

Use of bacterial vaccines in the livestock industries



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The prophylactic use of antibiotics in animal feed has been a long-held practice in intensive livestock production for maintaining animal health by controlling disease and promoting growth enhancement. However, the continuous use of antibiotics has evoked strong concerns over emergence of antibiotic-resistant bacteria. There has been a concerted effort over the years by US, EU and Australian legislative authorities to reduce or eliminate prophylactic use of antibiotics in animal feed. In principle, these efforts are commendable; however, an alternative and effective method to managing disease must be available to ensure the health and welfare of livestock. There will likely be a greater reliance on vaccination programs to protect livestock from various infectious diseases. With respect to bacterial diseases, bacteria themselves form the core of vaccine development. In this article, an overview of bacterial vaccine technologies available to the livestock industries will be presented.

There is a worldwide demand for increased food production that is placing great pressure on farming systems to maximise animal productivity and yet maintain safety and high quality. The global production and consumption of meat will continue to rise, from 233 million metric tons (Mt) in the year 2000 to 300 million Mt in 2020¹. With the increase in livestock production there has been an increase in antibiotic usage. More than half of the antibiotics produced globally are used for animals². According to the Food and Drug Administration (FDA), approximately 13.500 tonnes of antibiotics for use in food-producing animals were sold in the US in 2010³. In addition to disease control, antibiotics are also used as growth promotants^{4,7}. Australia imports about 700 tonnes of antibiotics per year with two-thirds being used for veterinary use⁷.

Risk-based assessment over the extensive use of medically important antimicrobials has resulted in legislative initiatives in

Europe, US and Australia to eliminate the prophylactic use of antimicrobials in animal feed and drinking water^{7,8}. It is important to note that FDA legislations are voluntary measures. It would, therefore, be reasonable to assume that such initiatives would be difficult to adopt by producers unless effective means of disease control and performance enhancement are available. Vaccines offer an alternative therapy that will address the central problem of managing disease. Veterinary bacterial vaccines have been available for decades as prophylaxis against bacterial diseases. They are of two main types, inactivated (killed) or live vaccines.

Inactivated (bacterin) vaccines consist of whole-cell, killed microorganisms, organism components or organism by-products. They are usually inactivated by formalin and then combined with adjuvants such as aluminum hydroxide, oil in water or polymer and water formulations to produce a sufficient immune response. Inactivated vaccines offer an economical, safe, albeit limited homologous (same isolate, strain or serovar) protection⁹. Killed vaccines are generally administered parenterally and hence are not conducive to mass administration methods. Examples of registered whole-cell, killed vaccines include Nobilis® Salenvac T for the immunisation of chickens against *Salmonella enteritidis* and *S. Typhimurium*. Also, vaccines for swine include Respire®[®], M-Pac®, Suvaxyn® and Porcilis® M hyo for immunisation against *Mycoplasma hyopneumoniae*. Autogenous bacterial vaccines (used under permit) are generally killed vaccines but some can be live. They are mainly used in the absence of commercial vaccines or vaccines that do not provide sufficient protection against the disease on a specific farm. Autogenous vaccines are derived from the disease-causing bacteria isolated from the affected farm. The resulting product is, therefore, active against the specific pathogenic strain in that herd or flock. For live autogenous vaccines controlled exposure and correct timing of vaccination is essential to ensure that the animal does not succumb to disease. Subunit and toxoid vaccines are variations of killed vaccines that

are composed of either a part of the organism or a secreted toxin(s). The toxins are usually inactivated by formalin converting them to the toxoid (safe) form. Novartis Animal Health has a “*Clostridium perfringens* Type A Toxoid” vaccine that aids in the control of deadly gastrointestinal disease in cattle. Examples of subunit vaccines for *Actinobacillus pleuropneumoniae* (APP) are Porcilis® APP (Intervet) and PleuroStar APP (Novartis). Vaccination with whole-cell, killed vaccines has shown limited success due to their inability to offer cross-serotype protection. Porcilis® APP is based on four antigens, the outer membrane protein (OMP) and three toxoids¹⁰. PleuroStar APP is based on five antigens¹¹. With these components it is possible for the vaccines to offer cross-protection against nearly all the serovars of APP.

Live vaccines are based on either mild or modified strains of an organism in which the ability to cause clinical disease has been reduced or removed (that is, attenuated). The advantage of live vaccines is they can elicit strong cellular and antibody responses. They also provide a more rapid and a wider spectrum of protection than killed vaccines¹². There are many examples of live attenuated vaccines. Vaxsafe® MS and Vaxsafe® MG (Bioproperties Pty Ltd) are two examples of live mycoplasma vaccines used in the poultry industry that were developed by chemical mutagenesis and temperature-based selection. These vaccines are administered only once and offer lifelong protection in the control of chronic respiratory disease in chickens. ART VAX® (Schering-Plough Animal Health) is a live temperature-sensitive mutant of *Bordetella avium* that aids in the prevention of rhinotracheitis (coryza) in turkeys. Ovilis® Enzovax (Intervet) is another temperature-sensitive, based, live vaccine for the active immunisation of susceptible breeding female sheep as an aid in the prevention of abortion and stillbirth caused by *Chlamydia psittaci* infection. Vaxsafe® ST and Vaxsafe® PM (Bioproperties Pty Ltd) are live vaccines used in the control of *Salmonella* Typhimurium and *Pasteurella multocida* (fowl cholera) in chickens, respectively. For these vaccines the original wild strains of the chicken isolate of *S. Typhimurium* and *P. multocida* were attenuated by deletion of part of the *aroA* gene. This deletion renders the organisms non-virulent and dependent on aromatic amino acids and vitamins for growth.

The challenge is on for vaccine producers to develop novel vaccines that are easily integrated into the current vaccination regimen. Future improvements to vaccines could be the development of more effective adjuvants, cytokines and vectored vaccines. Combination vaccines exist for a growing number of injectable vaccines allowing for concomitant administration of two or more vaccines. Live vaccines have the added benefit of accommodating mass administration such as in-ovo, spray on animal, spray on feed, intranasal and vaccination in drinking water. Many live vaccines are in fact co-administered in this way for poultry. While it may appear that the issues are insurmountable, the poultry industry in general has made great strides over the past decade or so to reduce their reliance on antibiotics as a result

of successful application of vaccination. Nevertheless, reliance on antibiotics is still high in industrial livestock production. Future efforts should be directed at reducing such reliance by the implementation of vaccination programs. It can be achievable so long as research and development work hand in hand with the needs of the end user.

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Biographies

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