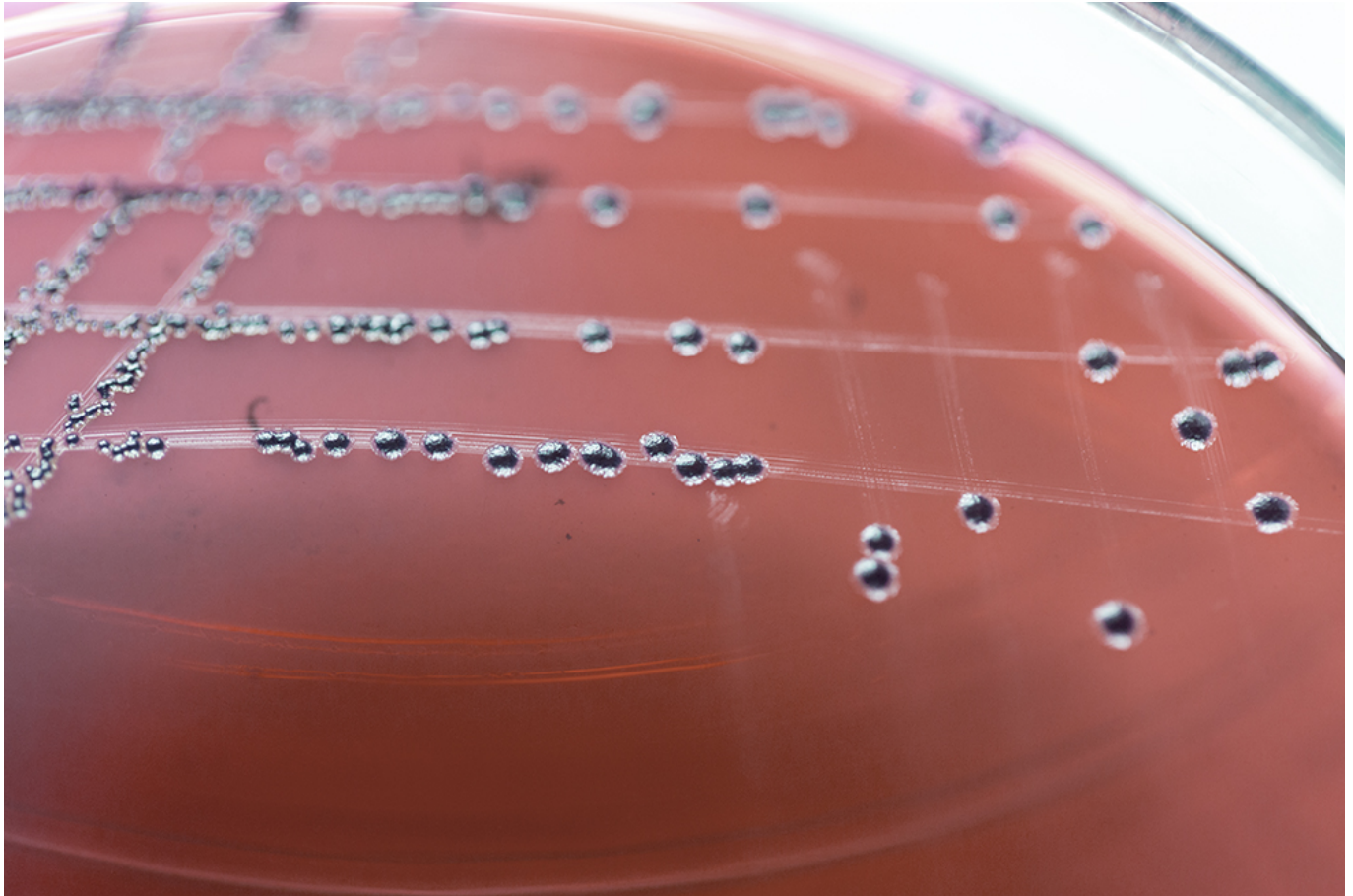
[Khan, Rosina, Barira Islam, Mohd Akram, Shazi Shakil, Anis Ahmad Ahmad, S. Manazir Ali, Mashiatullah Siddiqui, and Asad Khan. "Antimicrobial Activity of Five Herbal Extracts Against Multi Drug Resistant \(MDR\) Strains of Bacteria and Fungus of Clinical Origin." Molecules 14, no. 2 \(February 04, 2009\): 586-97. doi:10.3390/molecules14020586.](#)

[Manafi, Milad, Mahdi Hedayati, Saeed Khalaji, and Mohammad Kamely. "Assessment of a Natural, Non-antibiotic Blend on Performance, Blood Biochemistry, Intestinal Microflora, and Morphology of Broilers Challenged with Escherichia Coli." Revista Brasileira De Zootecnia 45, no. 12 \(December 2016\): 745-54. doi:10.1590/s1806-92902016001200003.](#)

Photo source: [Aviagen](#)

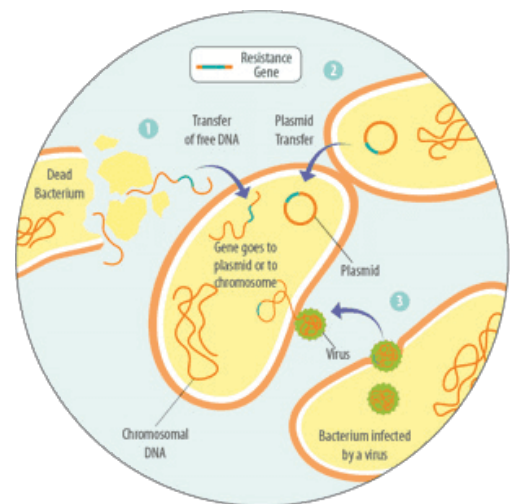
---

# Secondary Plant Compounds (SPC's) to reduce the use of antibiotics?



**Initial in vitro trials give reason for hope**

## **Antibiotic Resistance**



Some bacteria, due to mutations, are less sensitive to certain antibiotics than others. This means that if certain antibiotics are used, the insensitive ones survive. Because their competitors have been eliminated, they are able to reproduce better. This resistance can be transferred to daughter cells by means of „resistance genes“. Other possibilities are the intake of free DNA and therefore these resistance genes from dead bacteria 1, through a transfer of these resistance genes by viruses 2 or from other bacteria by means of horizontal gene transfer 3 (see figure 1). Every application of antibiotics causes a selection of resistant bacteria. A short-term use or an application at a low dosage will give the bacteria a better chance to adapt, promoting the generation of resistance (Levy, 1998).

### **Antibiotics are promoting the development of resistance:**

- Pathogenic bacteria possessing resistance genes are conserved and competitors that do not

- possess these genes are killed
- Useful bacteria possessing the resistance genes are conserved and serve as a gene pool of antibiotic resistance for others
- Useful bacteria without resistance, which probably could keep the pathogens under control, are killed

### Reducing the use of antibiotics

Ingredients from herbs and spices have been used for centuries in human medicine and are now also used in modern animal husbandry. Many SPC's have antimicrobial characteristics, e.g. Carvacrol and Cinnamon aldehyde. They effectively act against *Salmonella*, *E. coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, Enter- and *Staphylococcus*, and *Candida albicans*. Some compounds influence digestion, others act as antioxidants. Comprehensive knowledge about the single ingredients, their possible negative but also positive interaction (synergies) is essential for developing solutions. Granulated or microencapsulated products are suitable for addition to feed, liquid products would be more appropriate for an immediate application in the waterline in acute situations.

	(Activo* Liquid)		
	10%	2%	1%
Central Poultry Diagnostic Laboratory, Kondapur, Hyderabad (India)			
<i>E. coli</i> (reference strains)	++	+	+
<i>Proteus vulgaris</i> (reference strains)	+	+	+
<i>Pseudomonas fluorescens</i>	++	+	-
<i>Salmonella pulmorum</i>	++	++	+
<i>Salmonella gallinarum</i>	++	++	+
<i>Staphylococcus aureus</i> (reference strains)	+++	++	++
+++	22 – 29 mm ZOI (zone of inhibition)		
++	15 – 21 mm ZOI		
+	10 – 14 mm ZOI		
-	< 10 mm ZOI		

### SPC's (Activo Liquid) against livestock pathogens in vitro

In "agar diffusion tests", the sensitivity of different strains of farm-specific pathogens was evaluated with different concentrations of Activo Liquid. The effectiveness was determined by the extent to which they prevented the development of bacterial overgrowth. The larger the bacteria-free zone, the higher the antimicrobial effect.

In this trial, Activo Liquid showed an antimicrobial effect on all bacteria tested. The degree of growth inhibition positively correlated with its concentration.

Table 1: Inhibition of field isolated standard pathogens by different concentrations of Activo Liquid



## Activo Liquid against antibiotic resistant field pathogens in vitro

It cannot be excluded that resistant pathogens not only acquired effective weapons to render antibiotics harmless to them but also developed general mechanisms to rid themselves of otherwise harmful substances. In a follow-up laboratory trial, we evaluated whether the Activo Liquid composition is as effective against ESBL producing *E. coli* and Methicillin resistant *S. aureus* (MRSA) as to non-resistant members of the same species.

Laboratory: Vaxxinova, Muenster, Germany	SPC's (Activo® Liquid)			
	0.1%	0.2%	0.4%	1%
<i>E.coli</i> reference ATCC25922	+	++	++	++
ESBL 1 (Pig)	-	++	++	++
ESBL 2 (Pig)	+	++	++	++
ESBL 3 (Poultry)	+	++	++	++
ESBL 4 (Poultry)	-	++	++	++
<i>S. aureus</i> reference ATCC29213	-	+	+	++
MRSA 1 (Pig)	-	+	+	++
MRSA 2 (Pig)	-	+	+	++

- no effect  
+ growth inhibiting  
++ bactericide

Trial Design: Farm isolates of four ESBL producing *E. coli* and two MRSA strains were compared to nonresistant reference strains of the same species with respect to their sensitivity against Activo Liquid. In a Minimal Inhibitory Concentration Assay (MIC) under approved experimental conditions (Vaxxinova Diagnostic, Muenster, Germany) the antimicrobial efficacy of Activo Liquid in different concentrations was evaluated.

The efficacy of SPC's (Activo Liquid) against the tested strains could be demonstrated in a concentration-dependent manner with antimicrobial impact at higher concentrations and bacteriostatic efficacy in dilutions up to 0,1% (ESBL) and 0,2% (MRSA)(table 2).

### Conclusion:

To contain the emergence and spread of newly formed resistance mechanisms it is of vital importance to reduce the use of antibiotics. SPC's are a possibility to [decrease antibiotic use](#) especially in pro- and metaphylaxis, as [they show good efficacy against the common pathogens](#) found in poultry, even against resistant ones.

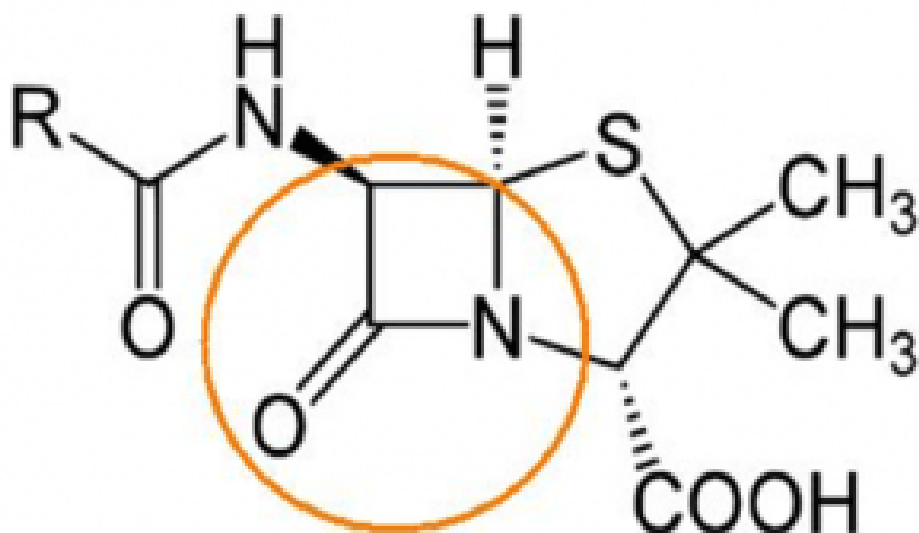
# Secondary plant compounds against antibiotic-resistant *E. coli*



Due to incorrect therapeutic or preventive use of antibiotics in animal production as well as in human medicine, occurrence of antibiotic resistant pathogens has become a widespread problem. Enterobacteria in particular (e.g. *Salmonella*, *Klebsiella*, *E. coli*) possess a special mechanism of resistance. By producing special enzymes ( $\beta$ -lactamases), they are able to withstand the attack of so-called  $\beta$ -lactam antibiotics. The genes for this ability (resistance genes) can also be transferred to other bacteria resulting in a continuously increasing problem. Divers point mutations within the  $\beta$ -lactamase genes lead to the occurrence of „Extended-Spectrum-Beta-Lactamases“ (ESBL), which are able to hydrolyse most of the  $\beta$ -Lactam-antibiotics. AmpC Beta-Lactamases (AmpC) are enzymes, which express a resistance against penicillins, cephalosporins of the second and third generation as well as cephamycins.

## **What are $\beta$ -lactam antibiotics?**

The group of  $\beta$ -lactam antibiotics consists of penicillins, cephalosporins, monobactams and carbapenems. A characteristic of these antibiotics is the lactam ring (marked in orange):

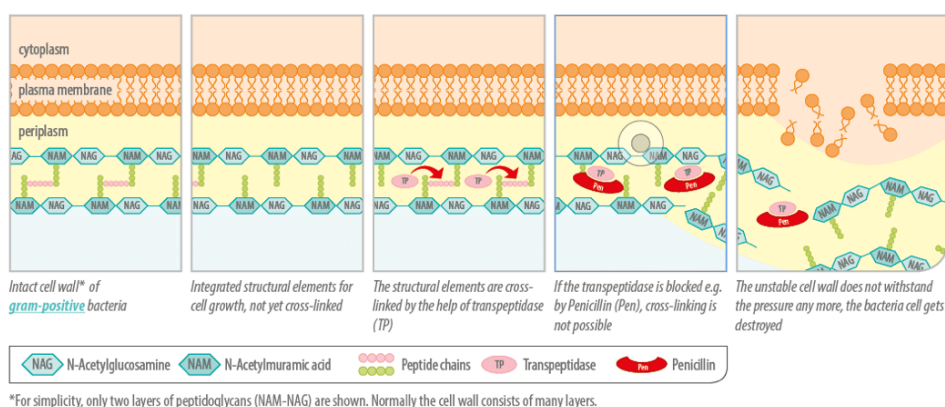


### Mode of action of $\beta$ -lactam antibiotic

If a bacterial cell is growing, the cell wall also has to grow. For this purpose, existing conjunctions are cracked and new components are inserted.  $\beta$ -lactam-antibiotics disturb the process of cell wall construction by blocking an enzyme needed, the transpeptidase. If crosslinks necessary for the stability of the cell wall cannot be created, the bacteria cannot survive. Resistant bacteria, which are able to produce  $\beta$ -lactamases, destroy the  $\beta$ -lactam antibiotics and prevent their own destruction.

### Secondary plant compounds

[Secondary plant compounds and their components](#) are able to prevent or slow down the growth of moulds, yeasts, viruses and bacteria. They attack at various sites, particularly the membrane and the cytoplasm. Sometimes they change the whole morphology of the cell. In the case of gram-negative bacteria, secondary plant compounds (hydrophobic) have to be mixed with an emulsifier so that they can pass the cell wall which is open only for small hydrophilic solutes. [The modes of action of secondary plant compounds](#) depend on their chemical composition. It also depends on whether single substances or blends (with possible positive or negative synergies) are used. It has been observed that extracts of spices have a lower antimicrobial efficacy than the entire spice.



The best explained mode of action is the one of thymol and carvacrol, the major components of the oils of thyme and oregano. They are able to incorporate into the bacterial membrane and to disrupt its integrity. This increases the permeability of the cell membrane for ions and other small molecules such as ATP leading to the decrease of the electrochemical gradient above the cell membrane and to the loss of energy equivalents of the cell.

### Trial (Scotland)

Design



Two strains of ESBL-producing and AmpC respectively, isolated from the field, a non-resistant strain of *E. coli* as control. Suspensions of the strains with  $1 \times 10^4$  KBE/ml were incubated for 6-7 h at 37°C together with different concentrations of [Activo Liquid](#) or with cefotaxime, a cephalosporin. The suspensions were then put on LB-Agar plates and bacteria colonies were counted after a further 18-22h incubation at 37°C. Evaluation of the effects of Activo Liquid on ESBL-producing as well as on *E. coli* resistant for aminopenicillin and cephalosporin (AmpC)

#### *Results*

The antimicrobial efficacy of the blend of secondary plant compounds depended on concentration with bactericidal effect at higher concentrations and bacteriostatic at dilutions up to 0,1%. It is also possible that bacteria could develop a resistance to secondary plant compounds; the probability is however relatively low, due to the fact that essential oils contain hundreds of chemical components (more than antibiotics) making it difficult for bacteria to adapt.

---

## Phytogenics can positively influence the efficacy of antibiotics





Many veterinary antibiotics are applied via the waterline, [where they are dosed in combination with other feed additives](#). Amongst those are mixtures of secondary plant compounds with a proven antimicrobial efficacy against veterinary pathogenic bacteria. However, little research has been done to evaluate any effect that antibiotics and phytochemicals may have on each other. A possible influence of phytochemicals on the efficacy of antibiotics through the combined administration would require a change in application recommendations of antibiotics and phytochemical feed additives. In the case of no interaction, no changes would be necessary. If they were to interact in a positive way, the dosages could be lowered and if they interact in a negative way, a combined application would be avoided.

### **Antibiotics and SPC's in co-incubation**

There are different groups of antibiotics depending on the chemical structure and on the pathogen they target. Some impair the cell wall or the cytoplasmic membrane (polymyxins,  $\beta$ -lactam antibiotics) and some affect protein synthesis (macrolides, Chloramphenicol, Lincospectin, tetracyclines, aminoglycosides). Others compromise DNA and RNA synthesis (fluorquinolones, ansamycines) and some disturb the metabolism of e.g. folic acid (Trimethoprim).

The intention of a trial with these different groups of antibiotics was to evaluate possible interactions they may have with a combination of secondary plant compounds. Four ESBL producing *E. coli* field isolates from poultry flocks were experimentally assessed as well as a  $\beta$ -lactamase positive and a  $\beta$ -lactamase negative reference strain as quality control strains for antimicrobial susceptibility testing.

Two-fold serial dilutions of antibiotics and the liquid product based on secondary plant compounds were co-incubated in a checkerboard assay. The highest concentration of the antibiotic was chosen according to CLSI standard recommendations. The control of the serial dilution of SPC's was made without antibiotics and vice versa.

### **Lowering the antibiotic dosage by the use of SPC's**

In the experiment all field isolates proved resistant against the  $\beta$ -lactam antibiotics, two field isolates and one reference strain were resistant against tetracyclines and macrolides and one field isolate and one reference strain against aminoglycosides.

The results showed that there was no negative influence of the antibiotics on the SPC's and vice versa. Moreover, for several classes of antibiotics an additive to synergistic effect was observed to such an extent that an antibiotic effect could be achieved with half or even one quarter of the former effective dosage. The dosage of the SPC-mixture could also be reduced. Based on the results of this *in vitro* experiment it can be stated that in the case of antibiotic resistance, the option exists to apply a phytochemical product with broad antimicrobial efficacy. Even more, for most combinations between antibiotics and [Activo Liquid](#), a defined mixture of secondary plant compounds, their combined use potentiates the individual efficacy of either compound class against *E.coli* strains *in vitro*. This adds further benefits to the improvements in animal performance and health, for which a number of [phytochemical feed additives have already proven effective](#).