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Antibiotics in Poultry Production

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What Is an Antibiotic?

An antibiotic is a chemical that either kills infectious bacteria or inhibits their growth. The term antibiotic is also used for chemicals that kill other microorganisms, such as single celled organisms (also known as protozoans). Antibiotics were initially produced by microorganisms but are now synthesized chemically. Antibiotics do not affect viruses.

Antibiotic-Resistant Bacteria

Bacteria that cause diseases in people are increasingly becoming resistant to anitbiotics. The World Health Organization (2015) considers antimicrobial resistance a major threat to public health globally.

The Centers for Disease Control and Prevention Atlanta (2013) estimated that there are more than 2 million illnesses and about 20,000 deaths each year in the United States caused by antibiotic-resistant bacteria. Multidrug-resistant bacteria were estimated to be responsible for 3,000 deaths in the U.S. and 25,000 deaths in Europe (Gross, 2013). The reason attributed to the spread of antibiotic-resistant bacteria is the widespread use of antibiotics. In 2014, Dr. Boris Lushniak, the then U.S. Acting Surgeon General, stated that "the primary driver of antibiotic resistance is the use of antibiotics."

Antibiotic-resistant bacteria are spread from people treated with antibiotics due to reasonable use but are also due to overuse and/or unnecessary use and/or incomplete use (failure to use all the medication in a prescription and follow the instructions) and/or inappropriate use (Centers for Disease Control and Prevention Atlanta, 2013; Martin et al., 2015; Ventola, 2015).

It was estimated that 80 percent of antibiotics in the U.S. were used for livestock and poultry in 2015 (Ventola, 2015). It is, therefore, not surprising that the Centers for Disease Control and Prevention Atlanta (2013) consider that antibiotic-resistant bacteria are spread from livestock receiving sub-therapeutic and therapeutic doses of antibiotics. In the case of the latter, antibiotic-resistant bacteria can be spread via poor handling of meat and contamination of vegetables with animal excreta used as fertilizer (Centers for Disease Control and Prevention Atlanta, 2013).

Indeed, Donald Kennedy, former editor of *Science* and former president of Stanford University, concluded that "farming practices are largely to blame for the rise of antibiotic-resistant strains." Tang and colleagues (2017) concluded, based on a meta-analysis, that restricting "antibiotic use in food-producing animals are associated with a reduction in the presence of antibiotic-resistant bacteria."

Antibiotic-resistant bacteria can potentially be transferred from animals to humans through inadequately cooked food and also from animal excreta, with resistance transferable between different species of bacteria (National Research Council, 1998). Moreover, methicillin-resistant *Staphylococcus aureus* (MRSA) has been demonstrated to be present in livestock (Bosch and Schouls, 2015; also see review: Fitzgerald, 2012). Poultry and livestock are thought to be an "important source of antibiotic resistance" (Martin et al., 2015). In contrast, Cervantes (2015) stated that "there is little convincing scientific evidence that the use of antibiotics in food-producing animals is contributing to the antibiotic resistance issues that are relevant to human medicine."

The Food and Drug Administration considers antibiotics or antimicrobials under two categories:

1. Medically important antibiotics or those that are used in human medicine.
2. Not medically important (NMI) antibiotics – these being antibiotics that are not used in human medicine.

Antibiotics and Poultry Production

Poultry may receive antibiotics in their feed (National Chicken Council, 2017). Based on the Food and Drug Administration (2017) categories, these antibiotics fall into two groups:

1. Medically important antibiotics
   - Chlortetracycline
   - Penicillin
   - Macrolide, Tylosin
   - Streptogramin, Virginiamycin
2. Not medically important (NMI) antibiotics as they are not used in human medicine and do not exhibit cross resistance
   - Bacitracin
   - Ionophores, e.g., Monesin and Naracin

There are also non-antibiotic coccidiostats, such as Decoquinate, Diclazuril, Nicarbazin and Robenedine Hydrochloride), that are widely used in poultry production (National Chicken Council, 2017).

In 2016, chickens and turkeys used, respectively, 6 percent and 9 percent of "medically important antibiotic sales" (Food and Drug Administration, 2017). In contrast, pigs used 37 percent and cattle 43 percent (Food and Drug Administration, 2017). The cessation of use of NMI antibiotics eliminates among the most effective measures to control coccidiosis. Moreover, with increasingly severe coccidia infestations, the incidence of necrotic enteritis (caused by *Clostridium perfringens)* (Al-Sheikhly and Al-Saieg, 1980) is likely to increase dramatically, with consequent economic loss to producers. The Food and Drug Administration (2017) considers that "ionophores, for example, lack utility in human medicine and their use in animals, primarily as coccidiostats, does not pose cross resistance concerns; thus, they do not have the same public health risks as medically important antimicrobials." It is difficult to justify stopping the use of ionophores or even non-antibiotic coccidiostats.

Antibiotic-Free Poultry Production

A shift to antibiotic-free poultry production is underway for the following reasons:

- Marketing position/consumer preferences: "Consumer perception is that antibiotic-free produced poultry is superior to conventionally raised poultry in spite of a lack of supporting scientific data" (Cervantes, 2015).
- The voluntary plan announced by the Food and Drug Administration (FDA) "to phase out" medically important antibiotics in animal agriculture (Food and Drug Administration, 2013).

It is widely assumed that raising antibiotic-free broiler chickens is accompanied by reduced performance in such parameters as average daily gain, feed conversion ratio (FCR) and mortality (Rosen, 2004). A research team at Eli Lilly concluded that eliminating antibiotics from broiler feeds would have negative consequences (Cady et al., 2015). These include reduced growth rates and stocking density together with more feed required, more excreta per unit of meat, longer time to market weight and other increased costs.

Challenges of Antibiotic-Free Poultry Production

What are the challenges of raising chickens in an antibiotic free manner?

- Intensifying husbandry.
- Health challenges such as the following:
  - Coccidiosis
  - Necrotic enteritis caused by *Clostridium perfringens*
- Assuring sanitation, including flushing water lines.
- Regular disposal of mortalities.
- Extended down time.
- Any adverse consequences on bird welfare.
- Possible alternate approaches
  - Enzymes
  - Prebiotics or probiotics
  - Botanics

Experience of Antibiotic-Free Production at the University of Arkansas

It was thought that production would likely be negatively impacted by the shift from conventional to antibiotic-free production. However, increased attention to husbandry could overcome any negative consequences. Neither body weight at marketing nor feed efficiency were negatively impacted by the transition (Table 1). In fact, there was some tendency for improvements in both (Table 1). In addition, the duration to marketing tended to be lower in antibiotic-free chickens (Table 1). In contrast, there was some decrease in the live-ability (Table 1), reflecting the ability of sub-therapeutic levels of antibiotics to depress disease and deaths.

As was expected, the number of chicks placed was lower in flocks raised in an antibiotic-free manner (Table 1). The corollary of the reduction in the number of chicks placed is a small decrease in the stocking density. This decrease in chicks placed obviously leads to a reduction in the number of birds marketed per flock (Table 1). The interval between flocks tended to increase in antibiotic-free flocks (Table 1).

Table 2 shows data from a recent study in the Department of Poultry Science at the University of Arkansas. It was expected that following transfer from a feed containing bacitracin methylene disalicylate to an antibiotic-free diet, there would be changes to the small intestine. Anticipated changes included decreased villus height, crypt depth, smooth muscle (*Muscularis*) thickness and gastrointestinal integrity. However, the researchers found no changes in the anatomy of the small intestine (villus height, crypt depth and *Muscularis* thickness) and increased/improved gastrointestinal integrity in chickens on an antibiotic free diet.

Conclusions

1. The use of medically important antibiotics in poultry production has been reduced.
2. The cessation of the use of not medically important antibiotics is occurring, based on market considerations.
3. The impact of moving to antibiotic-free production can be mitigated by improved husbandry.

Table 1 Changes in production parameters in flocks at the University of Arkansas Savoy Applied Poultry Research Facility. Data is shown as mean ± (number of flocks) SEM. Data is adapted from Aldridge et al., 2018

Production parameters	Production responses	
	Conventional	**Antibiotic free (ABF)**
Body weight (lb)	6.12 ± (8) 0.10	6.40 ± (6) 0.17
Duration of rearing before marketing in days	44.8 ± (8) 2.83	43.5 ± (6) 0.67
Feed efficiency (F:G)	1.81 ± (8) 0.05	1.72 ± (6) 0.02
Live-ability (%)	95.0 ± (8) 0.34[b]	93.9 ± (6) 0.46[a]
Number of chicks placed	83,046 ± (8) 668[b]	79,139 ± (8) 972[a]
Number of broiler chickens marketed	78,863 ± (8) 434[b]	74,473 ± (6) 1,248[a]
Downtime between flocks (days)	17.0 ± (7) 2.64	21.5 ± (6) 2.45

[a, b] Different letters indicate difference $p<0.001$

Table 2. Effects of transferring broiler chickens (Cobb 500s) from an antibiotic-containing diet (50 g/ton of bacitracin methylene disalicylate) on the small intestine (specifically the duodenum) to antibiotic-free feed (based on data from Koltes et al., 2017)

	Pre-treatment (day 31) with bacitracin methylene disalicylate	3 days following transfer to antibiotic free-free diet
Villus Height (μm)	2019	2163
Crypt depth (μm)	385	392
Muscularis (intestinal smooth muscle) thickness (μm)	194	205
Gastrointestinal integrity (Ω cm^{-2})	396[a]	537[b]

[a, b] Different letters indicate difference $p<0.001$

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