Global trends in ABF-production in poultry and swine

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Over recent years, there has been a significant shift towards animal production systems that limit the use of antibiotics, such as “responsible use”, “reduced use”, “no antibiotics ever” (NAE), “raised without antibiotics” (RWA) or “antibiotic free” (ABF). Each would have its own interpretation and criteria but there has been a clear attempt by consumers, producers and legislators to address societal concerns about the uses of antibiotics in animal production and associations with antimicrobial resistance. These concerns are being integrated into a “One Health” approach to antibiotic use for both animals and humans. Current estimates suggest that approximately half of US broiler production is raised without antibiotics and this figure is expected to continue rising (Smith, 2018).

Until 2006, it was common for an antibiotic to be included in production animal diets at sub-therapeutic levels (AGP) to help them express genetic potential under various systems and conditions across the world. This practice was banned in the EU from 2006 and similar legislation has been introduced in other countries, including the USA (Food and Drug Administration, 2015). Whilst there remains some debate about the mode of action of AGP (Broom, 2017), limiting their use is associated with increased intestinal challenges, sub-optimal performance and greater costs (Gaucher et al., 2015).

Challenges

These quite dramatic changes to animal production systems, as well as the need to feed a growing human population more sustainably, have necessitated a thorough reevaluation of how farm animals are raised and managed. A focus for this approach needs to be on producing robust animals at the start of their life, which includes optimum breeding farm practices.

Inducing optimal immunity in young animals is critical. Neonatal animals receive varying degrees of passive protection from the mother, while it can take several weeks for their own immune capability to mature, particularly adaptive responses (Broom and Kogut, 2018). The neonatal animal is thus reliant on the quantity and quality of maternally-derived antibodies and their own innate immunities, including inflammatory, responses (Broom and Kogut, 2018). Therefore, it is imperative that vaccination strategies in breeding animals, possibly including autogenous vaccines and/or hyper-immunisation, are appropriate to provide relevant maternal antibodies (i.e. to resident disease strains) and in sufficient quantity for optimal protection. Immunosuppressive diseases, such as infectious bursal disease (IBD) in chickens and circovirus-associated disease in swine (PCVAD), are important challenges, particularly for younger birds and swine prior to immune system maturity. Thus, appropriate vaccination programs for these diseases are imperative in ABF production systems, as immunosuppressive diseases are associated with increased secondary bacterial infections that could require antibiotic treatment. *Escherichia coli* has become more of a problem in broiler complexes, which has been associated with the loss of antibiotics (e.g. gentamicin) from the hatchery (Cummings, 2018). Without appropriate sanitation, *Escherichia coli* carriage by chicks in the hatchery is more difficult to control, affecting first week mortality and subsequently manifesting secondary infection(s). For example, increased necrotic enteritis (NE) is typically followed by increased *E. coli* and it may become necessary to consider *E. coli* vaccines to prevent the need for antibiotic use. However, it is important to remember that a compromised immune system is likely to lead to inappropriate vaccine responses.

ABF production is particularly associated with increased incidences and/or severity of intestinal disorders. In poultry, coccidiosis (caused by species of the *Eimeria* parasite) and necrotic enteritis (NE) (caused by pathogenic strains of *Clostridium perfringens*) have become more prominent diseases in ABF production. In fact, NE was not considered a significant disease for poultry prior to the AGP ban in the EU in 2006 but now ranks amongst the most important diseases globally (Smith, 2018). Coccidiosis is a key predisposing factor for NE and the control of coccidiosis is considered critical for the prevention or severity of NE. In ABF production, the options for coccidiosis control are more limited (e.g. vaccines and synthetic anticoccidials) and require a better understanding of coccidial leakage management in flocks to optimize the development of immunity. Similarly, evaluating other factors (e.g. increased lighting) can accelerate bird preening, ingestion of the coccidiosis vaccine and hence immune development (Mathis, 2017). Appropriate early exposure to *Cl. perfringens* may also be helpful in the development of immunity to NE, and better NE control is associated with reduced foodborne pathogen (e.g. *Salmonella*) colonisation (Da Costa, 2019). New litter is also a risk factor for NE and it is reported that NE is more difficult to induce in challenge models on used versus new litter (Steve Davis, personal communication).
Respiratory (e.g. *Mycoplasma hyopneumonia*) and intestinal diseases (e.g. ileitis, *E. coli*) can pose key challenges when seeking to go ABF in swine (Wideman, 2018). Weaning age is a key factor determining the immunocompetence in piglets, and thus their susceptibility to, notably intestinal, diseases when maternal immune support is withdrawn. Pigs weaned at 20 days of age or more seem to perform better in ABF production systems, probably due to greater immune and digestive competence than those weaned at an earlier age (Sotto Jr., 2015). Zinc oxide and copper sulphate have been used, particularly in weaned piglet diets, at supranational inclusions to promote intestinal health, but such use is under scrutiny, or being outlawed, in many countries or regions (e.g. EU) due to excessive excretion and links to antimicrobial resistance.

High quality, nutritionally optimal diets are fundamental for ABF production. This includes an appropriate selection of ingredients as many ABF production systems use all-vegetable diets, which may encourage the application of suitable enzymes and/or other feed additives that can enhance diet digestibility. Mycotoxin contamination must also be reduced or counteracted as these secondary fungal metabolites can be immunosuppressive and may contribute to NE development (Broom, 2017). It is also important to avoid diet phase changes during critical windows when key diseases are emerging. Various other factors require critical appraisal for successful ABF production. These include building downtimes, stocking densities, as well as assessing the housing environment (e.g. temperature, sanitation (including water) and ventilation), and other potential stressors.

Table 1: Targets for successful ABF production and suitable interventions.

Target	Interventions
Robust neonate	• Suitable parent stock vaccination • Breeder facilities hygiene and sanitation
Control (including immunosuppressive) diseases	• Appropriate vaccination program
Quality of diets	• Quality ingredients • Nutritionally optimal • Counteract negative factors • Enzymes • Avoid phase changes when diseases typically emerge
Appropriate environmental management	• Downtimes • Stocking densities • Temperature control • Sanitation • Ventilation • Minimize other potential stressors

Complementary additives

Successful ABF production requires a very holistic approach to animal health and management, which can be supported by applications of appropriate additives. These would include well-researched and proven probiotics, prebiotics, organic and inorganic acids, and immunomodulators, as well as enzymes mentioned previously. Phytogenics have emerged as a particularly interesting group of, typically, feed additives that are defined as natural, plant-based substances derived

from herbs, spices, other plants and their extracts, like essential oils. This grouping includes a diverse range of compounds with a variety of proposed modes of action. Various phytogenic substances are well known for their antimicrobial effects, which can include antiprotozoal activity (Ayrle et al., 2016).
Therefore, feeding phytogenics has the potential to modulate the intestinal microbiome, as well as effects on specific community members (e.g. pathogens) through direct inhibition or affecting communication mechanisms used by bacteria (quorum sensing) to determine their population-dependent activity, such as pathogenicity (Yang et al., 2015). The gut microbiome is recognised for its key role in providing (colonisation) resistance to pathogens and in shaping the immune system of animals (Broom and Kogut, 2018). Phytogenics could thus be employed to help manage the intestinal microbiome and pathogens, such as *Eimeria, C. perfringens and E. coli*, as well as indirectly affecting the development of the immune system. In addition, phytogenics may have more direct effects on immune (and vaccine) responses, which often include increased lymphocyte numbers and higher antibody titres (Huang and Lee, 2018). Phytogenics are also reported to have 'anti-inflammatory' effects but such influences need to be balanced against the critical role that inflammatory responses play in the acute response to infection or tissue damage, the resolution of inflammation and the initiation of adaptive immunity as appropriate (Broom, 2018). There are, of course, various potential triggers for inflammatory responses and unnecessary ones need minimising/eliminating without compromising necessary responses (Kogut et al., 2018). Immune system activity often involves the production of reactive oxygen species (ROS) and infections/immune responses can lead to an imbalance between pro-oxidants and antioxidants, and oxidative stress (Lauridsen, 2018), which could be alleviated through the antioxidant properties of phytogenics (Chikara et al., 2018). Phytogenics also offer a means to enhance diet digestibility (Reyer et al., 2017), which can enhance the 'quality' of the feed, reduce adverse effects on the gastrointestinal microbiome and minimise wasteful nutrient excretion.
Phytogenics can, therefore, complement the fundamental strategies that must be employed to enable success in the ABF era. Phytogenics can modulate the gut microbiome, help optimise immunity and resistance to important immunosuppressive, gastrointestinal and secondary infections, diet quality and resilience to other production stressors.

Table 2: Successful ABF production targets and complementary additives (i.e. phytogenics)

Target	Complementary additives
Robust neonate	• Establish and manage appropriate gut microbiome and immune system development • Control pathogens
Control (including immunosuppressive) diseases	• Appropriately influence immunity and disease resistance
Quality of diets	• Enhance digestibility • Feed hygiene
Appropriate environmental management	• Attempt to control microbial contamination and pathogens • Reduce nutrient excretion • Counteract oxidative stress

Conclusion

ABF production invariably involves a transitional process from more traditional production systems to be successful, which may incur additional cost. ABF production systems focus on creating a more robust young animal and better management of factors that contribute to their lifetime challenges. Encouraging the acquisition of a beneficial gut microbiome and optimizing host immunity are key components of the strategies used in ABF production. This includes hygiene and sanitation practices that enable appropriate exposure to microorganisms. Farm complexes have demonstrated that it is possible to raise animals without the use of antibiotics and to also be amongst the best performing producers in their production class. Perhaps controversially, there can be welfare concerns in ABF systems if there is a reluctance to treat when necessary, which is not an acceptable practice. Through multiple mechanisms, phytogenics can help to create a more robust animal that is resilient to the various challenges it will undoubtedly encounter during its productive life. Moreover, phytogenics could be used in combination with other additive options benefitting from potential additive or synergistic effects to deliver more value and potentially safer food.
However, to obtain consistent results, it is critical to utilize consistent products that combine scientifically-proven phytogenic compounds or additives.