Understanding and managing Strep suis in swine: The essentials

Strep suis **causes vast losses in pig production and threatens human health, too. We still rely on antibiotics to control it – but we will have to change tactics to contain antimicrobial resistance.**

Streptococcus suis is one of the most economically harmful pathogens for the global swine industry. When I started working in pig production 25 years ago, *S. suis* was already a problem on practically all the farms that I visited. Back then, our understanding of the pathogen and hence our control strategies were rudimentary: in farrowing rooms, we cut piglets' teeth, used gentian violet spray on their navels, and sometimes applied penicillin lyophilized with iron. For the nursery phase, we only had penicillin or phenoxymethylpenicillin at our disposal – until the first amoxicillin-based premixes arrived, which turned out to be highly effective.

To this day, we control *S. suis* mainly through oral beta-lactam antibiotics (in feed or water) or injectable solutions, administered to piglets at an early age. However, pig production has evolved dramatically over the past decades, and so has the scientific research on this complex pathogen. Crucially, we now know that the excessive use of antibiotics contributes to the development of antimicrobial resistance.

Recent Australian research has discovered *S. suis* strains (both in humans and pigs) with a high degree of resistance to macrolides or tetracyclines, strains with intermediate sensitivity to Florfenicol, and others that are developing resistance to penicillin G. Additionally, we now know that *S. suis* is a zoonotic bacteria that affects not only at-risk farm or slaughterhouse personnel: *S. suis* is among the leading causes of death from meningitis in countries such as Thailand, China or Vietnam. In light of these threats to human health, we in the swine industry more than ever have a duty to help control this pathogen.

This article first reviews our current state of knowledge about the epidemiology and pathogenesis of *Strep suis*; it then lays out virulence factors and the role of coinfections. The second part considers the dimensions of a holistic approach to *S. suis* prevention and control and highlights the central role of intestinal health management.

What we know about *S. suis* epidemiology and pathogenesis

Practically all farms worldwide have carrier animals, but the percentage of animals colonized "intra-farm" varies between 40 and 80%, depending on several factors such as environmental conditions, hygiene measures, and the virulence of the *S. suis* strains involved.

How *S. suis* strains are classified

S. suis strains were once classified into 35 serotypes, according to their different *capsular polysaccharides*(*CPS*), *the*outermost layer of *the* bacterial cell. Due to phylogenic and genomic sequencing, some of the old serotypes (20, 22, 26, 32, 33, and 34) are now reclassified, either in other bacterial genera or in other *Streptococcus* species. This has reduced the total to 29 *S. suis* serotypes.

Globally, the prevalence of the disease varies between 3% and 30%. The main serotypes affecting pig population are type 2 (28%), 9 (20%), and 3 (16%); differences in the geographical distribution are shown in Figure 1.

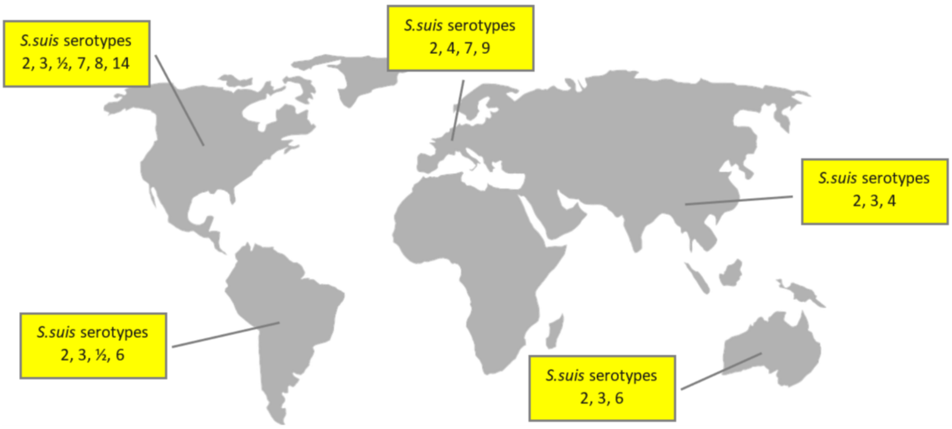


Figure 1: Global distribution of S. suis serotypes
Based on different sources, incl. [Goyette-Desjardins et al. (2014)](), [Zimmermann et al. (2019)](), and [Gebhart (2019)]()

In addition to the serotype classification based on CPS antigens, *S. suis* has also been genetically differentiated into “sequence types” using the MLST (Multi Locus Sequence Typing) technique. The distribution of both porcine and human sequence types is detailed in Figure 2.

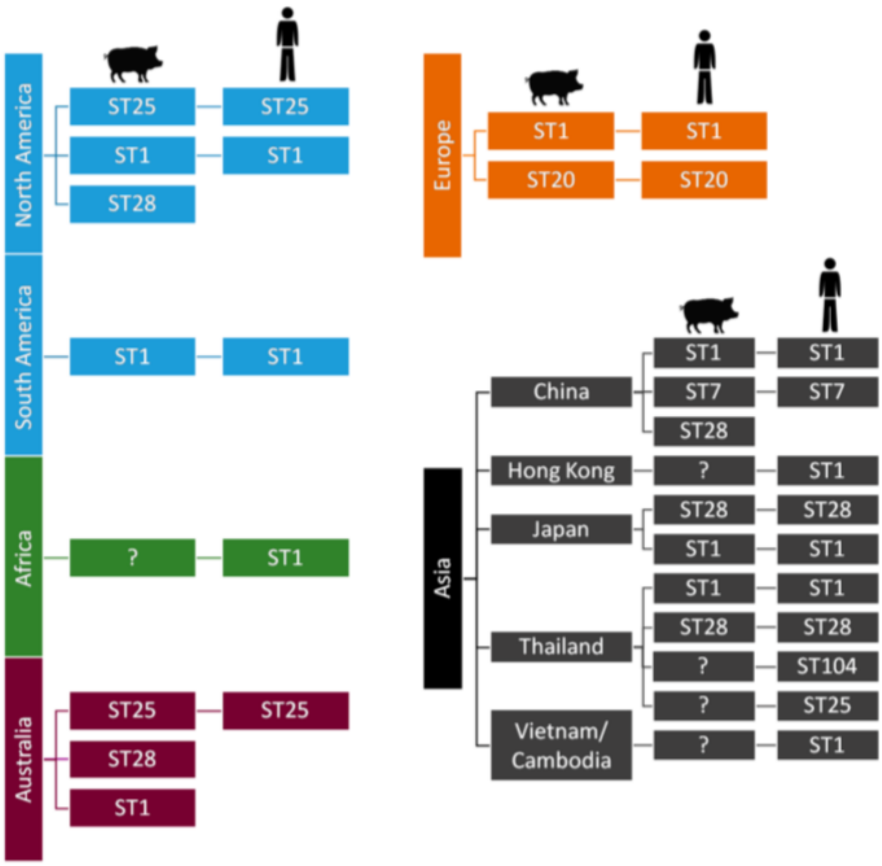


Figure 2: S. suis sequence types and their worldwide distribution

How *S. suis* is transmitted in swine

The main transmission routes are, firstly, the vertical sow-piglet route; the mucosa of the vagina is the first point of contamination. In the farrowing room, respiratory transmission from the sow to the piglets takes place. Horizontal transmission between piglets has also been proven to occur, especially during outbreaks in the post-weaning phase. This form of transmission happens through aerosols, feces, and saliva.

While in humans, the possibility of infection via the digestive tract has been confirmed, there are discussions about this route for swine. De Greeff et al. (2020) argue, based on *in vitro* and *in vivo* data, that infection through the digestive tract is associated with specific serotypes. Serotype 9, for example, would have a greater capacity for colonizing the gastrointestinal tract, and from there, the bacteria's translocation takes place. The same authors point out that, in Western Europe, *S. suis* serotype 9 has become one of the most prevalent serotypes in recent years.

How *S. suis* colonization occurs

Although there are still unknown mechanisms in the pathogenesis of the disease, it can be schematically summarized how colonization occurs (Figure 3). From the different infection routes, the pathogen always passes through the mucosa. When *S. suis* enter the bloodstream, it can lead to a systemic infection, ending in septicemia, meningitis, endocarditis, or pneumonia, or a local infection at the joints level, causing arthritis.

According to Haas and Grenier (2018), different pathogenicity factors intervene in each of the processes. The CPS, for example, are relevant during colonization and the initial progression (indicated by black arrows). Microvesicles released by *S. suis* cell membranes are more involved in the passage to the bloodstream or, for example, the progression towards local or systemic infection (indicated by white arrows).

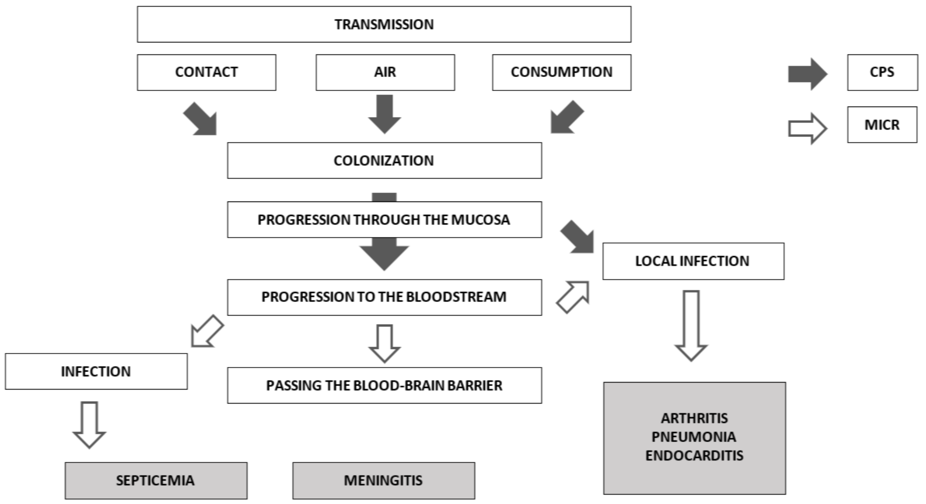


Figure 3: Pathogenesis of S. suis infection
Source: based on Haas and Grenier (2018)

Depending on the host and the immune response, the well-known clinical signs of the disease will occur. Although they may begin in the lactation phase, the highest prevalence of meningitis (the main clinical symptom) usually occurs between the 5th and the 10th week of life, that is, between two and three weeks after weaning.

How to diagnose *S. suis* infection

Diagnosing *S. suis* is relatively simple at a clinical level; however, we need to know how to differentiate it from *G. parasuis* in the case of animals with nervous symptoms. We also need to distinguish *S. suis* from other pathogens responsible for producing arthritis, such as *M. hyosynoviae* or the fibrin-producing agent *M. hyorhinis*.

Laboratory techniques are developing on two fronts. Among molecular techniques, multilocus sequence typing (MLST) is considered the gold standard for serotyping. It is still costly and not yet practicable for large samples at the farm level. In contrast, several types of polymerase chain reaction (PCR) show greater practical applicability. Quantitative PCRs (qPCR) are used for the evaluation of bacterial load, and some PCRs are based on the identification of specific virulence genes.

Due to the relevance of *S. suis* for human health, more complex techniques are also available, such as the complete sequencing of the bacterial genome. This type of method aims to develop epidemiological analyzes together with the differentiation between virulent and non-virulent *S. suis* strains. Research is also underway in serology, particularly on evaluating maternal immunity and its interference with the piglet, as well as autogenous vaccines monitoring.

Why *S. suis* sometimes causes disease: Virulence factors and coinfections

Streptococcus suis is a pathobiont, i.e., a microorganism that belongs to the commensal flora of animals but generates disease under certain conditions. In their daily work on farms, clinical veterinarians, for instance, find that *S. suis* often colonizes the upper respiratory tract, nasal cavity, and tonsils without causing disease. *S. suis* pathogenicity is associated with an astounding range of different circumstances or triggering factors; some sources list more than 100 virulence factors. Several factors are considered essential in the development of pathogenesis; others, however, are the subject of ongoing research (cf. Xia et al., 2019, and Segura et al., 2017).

Critical virulence factors

- One of the most important proteins is the CPS that establishes serotypes. The CPS largely determines the bacteria’s adhesion and colonization behavior. It can modify its thickness depending on the stage: it becomes thinner when adhering to the mucociliary apparatus and thicker when circulating through the bloodstream, protecting the bacteria against possible attacks by immune system cells.
- Likewise, *suis* has an adhesin known as Protection Factor H (FHB) that protects it from phagocytosis by macrophages and can also interfere with the complement activation pathways of the immune system.
- Suilysin is one of the most critical *suis*‘ protein toxins. This toxin plays a fundamental role in the interaction with host cells (modulating them to facilitate invasion and replication within the host cells) as well as in the inflammatory response.
- *S. suis* is a mucosal pathogen and, hence, triggers a mucosal immunity response, mainly by immunoglobulins A (IgA). *S. suis* has developed proteases capable of destroying both IgA and IgG.
- Research is still in progress, but both *suis* serotype 2 and 9 encode the development of adhesion proteins that facilitate mucociliary colonization when salivary glycoproteins are present (these are called antigens 1 and 2).
- Other than Suilysin, two of the bacteria’s protein components that have been studied in-depth to develop subunit vaccines are the MRP (Muramidase Release Protein) and EF (Extracellular Factor) protein. Whether the expression of these proteins is associated with virulence depends on the serotype.
- Recent research indicates that greater biofilm production capacity is associated with the more virulent *suis* strains. The production of biofilm is closely related to the production of fibrinogen, which allows the bacteria to develop resistance to the action of antimicrobials, to colonize tissues, to evade the immune system, etc.

Concomitant factors for *S. suis* infection

Even though *S. suis* is a primary pathogen that can cause disease by itself, many factors can exert a direct or indirect influence on whether or not and to which extent disease develops.

Veterinarians and producers are well aware of the influence of environmental and management factors such as temperature variations, poor ventilation together with poor air quality, irritants for the respiratory tract, as well as correct densities for animals' welfare. Occasionally, depending on the geographical location, *S. suis* can be considered as a seasonal pathogen, showing a higher prevalence during the coldest months of the year when ventilation is lower or not well-controlled.

At the level of the individual animal, concomitant pathogens, environmental changes, diet changes, previous pathologies, piglet handling problems, etc., all come into play. Younger piglets tend to be more susceptible because of the decrease in maternal immunity or insufficient colostrum intake; diarrhea during the lactation phase also increases disease vulnerability.

Recently, researchers have started to explore the hypothesis that a change in the digestive tract microbiome balance may favor a pathogenic trajectory. Some results indicate that changes in the microbiota around the moment of weaning could indeed trigger disease. I will return to the vital topic of the digestive tract in *S. suis* pathogenesis below.

The role of coinfections

The virulence of *S. suis* can increase in the presence of other pathogens, both viral and bacterial. Among the main viruses, key interactants are the PRRS virus, the influenza virus (SIV), as well as Porcine Circovirus (PCV) and Porcine Respiratory Coronavirus (PRCV). At the bacterial level, *Bordetella bronchiseptica* and *Glaesserella parasuis* have the most direct interaction with *S. suis* (Brockmeier, 2020).

There are several mechanisms by which coinfections might increase S. suis virulence: some of them (i.e., *B. bronchiseptica* and SIV) alter the epithelial barrier, facilitating the translocation of *S. suis*. Moreover, viruses such as PRRS either cause an alteration in the response of the immune system or destroy relevant immune system cells.

Valentin-Weigand et al. (2020) posit that the influenza virus increases the pathogenic capacity of *S. sui*s so that, for specific strains, the disease can develop even in the absence of the key virulence factor suilysin. This highlights the importance of controlling coinfections for successful *S. suis* management.

The five pillars of holistic *S. suis* management in swine

The challenge of managing this problematic pathogen with limited use of antibiotics prompts a review of all strategies within our reach. From birth to slaughterhouse, interventions must be coordinated and cannot work independently.

1. Biosecurity

The principles of biosecurity are easily understood. Yet, across different locations and production systems, farms struggle with consistently executing biosecurity protocols. For the moment, it appears unrealistic to avoid the introduction of new *S. suis* strains altogether. Also, complete eradication is not feasible with the currently available tools.

Genetic companies and research centers will likely continue to explore how to reduce bacterial colonization in animals, to produce piglets that have no or only minimal *S. suis* populations. Again, this option is not available for now.

At the farm level, the most promising and feasible approach is to reduce the risk of bacterial transmission, i.e., to optimize internal biosecurity. This extends to controlling both viral and bacterial coinfections. The two major viruses affecting the nursery stage are the PRRS virus and Swine Influenza virus. Bacteria that can contribute to the disintegration of the mucosa, both at the respiratory level and the digestive level, are

Atrophic Rhinitis (progressive or not) and digestive pathogens such as *E. coli*, Rotavirus and *Eimeria suis*. All possible measures to reduce the prevalence and spread of these co-infectants must be executed to help control *S. suis*.

2. The pre-weaning period

We need to consider several elements in the first hours after birth that influence the spread of the bacteria in the farrowing rooms:

- How is the colostrum distribution between the litters and the subsequent distribution of the piglets carried out?
- How is the "processing" of the piglets carried out after farrowing: iron administration, wound management, and tail docking?
- Are we taking any measure to prevent iatrogenic transmission of pathogens through needle exchange?

Until today, it is common practice to administer systemic (in-feed) or local (vaginally applied) antibiotics during the pre-weaning phase, albeit with partial or inconsistent successes in terms of reducing infection pressure. Notably, during the pre-weaning phase, the development of the piglet's microbiota begins to take shape, and the systematic and prophylactic application of antibiotics in young animals can reduce bacterial diversity of the microbiome (Correa-Fiz et al., 2019). This, in turn, leads to a proliferation of bacteria with a pathogenic profile that could detrimentally influence subsequent pathology.

S. suis is an ultra-early colonizer; piglets can get infected already at birth

3. The post-weaning period

The post-weaning period undoubtedly constitutes the most critical stage of the piglets' first weeks of life. In addition to social and nutritional stress, piglets are exposed to new pathogens. While maternal immunity is decreasing, piglets have not developed innate immunity yet; they are now most susceptible to the horizontal transmission of diseases. Hence, *S. suis* prevention during this phase center on measures that improve piglet quality. Key parameters include:

- Do we have a correct and homogeneous weight/age ratio at weaning?

- What is the level of anorexia in piglets? Do we practice suitable corrective measures to encourage the consumption of post-weaning feed?
- How are we feeding them? What medications do they routinely receive?
- How are housing facilities set up concerning density, environment, and hygiene?

Again, gut health is critical: Ferrando and Schultsz (2016) suggest that the status of the piglet's weaning gastrointestinal tract centrally influences the subsequent development of the disease. Their research supports the idea that some specific *S. suis* serotypes can develop their pathogenesis from the digestive tract, just as in human medicine. While in humans, this digestive route is associated with the consumption of raw or insufficiently processed pork, in swine, the most susceptible moments are sudden changes in diet. The transition from milk to solid feed, in particular, leads to an increase in alpha-glucans that favor bacteria proliferation. Likewise, an increase in susceptibility occurs when the integrity of the intestinal wall is lost, for example, due to viral and bacterial coinfections.

4. Treatments and vaccination

Since weaning is such a difficult phase for the life of the piglet, it is a common practice on farms across the world to include one or several antibiotics in the post-weaning phase. Sometimes, when the legal framework allows, producers use a systematic antibiotic (i.e., beta-lactams or tetracyclines) and another one with a digestive profile (e.g., pharmacological doses of ZnO, trimethoprim, sulfa drugs and derivatives).

While antibiotics, for the most part, effectively prevent infection in the post-weaning phase, they can have adverse effects on the digestive tract. According to Zeineldin, Aldrige, and Lowe (2019), continued antibiotics use:

- might increase the susceptibility to other infections because of the imbalance of the microbiome,
- the immune system might be weakened, together with an alteration in metabolism,
- and it fosters a greater accumulation of bacteria that are resistant to antibiotics.

The effectiveness of curative antibiotics treatments varies considerably. In any case, early detection is critical; affected animals need to be isolated and provided with a comfortable environment. Therapeutic parenteral antibiotics are best combined with high-dose corticosteroids. Some sick animals are unable to stand or walk. As a complementary measure, it is recommended, where possible, to help them ingest some feed and water.

Much research attention is focused on finding suitable vaccines to control the disease. This is a challenging task: *S. suis* shows high genetic diversity, making the identification of common proteins difficult, and is protected against antibody binding by a sugar-based envelope. The research group around Mariela Segura and Marcelo Gottschalk, for example, is working on a subunit vaccine strategy that addresses both dimensions. Recently, Arenas et al. (2019) identified infection-site specific patterns of *S. suis* gene expression, which could serve as a target for future vaccines.

The arrival of a universal, affordable *S. suis* vaccine is still a distant hope, though. Inactivated vaccines generally offer low levels of antibodies at the mucosal level and would need some adjuvant to increase them. A multiple injection protocol will not work from a commercial and practical point of view. On the other hand, live attenuated vaccines risk re-developing virulence with potentially drastic effects on human health. To complicate the topic of vaccination further, there is a controversy regarding the time of application and what animals we should vaccinate – sows, piglets, both?

Today, though with variable results, the alternative to scarce commercial vaccines is autogenous vaccines. These are based on the suspected serotype(s) present on a particular farm. This strategy hinges on the difficult procedure of isolating the strain from the meninges, spleen, or joints of the animals. If this step is successful, a laboratory can then develop the autogenous vaccine. Immunization occurs mainly in piglets, but occasionally some sows are vaccinated during the lactation period.

5. Hygiene

Just as for any other pathogen, hygiene management is critical. The infection pressure can be lowered through simple steps, such as washing the breeders before they enter the farrowing room. It is, or it should be, standard practice to maximize hygiene in the processing of piglets, avoiding injuries or pinching of the gums during teeth cutting, as well as disinfecting the umbilical area.

We know that *S. suis* is usually very sensitive to most disinfectants, but that is can form a biofilm that allows it to withstand hostile conditions. Physical or chemical methods to eliminate biofilm-formation are thus vital for combatting *S. suis* effectively.

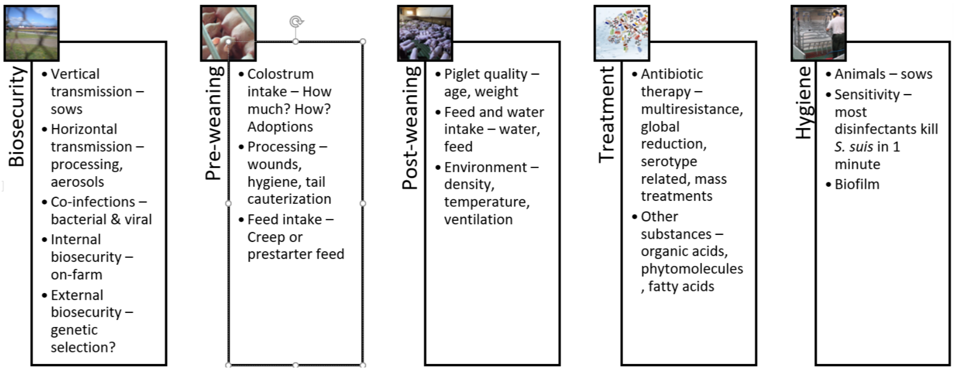


Figure 4: The 5 pillars of S. suis control and prevention

S. suis control and prevention: The future lies in the gut

There is no ideal solution for totally controlling *S. suis* yet: autogenous vaccines are only partially effective, and since we cannot continue to administer antibiotics systematically, it is necessary to look for alternatives. Pending the arrival of a universal vaccine, the most promising efforts focus on the gastrointestinal tract.

Microbiome balance to keep *S. suis* in check

The gastrointestinal tract is not only the site where nutrient absorption takes place. The gut is the largest immune system organ in the body and most exposed to different antigens; therefore, what happens at the digestive level has a considerable influence on the immune system, locally and systemically.

The microbiome can be defined as the set of autochthonous bacteria that reside in the digestive system of animals. This group of bacteria is continually evolving and changes at critical moments in the life of animals. Simply put, a healthy microbiome is one that has a high bacterial diversity in the digestive tract (alpha diversity). The diversity between animals, on the other hand, should be low (beta diversity). A healthy microbiota implies the absence of dysbiosis and pathogens. Finally, one wants to promote the presence of bacteria that can produce substances with a bactericidal effect, such as short-chain fatty acids or bacteriocins.

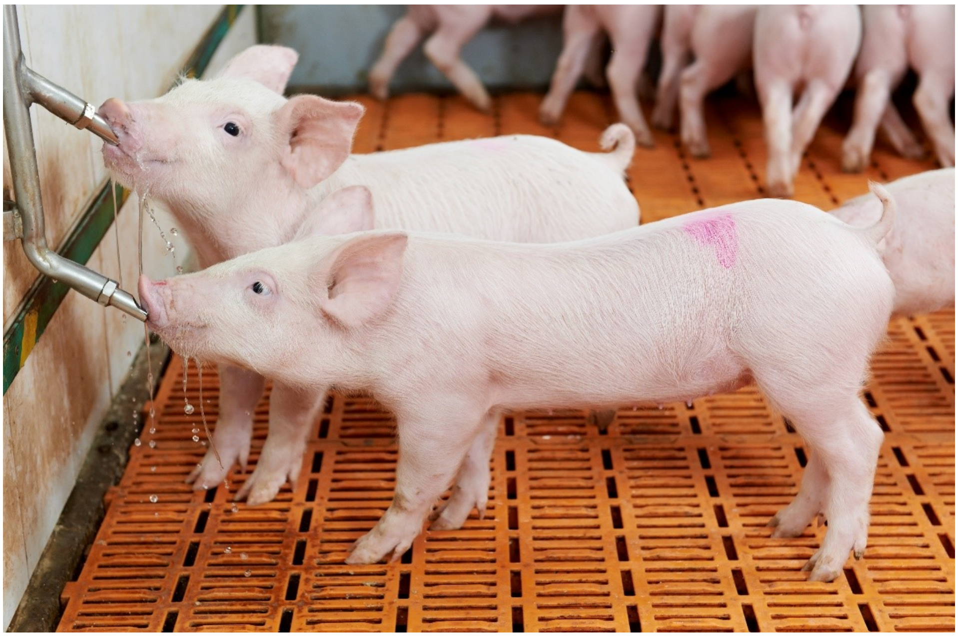
Can we influence the microbiome to have fewer *S. suis* problems? Research by [Wells, Aragon, and Bessems (2019) compared](#) microbiota samples of the palatine tonsils from healthy and infected animals. They found that animals that would later develop the disease showed less diversity and, in particular, a diminished presence of the genus *Moxarella*. Importantly, they found that these differences in the microbiome's composition of animals that later developed the disease were noticeable *before* weaning and at least two weeks before the outbreak occurred.

The same authors investigated in more depth, which bacteria in the microbiome were able to maintain homeostasis at the digestive level, finding that this was mostly the case for the genera *Actinobacillus, Streptocuccus*, and *Moraxella*. Moreover, they found that *Prevotellacea* and *Rhotia* produce antibacterial substances against *S. suis*.

Nutrition can impact the microbiome through targeted ingredients

We have to think about the microbiome of locations other than the digestive system as well. As we previously saw, the bacteria are transmitted through the mucosal route in the vagina, through the respiratory route, and there are recent studies that consider saliva as a leading source of infection in oral transmission.

This research contributes insights into how we might approach *S. suis* management through nutritional strategies. The question for nutritionists is, can you formulate feed that reduces the availability of *S. suis'* favorite nutrients? *S. suis* appears to develop best when the feed contains large quantities of carbohydrates or starches. Other nutritional factors include the feed's buffering capacity and the stomach pH of the piglets.



In times of antimicrobial resistance, additives are crucial for S. suis control and prevention

Gut health and nutrition approaches come together in the area of additives: targeted gut health-enhancing additives to feed or water will become a cornerstone of *S. suis* control. What we want to see in such products are molecules or substances that are capable of limiting, inhibiting, or slowing down the growth of *S. suis* by altering the membrane or interfering with the energy mechanisms of the bacteria.

There are already several products on the market with different active ingredients, such as phytomolecules, medium-chain fatty acids, organic acids, prebiotics, probiotics, etc. Soon, those products or combinations of them will be a part of our strategy for controlling this pathogen of such importance to our industry.

By Technical Team, EW Nutrition

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5 principles to consider when designing biosecurity programmes

Biosecurity is the foundation for all disease prevention programs and all the more important in antibiotic reduction scenarios. It includes the combination of all measures taken to reduce the risk of introduction and spread of diseases and is based on the prevention of and protection against infectious agents. Its fundament is the knowledge of disease transmission processes.

Although biosecurity is considered the cheapest and most effective intervention in antibiotic reduction programmes, compliance is often low and difficult.

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.

Lower use of antimicrobials with higher biosecurity

Studies and assessments such as those done by (Laanen, *et al*., 2013), (Gelaude, *et al*., 2014), (Postma, *et al*., 2016), (Collineau, *et al*., 2017) and (Collineau, *et al*., 2017a) relate a high farm biosecurity or improvements in biosecurity with lower antimicrobial use. Laanen, Postma, and Collineau studied the profile of swine farmers in different European countries, finding a relation between a high level of internal biosecurity, efficient control of infectious diseases, and a reduced need for antimicrobials.

Others such as Gelaude and Collineau studied the effect of interventions. The former examined Belgian broiler farms, finding a reduction of antimicrobial use by almost 30% when biosecurity and other farm issues were improved within a year. The latter studied swine farms located in Belgium, France, Germany and Sweden, in which antimicrobial use was also reduced in 47% across all farms and observed that farms with the higher biosecurity compliance and who also took a holistic approach, making other changes (e.g. management and nutrition), achieved a higher reduction in antimicrobial use.

Biosecurity interventions pay off

Of course, the interventions necessary to achieve an increased level of biosecurity carry some costs. However, the interventions, especially if taken with other measures such as improved management of new-born animals and nutritional improvements, also improve productivity. The same studies which report that biosecurity improvements decrease antimicrobial 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) obtained an improvement during both the pre-weaning and the fattening period of 0.7 and 0.9 percentual points, respectively.

Implementation, application and execution

Although biosecurity is considered the cheapest and most effective intervention in antibiotic reduction programmes, compliance is often low and difficult. The implementation, application, and execution of any biosecurity programme involve adopting a set of attitudes and behaviours 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 at improving the health of animals and people, and a piece of the holistic approach to reduce antibiotics and improve performance.

Designing effective biosecurity programmes: Consider these 5 principles

When designing or evaluating biosecurity programmes, we can identify 5 principles that need to be applied. 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 separation between high and low-risk animals or areas on the farm, as well as dirty (general traffic) and clean (internal movements) areas on the farm. This avoids not only the entrance but the spread of disease, as possible sources of infection (e.g. 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, lowering the pressure of infection e.g. by an effective cleaning and disinfection programme, 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. For each of these, it is necessary to understand the likely routes of introduction into a farm and how it can spread within it. Taking into account that not all disease transmission routes are equally important, the design of the biosecurity programme should focus first on high-risk transmission routes, and only subsequently on the lower-risk transmission routes.

4. **Repetition**: ***Increasing the probability of infection***

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 programmes, 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; 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 programme, but not in all cases is it effective or completely effective. BioCheck UGent, a standardised biosecurity questionnaire applied worldwide, shows an average of 65% and 68% of conformity, from more than 1000 broiler and 2000 swine farms between respectively; opportunities to improve can be found in farms globally, and they pay off.

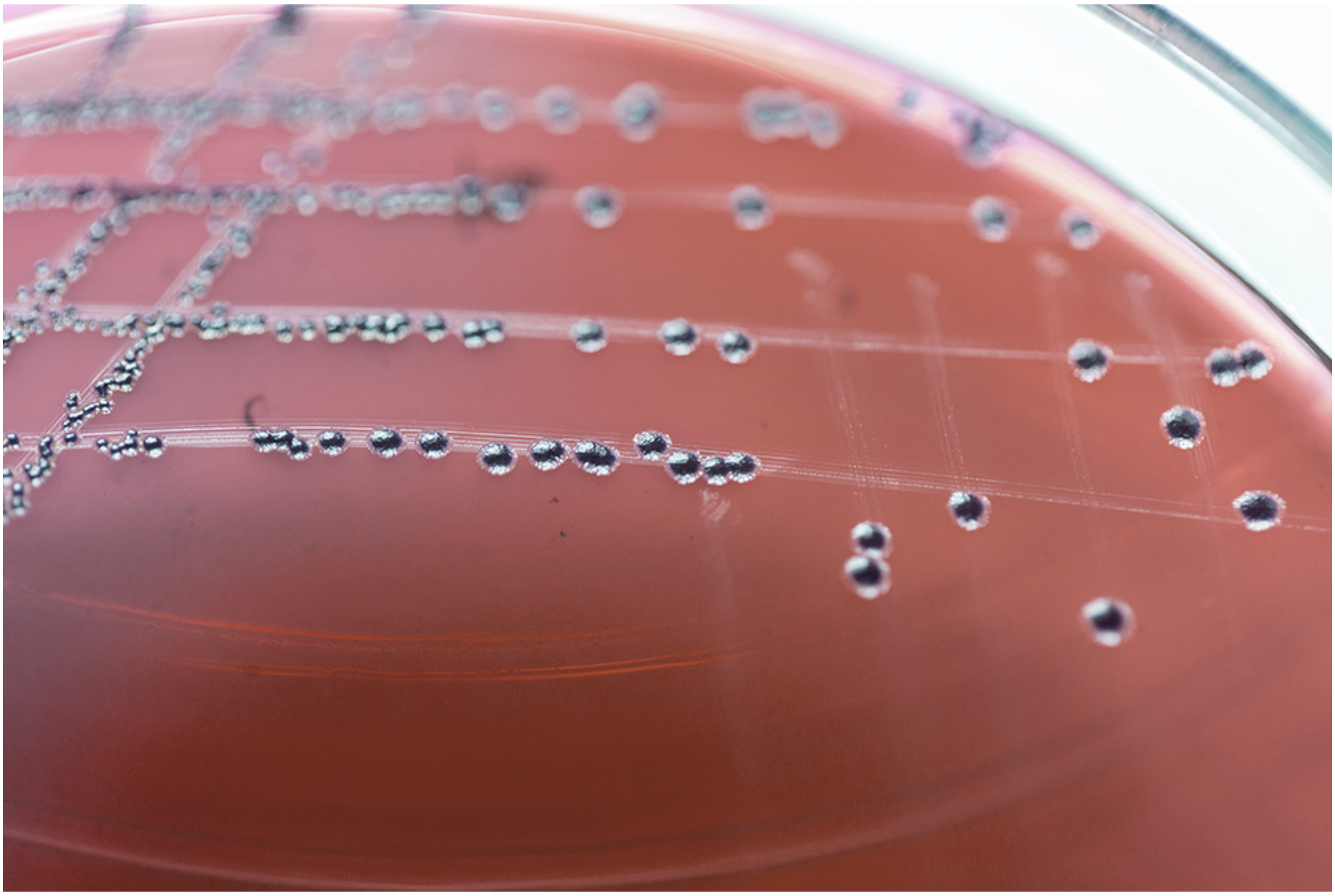
The bottom line

Biosecurity is necessary for disease prevention in any profitable animal production system. To make effective plans, these 5 principles should be applied to choose the right interventions that prevent the entrance and spread of disease. However, maintaining a successful production unit requires a holistic approach in which other aspects of biosecurity need to also be taken seriously, as well as actions to improve in other areas such as management, health and nutrition.

Authors: Technical Team – EW Nutrition

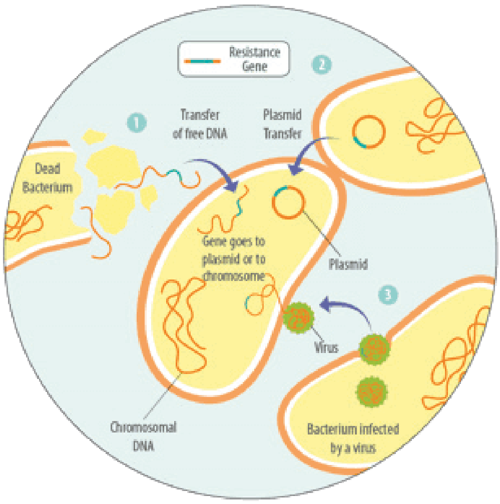
References available under request.
Article published in Pig Progress.

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

	Activo Liquid		
Central Poultry Diagnostic Laboratory, Kondapur, Hyderabad (India)	**10%**	**2%**	**1%**
E. coli (reference strains)	++	+	+
Proteus vulgaris (reference strains)	+	+	+
Pseudomonas fluorescens	++	+	-
Salmonella pulmorum	++	++	+
Salmonella gallinarum	++	++	+
Staphylococcus aureus (reference strains)	+++	++	++
- *no effect* + *growth inhibiting* ++ *bactericidal*			

Table 1: Effect of Activo Liquid against standard pathogens

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*, Entero– 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.

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

	Activo Liquid			
Laboratory: Vaxxinova, Münster, Germany	**0.1%**	**0.2%**	**0.4%**	**1%**
E.coli Reference ATCC25922	+	++	++	++
ESBL 1 (Pig)	-	++	++	++
ESBL 2 (Pig)	±	++	++	++
ESBL 3 (Poultry)	±	++	++	++
ESBL 4 (Poultry)	-	++	++	++
S. aureus Referenz ATCC29213	-	+	++	++
MRSA 1 (Pig)	-	+	++	++
MRSA 2 (Pig)	-	+	+	++
- no effect ± bacteriostatic	+ growth inhibiting ++ bactericidal			

Table 2: Effect of Activo Liquid against field-isolated standard pathogens

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.

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.

I. Heinzl

Necrotic enteritis in poultry

Enteric diseases cause significant economic losses due to decreased weight gain, higher mortality, higher feed conversion, higher veterinary costs and medicine and a higher risk of contamination by poultry products in food production. The losses due to necrotic enteritis mainly occurring in broilers and fattening turkeys in intensive floor or free-range management are put at 2 billion US$ per year.

After the ban of antibiotic growth promoters, the relevance of this formerly well controllable disease reappeared and increased.

Necrotic enteritis is a disease of the gut
It is caused by specific gram-positive, anaerobic bacteria – *Clostridium perfringens,* mostly Type A. Clostridia are found in litter, faeces, soil, dust and in healthy animals' guts. These spore forming bacteria are extremely resistant against environmental influences and can survive in soil, feed, and litter for several years and even reproduce.
Clostridium perfringens is a component of the normal gut flora. It occurs in a mixture of diverse strains in a concentration of up to 10^5 CFU / g intestinal content. In animals suffering from necrotic enteritis particularly one strain of *Clostridium perfringens* is found in a much more higher concentration of 10^6-10^8 CFU / g.
Necrotic enteritis affects chickens and turkeys at the age of 2-16 weeks, proliferating at the age of 3-6 weeks. There is an acute clinical, and a subclinical form.
Birds suffering from the clinical form clearly show symptoms like a poor general state of health and diarrhoea. Mortality rates up to 50 % can occur. Subclinical necrotic enteritis cannot be diagnosed easily, as there are no clear symptoms. This form, however, stays within the flock and causes losses due to decreased growth.

Factors promoting an infection with necrotic enteritis should be avoided!
In general, factors have to be cited that create an intestinal environment favourable for the facultative anaerobic *Clostridium perfringens* or weaken the immune status of the host:

1. **Feed:**
   Here **NSP's** have to be mentioned. Undigested NSP's serve as substrate and some of them cause higher production of mucus also serving as substrate and providing ideal anaerobic conditions. Undigested **proteins** due to high contents in the diet also serve as substrates. **Animal protein** and **fat** are worse than vegetable variants and a homogeneous size of particles in the diet is better than an **inhomogeneous mixture**.
2. **Stress**
   Stresses such as feed change or high stocking density favour NE
3. **Diseases**
   Immunosuppressive diseases such as infective chicken anaemia, Gumboro or Marek's decrease resistance against intestinal infections and facilitate their colonisation. Some pathogens exert pressure on the gut and prepare the way for clostridia. Here Cryptosporidia and salmonella have to be mentioned.

New approaches
Secondary plant compounds show good results against the two microorganisms just mentioned. In a trial conducted with free range broilers in France, a combination of a vaccination against coccidia and a mixture of secondary plant compounds (Activo liquid) resulted in a reduced occurrence of necrotic enteritis in the trial group compared to the control. Additionally due to an improved feed conversion, the margin per animal in the trial group was 5 Cent higher than in the control (1,44 € vs 1,39 €).
In an *in vitro* test, Activo liquid also showed bactericidal efficacy against field isolated *Salmonella pulmorum* and *Salmonella gallinarum* at a 2 % concentration.
The trials show that combined with a good feeding and stress management, secondary plant compounds, could be a good tool to eliminate predisposing factors for necrotic enteritis and could therefore help control this economically important disease.

Secondary plant compounds are the new frontier in poultry nutrition

Why should you read another story about phytogenics? Or, is it botanicals, spices, herbs, and extracts? No matter what we call them, scientists have named them "secondary plant compounds", and if we are to follow the American tradition we can call them SPC. Then, here is the first interesting thing we can discuss about this plant-derived class of active compounds. They are "secondary" in nature, but not insignificant. They play no role in normal metabolism, but they help plants (and now animals) survive under adverse conditions. Perhaps, this is why some experts consider them as the next frontier in poultry nutrition. With poultry that are raised in less than ideal conditions, especially when we consider the movement towards antibiotic reduction (for growth promoting reasons, not complete removal of all medicines), we understand that such natural compounds can be of significant help.

As it happens, the majority of poultry specialists in Europe and increasingly in the Americas consider SPC as an almost-essential element in diets for broilers and layers (and turkeys, ducks, and all poultry for that matter) when birds are raised without antibiotics. Some go even further and use them along with antibiotics because, as we all know, antibiotics are never 100% efficient as bacteria sooner or later develop some form of resistance. Such resistance has not yet been observed with SPC. So if one is to use SPC in poultry feds, which ones to buy? A quick glance at the market will reveal more commercial products than can possibly be imagined. Some must be better than the rest, but how can we separate the wheat from the chaff? Price alone is not always a good indicator. A high quality product must be expensive – for there is no such thing as a free lunch – but all expensive products are not always of the highest possible quality!

There are three basic criteria, which we can mention briefly here:

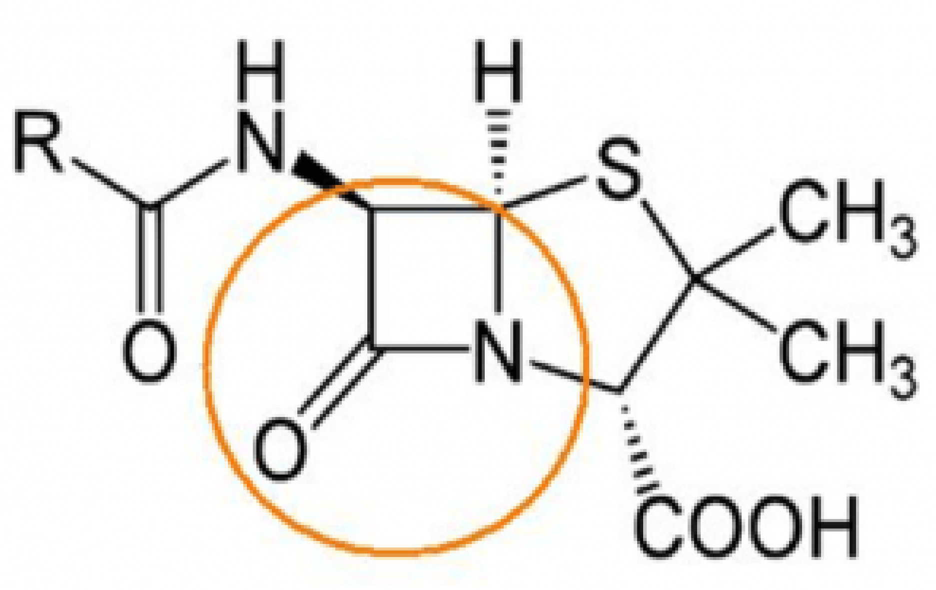
1. **SPC are volatile** – at least most of them. As such, unprotected products will soon evaporate if left in the open air as it happens with feed prepared in commercial farms. So, some form of protecting SPC is essential.
2. **SPC are innumerable** – so finding the right mix for the job required is important. You cannot get the same results with any kind of mix. So, in designing an SPC mix, the manufacturer must declare and have knowledge of the target to be accomplished.
3. **SPC are powerful** – meaning you cannot just keep adding as much as possible. Here finding the exact dosage for the right purpose is a difficult balancing exercise. So, the right mix and the right dosage must be combined, otherwise animals will refuse the feed (worst case scenario) or just fail to benefit from SPC inclusion.

There is so much more to learn about this exciting class of compounds that can replace the growth promoting action of antibiotics that it is worth spending time learning more about them.

Secondary plant compounds against antibiotic-resistant E. coli

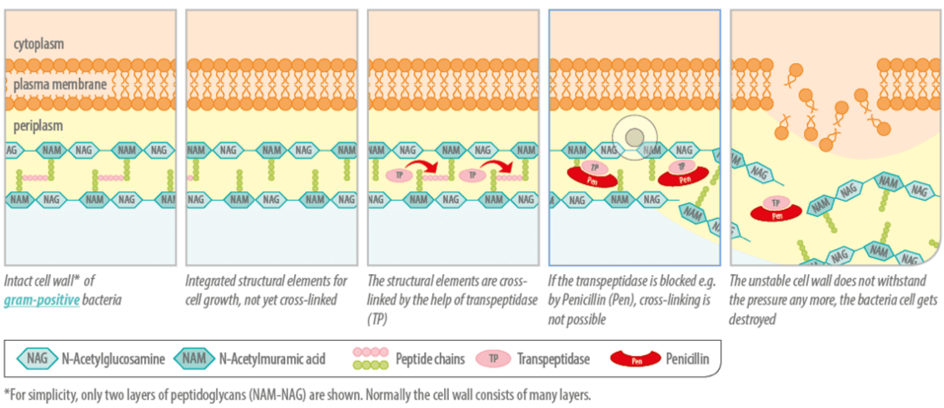
Due to incorrect therapeutic or preventive use of antibiotics in animal production as well as in human medicine, occurrence of antibiotic resistant pathogens has become a widespread problem. Enterobacteria in particular (e.g. Salmonella, Klebsiella, E. coli) possess a special mechanism of resistance. By producing special enzymes (ß-lactamases), they are able to withstand the attack of so-called ß-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 ß-lactamase genes lead to the occurrence of „Extended-Spectrum-Beta-Lactamases“ (ESBL), which are able to hydrolyse most of the ß-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 ß-lactam antibiotics?
The group of ß-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 ß-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. ß-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 ß-lactamases, destroy the ß-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 1×10^4 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 phytogenics may have on each other. A possible influence of phytogenics on the efficacy of antibiotics through the combined administration would require a change in application recommendations of antibiotics and phytogenic 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, ß-lactam antibiotics) and some affect protein synthesis (macrolides, Chloramphenicol, Lincospectin, tetracyclines, aminoglycosides). Others compromise DNA and RNA synthesis (fluorchinolones, 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 ß-lactamase positive and a ß-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 ß-lactam antibiotics, two field isolates and one reference strain were resistant against tetracyclines and macrolides and one field isolate and one reference strain against aminoglycocides.

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 phytogenic 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 phytogenic feed additives have already proven effective.

Using egg immunoglobulins to enhance piglet survival

The number of healthy piglets weaned is the most important factor for the calculation of profit in piglet production.

Losses in the farrowing unit normally occur during the first seven days of life as piglets are born with very little protection in the form of immunity. The intake of immunoglobulins from colostrum is therefore of vital importance. Besides cleanliness and special feeding, piglets can be additionally supported by two strategies that mimick the effect of colostrum:
– a direct one, meaning the feeding of immunoglobulins (IgY from eggs) to piglets that would support the immune system in the gut or
– an indirect one, meaning a supply of IgY to the sow to keep the pathogenic pressure in the farrowing unit as low as possible.

Piglets are born with no immune protection and very low energy reserves
It is well known that piglets are physiologically immature at birth. Their energy reserves are very low with only 1 – 2% body fat comprising mainly of structural and subcutaneous fat. Therefore, in the first hours of life they rely on the glucose supply from glycogen from the liver as their main energy source. However, this will only cover their needs for a few hours.
Due to the construction of the sow's placenta, a transfer of immunoglobulins (antibodies) within the uterus is not possible. This means that piglets are born with practically no immune protection and depend on the immediate intake of immunoglobulins from colostrum. The immunoglobulins can be absorbed in the gastrointestinal tract and immediately transferred into the bloodstream – but also only for a short time. The absorption ability of the piglets starts to decrease soon after birth and ends after 24 to 36 hours.

Strategy 1: Making the farrowing unit as safe as possible
The piglets' environment should be warm to prevent hypoglycaemia. Piglets looking for heat close to the sow can also get crushed. Since the temperature needs of the sow and piglets are different, a piglet nest with a special heat lamp is recommended. Furthermore, the farrowing unit should be clean. Due to their low immune status, piglets are susceptible to common pathogens such as *E. coli, Clostridium perfringens*, and rotavirus that can all lead to diarrhoea.

Most pathogens can be traced to those found in the sow's faeces. To keep this amount as low as possible, different measures can be taken:
– A vaccination increases the immune defences of the sow. The antibodies fight against the pathogens so that less "functioning" pathogens are excreted.

– Feeding of probiotics increases the number of good bacteria like Lactobacilli and Bifidobacteria competing with the pathogens for binding sites and nutrients.
– Administration of egg immunoglobulins, which bind to the pathogens within the gastrointestinal tract and make them harmless. These pathogen-immunoglobulin-complexes can be ingested by the piglets without any danger.

Strategy 2: Supporting the piglets with immunoglobulins
The aim here is to strengthen the local immunity in the gastrointestinal tract by increasing the amount of immunoglobulins (Ig). As already mentioned, the intake of sow colostrum is of vital importance. With the vaccination of the sow, the content of antibodies in the colostrum can even be enhanced.
An additional measure would be to orally supply the piglets with egg immunoglobulins (IgY). Both classes of immunoglobulins (IgG from mammals, and IgY from birds) can bind to pathogens in the gut, preventing them from binding to the intestinal wall and reducing the incidence of diarrhoea. The difference is in the degree of effectiveness and specificity.

Conclusion
To maximize the number of piglets weaned, it is necessary to support their immune system during the first days of life. Besides good hygiene management, the administration of egg antibodies to the sow will also help reduce the amount of shed pathogens keeping the pathogenic pressure low. The application of egg antibodies directly to the piglets supports their immune system by binding the pathogens in the gut, minimizing the risk of diarrhoea.

A powerful alternative to antibiotics for Aquaculture

Global aquaculture has grown dramatically and shrimp cultivation areas, in particular, have expanded. Unfortunately, the shrimp industry, in particular, faces major problems with bacterial diseases. One of the most important diseases in shrimp is vibriosis. Mortality rates of up to 100 % are possible, so economic losses can be devastating.

Characteristics of vibriosis
Vibriosis generally occurs in all life stages, but mainly in hatcheries. Vibrios are found as normal flora in the hepatopancreas of the healthy crustacean. They can turn from tolerated to pathogenic, if environmental conditions are compromised: e.g. over / underfeeding, overcrowding or decreased levels of oxygen.
The animals can be infected orally, through wounds in the exoskeleton or pores, the gills or the midgut. There are different expressions of the disease depending on which parts of the animal are affected (e.g. appendage and cuticular vibriosis).

Negative effects on the ecology
As antibiotics for shrimps are applied orally together with the feed, not all of them reach their target. An estimated 15-40 % are not ingested due to feeding falling to the bottom. A fraction of the ingested antibiotics is also not absorbed in the body and is excreted. All of these antibiotics stay in the water or sink to the bottom. The number of antibiotics that remain in the water or sediment varies from 1 % (chloramphenicol) up to 90 % (Oxytetracycline).
It is estimated that 70-90 % of antibiotics used in the therapy of farmed organisms end up in the environment and sediment and lead to the development of antibiotic resistance.

Secondary Plant Compounds (SPCs) – a good tool to reduce the use of antibiotics?
SPCs and their components are able to slow down or prevent the growth of molds, viruses, and bacteria. They impair them by acting at different parts/mechanisms of the cells (e.g. cell membrane, transport systems, cell contents, flagella development, quorum sensing…). The best-explained mode of action is one of thymol and carvacrol extracted from thyme and oregano. These substances are able to penetrate the bacterial membrane and disrupt its integrity causing loss of ions or energy equivalents.

Several trials conducted show the high efficacy of secondary plant compounds in aquaculture.

1. Scientific Trial (Kasetsart University, Thailand)

Design

a) 4 groups (6 replicates each) of White Leg Shrimp (L. vannamei) were housed in 100 L aquaria with 10 animals each.

Control: Standard feed, no additive
AB-Group: Standard feed + 10 ppm Enrofloxacin
Activo Group 1: Standard feed + 100 g Activo/t of feed
Activo Group 2: Standard feed + 200 g Activo/t of feed

Evaluation of mortality and specific growth

a) End of the feeding trial: stressing of the shrimp (high water temperature, 33°C for 1 hour), then challenge with Vibrio parahaemolyticus (7,6 x 106 cfu/ml) by subcutaneous injection.

Evaluation of mortality

a) Survival rates in the AB-Group (93,3 %) and in the Activo Group 2 (90,0 %) were similar. The specific growth rate of the AB-Group (2,32 %/day) and the Activo Group 2 (2,22 %/day) were higher than the control (1,94 %/day). The Activo Group 1 (2,18 %/day) ranged performance-wise between the control and AB-Group.

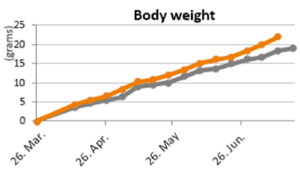
b) After the challenge, mortality in the control group (43,3%) was approximately twice as high as in the AB-Group (20 %) and in the two Activo groups (both 23,3%).

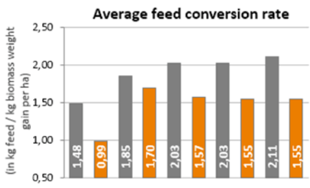
2. Field Trial (Shrimp farm Ecuador)

Design
Two ponds with 80.000 shrimps/ha
Control (3 ha): standard feed
Activo Aqua Group (5 ha): standard feed + 2 kg Activo Aqua (Activo upgraded by immune system stimulating- mannan-oligosaccharides) /t of feed on top

Evaluation of average shrimp weight at regular intervals

Results
Activo Aqua Group showed a consistently better development of body weight compared to the control, resulting in a shorter cultivation period until harvesting (112 compared to 123) and therefore a higher turnover of animals. Feed conversion in the Activo Aqua group was better in every growth stage.





Both trials present secondary plant compounds as a good alternative to antibiotic growth promoters. In the case of disease, they decrease mortality. Under standard conditions, the improved development shortens time to harvest and increases the turnover. The improved feed conversion lowers feeding costs.

Using milk thistle to reduce liver damage from mycotoxins

Mycotoxins not only reduce animal performance, but they also cause significant liver damage.
The seeds of the herb plant milk thistle contain a mixture of flavonolignans known as [silymarin] and can help in [reducing liver damage] when animals get in contact with mycotoxin contaminated feed.

Mycotoxins are a constant problem in cereals causing economic losses to the global animal industry. Mycotoxins are produced by filamentous fungi varying widely in their chemical and biological characteristics and effects on animals. Among the various mycotoxins, aflatoxins, and more specifically aflatoxin B1, is one of the most problematic because it affects maize, one of the major staple ingredients in animal diets worldwide. Of course, in nature, mycotoxins mostly occur in combinations, but even with singly contaminated ingredients, the nature of animal feeds leads to the concurrent presence of multiple mycotoxins, coming from the different ingredients. The separation of mycotoxins in polar and non-polar, however, simplifies their management. For example, aflatoxins (polar) are easily addressed by the inclusion of an adsorbent (like bentonite, for example). The same ingredient adsorbs not only aflatoxins, but also other mycotoxins, like zearalenone, ochratoxin A, and T-2 toxin, albeit at reduced efficiency.

Products limited to work in gut

Certainly, anti-mycotoxin agents are effective only while the feed is being digested, that is, while the feed remains in the lumen of the gastrointestinal tract. Anti-mycotoxin agents are not absorbed by the animal, whereas non-adsorbed mycotoxins are; leading to the need for further detoxification within the organism. Parts of mycotoxins might enter the organism despite the use of an anti-mycotoxin agent in feed due to the fact that no product is 100% effective, not all mycotoxins are affected similarly by a single product, non-polar mycotoxins might not be inactivated if only a polar agent is used, and vice versa and lastly, high contamination might render the normal dosage inadequate. This is often seen as being the most common cause, In other words, part of mycotoxins in the feed can still enter the animal. The exact effects on animal health and performance will depend, of course, on the initial contamination levels in the feed and on the constitution of the liver.

Mycotoxins and liver damage

Even short-term exposure to mycotoxins suffices to cause significant liver damage and loss of performance. In a study (Meissonnier, 2007), pigs were given 385, 867, or 1807 µg aflatoxin B1/kg feed for four weeks. Pigs receiving the highest level of aflatoxin developed clear signs of aflatoxicosis: hepatic dysfunction and decrease in weight gain. Also, the pigs exposed to the lower levels of mycotoxins showed clear signs of impaired metabolism and biotransformation. Additionally, mycotoxins and particularly aflatoxins inhibit the major hepatic biotransformation enzymes. This has significant consequences in veterinary medication applications as animals become unable to clear medications from their system – and of course, other toxins.

Read Using milk thistle to reduce liver damage from mycotoxins the full article

ALL ABOUT FEED, Volume 23, No. 3, 2015