20. Growth Promotants for Pigs and Poultry

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Learning objectives

On completion of this topic you should be able to:

• Discuss the need for alternatives to antibiotic use in monogastric feeding systems.
• Define probiotics and prebiotics and how they can be used to improve production in monogastric production systems.
• Describe how organic acids and feed enzymes can be used in monogastric diets to achieve improved production.
• Describe why hormones are not used in commercial poultry production systems

Key terms and concepts

Antibiotics, mechanism of action and current status; Alternatives to antibiotics; Probiotics; Feed enzymes; Organic acids; Prebiotics.

Introduction to the topic

Animal production in the last 50 years has become much more intensive. Intensification has imposed a need to maintain consistently high production rates and a greater degree of disease control. This quest for increased animal performance and health status has resulted in reliance on application of low doses of antibiotics in feeds. Between 1950 and 1970, most classes of antibiotics were used as growth promotants, primarily in pigs and poultry, at inclusion rates in diets of about 50 ppm. Responses in production were consistently of the order of 10 to 15 %, and improvements in feed conversion averaged 5%, although the level of response has depended on environmental factors and, of course, pathogen loads present. Consistent growth responses to these antibiotics have been maintained over the years, and have provided livestock managers with a reliable tool to maintain good production levels.

Antibiotic. Compound that kills bacteria without affecting the host.

The emergence of antibiotic–resistant human pathogens, and public concern over the routine use of antibiotics in livestock production has led to a search for alternative growth promoters for use in the animal industries. Probiotics added to feeds have been considered as a possible alternative to antibiotics.

20.1 Antibiotics: mechanism of action and current status

The mechanisms by which antibiotics improve growth or feed efficiency of animals are not well understood. A simplistic explanation is that the intestinal microflora are modified such that the ability of the host to respond to a fixed feed intake is maximised. Different antibiotics have different effects on bacteria— some affect bacterial cell walls and others protein synthesis in microorganisms; some antibiotics are absorbed through the gut wall, others are not. The turnover rate of intestinal mucosal cells is much lower in antibiotic–fed animals.
The indiscriminate use of all classes of antibiotics for growth promotion, and concerns about residues in animal products for human consumption, led to a series of inquiries globally (eg. The Swan Report, HMSO, London, 1969). The outcomes were decisions to restrict the use of antibiotics as growth promoters to those not in use for either human or veterinary therapeutic purposes. In Britain, for example, the important recommendations were that supply of penicillin, chlortetracycline and oxytetracycline without prescription should be stopped, and that tylosin, nitrofurantoin and sulphonamides should only be available on prescription. Defined ‘feed’ antibiotics should be available without prescription for pigs and poultry, and for calves up to 3 months’ old. ‘Feed’ antibiotics included bacitracin, virginamycin, flavomycin and nitrovin. ‘Therapeutic’ antibiotics were only to be used in animals if prescribed by a veterinarian for a treatment of a specific disease condition.

In more recent times, there has been a global trend, led by Sweden and Denmark, to prohibit use of all antibiotics as animal growth stimulants. This has occurred because of a growing concern that regulations developed in the 1970s were being flouted, and that producers have continued to use ‘therapeutic’ antibiotics as growth stimulants. The detection of residues has not been the main concern, but rather the development of gastrointestinal bacteria with drug resistance.

In 1986 Sweden decided to ban the use of all antibiotics as animal growth promotants. When Sweden joined the European Community in 1995, it was allowed to retain this ban until 1998, at which time it would have to argue its case with the other European nations to maintain the ban, or fall into line with them. Accordingly, the Agriculture Ministers of the 15 EU nations met in December 1998 and decided to ban four antibiotics used as growth promotants — tylosin phosphate, bacitracin zinc, spiramycin and virginiamycin. EU farmers were given until June 1999 to comply. Another four drugs were also listed for further consideration for banning.

When first introduced, the bans led to huge increases in mortality and morbidity rates and a drop in production. In the poultry industry, the most significant consequence has been the sporadic outbreaks of necrotic enteritis which causes sub-clinical losses in production and, in severe cases, high mortality. The EU estimates that the increase in costs of pig production due to the banning of antibiotic use in feeds has been 8–15%. However, necrotic enteritis is largely a management problem.

In the USA, authorities have not yet moved to restrict the use of antibiotics as growth promotants. Indeed, the USA still allows antibiotics such as penicillin and chlortetracycline to be used, arguing that the case against their use is not convincingly proven. Several years ago the National Academy of Sciences in the USA was commissioned to determine whether low doses of antibiotics given to livestock posed a risk the development of anti-biotic resistant bacteria. The Academy was unable to resolve this issue. (There are, of course, political elements affecting these questions involving both sales by pharmaceutical manufacturers and world agricultural trade.)
In Australia, the consensus of the Joint Expert Advisory Committee on Antibiotic Resistance in 1999 was that the excessive use of antibiotics as growth promotants could lead to the development of antibiotic–resistant bacteria.

Swine dysentery in pigs in Australia is regarded as one of the most economically important diseases costing more than $100/sow per year on affected farms. Heavy reliance on antibiotics to control the disease has led to the development of resistant strains of *S. hyodysenteriae*. The good news is that research has suggested that the dysentery is controllable by dietary manipulation (it is reduced in pigs given diets low in rapidly fermentable fibre (ie. soluble NSP, oligosaccharides and/or resistant starch. The Australian pig and poultry industries are now also committing resources to investigate and evaluate alternatives to antibiotic growth promotants.

### 20.2 Alternatives to antibiotics

The bans on use of antibiotics have led, at least in Europe, to an urgent search for reliable alternative growth promotants. Alternatives being considered, developed and evaluated include: somatrophins (BST for dairy cattle milk production and PST for pig meat production), cytokines, enzymes, anabolic growth hormones, β–adrenergic agonists, prebiotics and probiotics, organic acids (eg., sodium n–butyrate in pigs), synthetic growth stimulants (eg., nitrovin, carbadox, olaquinox), and polyether ionophore antibiotics (monensin, lasalocid and salinomycin). The bans in Sweden have been a test case and Swedish producers, using strict hygiene programs and modified feed formulations along with alternatives such as organic acids, prebiotics (mainly oligosaccharides) probiotics and feed enzymes, have actually seen an improvement in overall health status of poultry.

**Probiotics**

Probiotic bacteria, principally various species of *Lactobacillus* and *Enterococcus faecium* (which appear to improve production by enhancing the properties of indigenous micro–flora in the gut) have been used in pigs, poultry and calves since 1970. Responses have been variable: they have depended on the quality and nature of the probiotic preparation used, and on the disease status of the animals. Table 20.1 is a summary of some trials with pigs and calves.

<table>
<thead>
<tr>
<th>Agonists</th>
<th>are substances that elicit the same response as a hormone naturally secreted in the body.</th>
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<tr>
<td>Prebiotics</td>
<td>are non–digestible feed ingredients (polysaccharides) that benefit the animal by selectively stimulating the growth and/or activity of one or a limited number of bacterial species already resident in the gut.</td>
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<tr>
<td>‘β–Adrenergic’ refers to a subdivision of the adrenergic system that influences physiological responses in the body including heart rate, blood pressure and bronchial constriction.</td>
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<tr>
<td>Bovine somatrophin (BST) is a protein that is produced naturally by the pituitary gland of cows and stimulates milk production by enhancing the partition of circulating nutrients towards the mammary gland. Porcine Somatotrophin (PST) is the similar protein in pigs</td>
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</tbody>
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Table 20.1 Summary of positive and negative results for growth and feed efficiency in trials with pigs and calves fed probiotics. Source: Choct and Iji (2006).

<table>
<thead>
<tr>
<th>Type of animals</th>
<th>Number of trials</th>
<th>Growth response</th>
<th>FCR response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piglets</td>
<td>26</td>
<td>16 - 9</td>
<td>8 - 9</td>
</tr>
<tr>
<td>Grower pigs</td>
<td>9</td>
<td>6 - 3</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Calves</td>
<td>17</td>
<td>13 - 4</td>
<td>0 - 0</td>
</tr>
</tbody>
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Similarly indeterminate results have been found with broiler and layer poultry. Where improvements in weight gains have occurred, these have averaged about 5%. However, Table 20.1 also clearly shows that gains have been inconsistent and that probiotic treatments can even reduce weight gain and feed conversion. As mentioned already, the proposed mechanisms of action by probiotic bacteria on the health and growth of the host are unclear. This is largely because of the complexity of gut ecosystems. Clearly, the probiotics have an ability to suppress harmful bacteria. This has been demonstrated in both in vitro and in vivo, and both in animal models and in humans. However, this effect on pathogens does not necessarily translate into consistently improved live-weight gains or improvements in feed conversion efficiency. There are three possible mechanisms by which probiotic bacteria can elicit their effect on the growth performance and well-being of the animal. Probiotic bacteria may act to:

a) suppress pathogens by production of antibacterial compounds (organic acids, bacteriocins, other antimicrobials), competition for nutrients, and competition for colonization sites;
b) change microbial/host metabolism by production of enzymes which support digestion (e.g. \( \beta \)-galactosidase), decreased production of ammonia, and improved gut wall function; bifidobacteria, in particular, use many prebiotic carbohydrates preferentially as carbon sources, which could permit improved feed utilisation by the host;
c) improve the immune response of the host by increasing antibody levels, and macrophage activity. Research into the modification of the immune system by probiotic bacteria is in its infancy, but it is conceivable that effects may include enhanced production of growth factors, which in turn could allow improved weight gain in the host. It is perhaps important to distinguish the use of probiotics to prevent infectious diseases by increasing the barrier function of the gut microflora, and as microbial growth promotants by being a source of enzymes to improve feed utilization and rate of growth important for regulatory approval reasons in the feed industry.

**Competitive exclusion** (CE) is an example of a specific mechanism where addition of mixed cultures of microorganisms have consistently improved survival of chicks, and lowered *Salmonella* levels in the flock. CE is the name usually reserved for treatment of day-old chicks with a mixed microflora resulting in colonisation resistance towards potentially pathogenic microorganisms, especially *Salmonella* spp. The treatment is usually given only once. Usually cultures of ill-defined composition are used, often derived originally from caecal or faecal contents of adult chickens. In contrast to the variable results obtained with a continuous treatment of probiotic lactic acid bacteria in older animals, CE cultures have been consistently beneficial in reducing *Salmonella* and *Campylobacter* loads. The principle of CE treatment is that young chicks are more susceptible to pathogen infection than older birds because a complex inhibitory gut flora is not present in the newly hatched birds. This flora takes some weeks to develop in hygienic hatcheries, as there is a lack of contact with adult birds. This allows a ‘Greenfield’ opportunity for pathogens to colonise the gut without competition. Studies specifically targeting the displacement of *Clostridium perfringens* using probiotics have yielded promising results.

**Future of probiotics**
Current evidence clearly indicates that probiotic bacteria have not yet been shown to consistently improve animal production or improve feed conversion efficiency. This is in contrast to data where antibiotics as growth promotants have been shown to consistently improve performance, and this gain has not decreased in magnitude over the last 45 years since the practice was adopted by the animal industries. Can we therefore realistically hope that probiotics will be able to provide an economic alternative in the future? The greatest weakness in probiotic treatment to date has been in the selection and testing of suitable probiotic strains with properties appropriate to the application; maintaining their viability in sufficient numbers in feeds; and preparing them in a
manner which ensures their delivery to the appropriate gut compartment of the animal. There are opportunities to combine their administration with a prebiotic carbohydrate, such as an oligosaccharide, lactulose, lactitol, or resistant starch, to enhance their effectiveness. Nothing is known of the interaction between probiotic bacteria and proteins with growth stimulating ability, such as certain whey protein fractions, somatotrophins, and cytokines.

In the future, probiotic packages may offer the opportunity to consistently improve animal production but at this stage their effectiveness is still uncertain. To demonstrate this will require much effort and money. Regardless of the rights and wrongs of the global debate on the future of antibiotics as growth promotants, bans on antibiotic use in animals will assist in determining the value of probiotics for such uses, and will lead to a much better understanding of gastrointestinal microbiology in important domestic animal species.

**Feed enzymes**
The benefits of antibiotics in feeds are gut–flora related and therefore investigation of diet–induced changes in the gut ecosystem is a good starting place for the search to find replacements for antibiotics. A sudden change in diet can disturb this ecosystem and introduction of a diet rich in NSP (wheat, barley) favours the proliferation of anaerobic microbes such as Clostridia. However, the use of feed enzymes to promote NSP breakdown in the gut of broilers can almost eliminate the development of an anaerobic fermentation in the small intestine and this effect coincides with improved production. Recent studies at UNE have also shown that populations of *C. prefringens* can be manipulated by diet and by the use of feed enzymes.

**Organic acids**
Organic acids are included in diets in Europe to inhibit growth of gut pathogens such as salmonella in both raw feed ingredients and in finished feed. Organic acids in their undissociated form can diffuse through the cell wall into bacteria and then they dissociate releasing hydrogen ions which lower the pH inside the cell and cause it to expend energy trying to restore the intracellular conditions. This use of energy for its survival minimises its capacity to grow and divide. At the same time, the anions produced from the dissociation of acids can disrupt DNA and protein synthesis which further affects cell replication. Benefits of organic acids on feed efficiency and animal performance have been reported, especially in young animals, but these seem to be greater for birds than for pigs. The benefits of inclusion of organic acids in diets may also depend on the composition of the diet and its buffering capacity.

**Prebiotics**
Small fragments of polysaccharides in the diet can selectively stimulate particular species of microbes in the gut and can thereby potentially bring about changes in the balance of the gut microflora that may improve animal production. There are potentially hundreds of potential fragments that could act as beneficial prebiotics but the ones currently available commercially for inclusion in diets are mainly oligosaccharides made up of the sugars galactose, fructose or mannose. These prebiotics appear to act by selectively feeding and favouring the ‘good’ bacteria at the expense of the harmful ones. It is claimed, however, that the prebiotic mannan oligosaccharides from yeast cell walls apparently act differently —by providing specific binding sites for gut pathogens. This reduces the chances of the pathogens attaching to the intestinal wall. The mannan oligosaccharides may also bind to, and cause detachment of, harmful microbes already attached to the gut wall and carry them out of the gut.

The use of feed enzymes is discussed elsewhere as a method of grain treatment.

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The prebiotics industry worldwide has grown largely because a range of prebiotic oligosaccharides can now be manufactured by enzymatic bio–technological methods. In Japan, for example, lactulose production reached 20 thousand tonnes in 1995.
Readings

The following readings are available on CD:


Activities

Multi-Choice Questions

Available on WebCT

Self Assessment Questions

Submit answers via WebCT

1. What is a ‘probiotic’ additive for feeds? What is its likely mode of action if it improves animal production?
2. How can addition of organic acids to feeds act as a growth promotant?
3. What has promoted the European countries to ban the use of antibiotics in feed?
4. How do antibiotics promote growth and feed efficiency in animals?

Useful Web Links

Available on WebCT

Assignment Questions

Choose ONE question from ONE of the topics as your assignment. Short answer questions appear on WebCT. Submit your answer via WebCT

Summary

Summary Slides are available on CD.

References


Joint Expert Technical Advisory Committee on Antibiotic Resistance (JETACAR) 1999. ‘The use of antibiotics in food-producing animals: antibiotic–resistant bacteria in animals and humans’. (Commonwealth Department of Health and Aged Care; Commonwealth Department of Agriculture, Fisheries and Forestry, Australia).


Siba, P.M., Pethick, D.W. & Hampson, D.J. 1996. ‘Pigs experimentally infected with Serpulina hyodysenteriae can be protected from developing swine dysentery by feeding them a highly digestible diet’. Epidemiology and Infection Vol 116 pp 207–216.

