Alternative Uses to Ionophores in the Feedlot Industry

Antibiotic-Free Feedlot Production

A report for

By Liz Manchee

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Executive Summary

The Australian feedlot sector is an important component of the beef industry, mitigating environmental factors that adversely affect the industry and adding market share, both domestically and internationally. The feedlot production system relies on ionophore use. These are an in-feed antibiotic, antimicrobial and anticoccidial agent that is fed prophylactically to prevent infection, increase animal welfare, assist in growth promotion to improve feed efficiency and to increase meat yield. Ionophores are technically classed as an antibiotic that increases cell membrane permeability, resulting in the change of rumen microbiota.

Ionophores are not considered to be critically important in human medicine by the World Health Organisation (WHO) because they are not used in human medicine, although antibiotic resistance has been identified as a critical global health issue.

Since ionophores are antibiotics, concerns are raised about their continued use and some supply chains include ionophores in their claim of using ‘no antibiotics’ in the raising of animals. Hence it is possible to conclude that the use of ionophores cannot be continued indefinitely. The author believes that an alternative is required, not only for the continuation of the feedlot industry but for insurance should the constant use of ionophores in food-producing animals give rise to unwanted or unknown side-effects. The authors intention is not to bring undue scrutiny to the industry but rather to encourage the development of alternative, effective production systems.

There are a number of reasons for seeking an alternative to the continued ionophore use, including mitigating the potential future negative effects, consumer concern about current food production systems, food labelling system requirements, potential future governmental legislation on chemical and antibiotic use and potential future changes to importing country requirements.

Alternatives to ionophore use are available and are effectively used in intensive feedlot situations. This paper looks at the evidence for and against the continuation of ionophore use and the driving forces behind the possibility of change.

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Foreword

Manchee Agriculture is a beef breeding enterprise with properties in Northern NSW and Southern Queensland with a focus on genetics production, with sales nationally and internationally. My involvement in agriculture stemmed from childhood where I developed a passion for animals and breeding. I have primarily been involved in the genetics side of the beef industry for the last 23 years and I am interested in genetic efficiency and profit maximisation. Our breeding philosophy has always been on paddock-to-plate, economically driven, commercial animal traits and believe the industry as a whole will have an advantage if product diversity is increased, not specifically pertaining to branded products or breeds, but rather an industry certified, consumer-focused system.

The beef industry is consumer driven, and our business as a genetics supplier is at the opposite end of the production system. Being consumer driven allows genetic suppliers to concentrate on efficient cattle that maximise value through the supply chain for the producer, lot feeder, or processor, by obtaining market share by increasing positive eating experiences for the consumer. These fundamental traits will continue to make beef a priority in consumer shopping and eating habits. This was most evident in a Whole Foods Market in Chicago, Illinois, where all meat sold was antibiotic-free, with no added hormones and fed a vegetable diet. This store, which sold various lines of general food products, was fundamentally focused on the consumer's need to feel good about their purchases, even if there was no scientific proof of the product claim. For example, they sell a drink with probiotics added and a marketing ploy to match, but, in reality, each drink contained less than a quarter of the daily recommended dose of the specific probiotic specified in Australian standards. It is no wonder consumers face difficulty trying to educate themselves and choose between a variety of product options.

The intention to remove ionophores, technically classed as an antibiotic that alters the rumen microbiota, from lot fed cattle diets evolved due to an industry partner approaching our business to provide a certified, antibiotic free, lot fed beef product to sell into the Chinese market. My limited research showed that the capacity to do this through conventional feedlots was not available. I then looked into facilitating the process in our feedlot and discovered that Australia had limited experience with the topic. It became obvious to me that this is a market space that could be filled, as there is no beef product that sits between grass fed, (which is both hormone-free (HGP) and antibiotic-free) and conventional lot fed cattle. I questioned why we cannot have a grain-fed production system without the use of antibiotics to gain market share for beef. I wanted to ascertain how much genetic gain is required to offset the production loss, if any, from not feeding ionophores in a lot fed system.

Acknowledgments

The support of my family has been of paramount importance to my successful Nuffield studies. I sincerely thank my husband and part-time travelling partner, John, and children Nick and Sophia for their support on the roller-coaster ride of 2016. Their ability to continue with life and to achieve and succeed in my absence makes me both incredibly proud and simultaneously feel superfluous. My extended family have supported me in many ways and I thank them for picking up the slack in my absence.

The opportunity to travel to eleven countries over the course of 18 weeks is attributed to the confidence Meat and Livestock Australia (MLA) and Nuffield Australia placed in my ability to contribute to the beef industry and I am extremely appreciative of both their support. I would like to acknowledge the Australian Lot Feeders Association (ALFA) for their support and encouragement. Over the course of my travels the hospitality and knowledge gained were accredited to a small group of key people.

I'd like to personally thank;

- Mary Barton who spent nearly an entire day of her spare time to educate me on antibiotics in the food chain and how they are irresponsibly used in human medicine, this was one of the learning highlights of my Nuffield journey.
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- Neil Keane and Petra Musa, who facilitated visits across two continents and three countries to learn about the alternatives to ionophores in feedlotting.

Lastly, I'd like to thank my Global Focus Program (GFP) travel partners, Randall, Tom, Suze, Angus, James, Fred, Robbie and Tom, who journeyed through the changeable dynamics of a GFP and made it fun.

Figure 1: The 2016 Brazil GFP group at Rogerio Pacheco property in Brazil, April 2016. Source: Author

Acronyms and Abbreviations

ABRI	Australian Business Research Institute
ALFA	Australian Lot Feeders Association
AMIC	Australian Meat Industry Council
AMPC	Australian Meat Processor Corporation
APVMA	Australian Pesticides and Veterinary Medicines Authority
CCA	Cattle Council of Australia
CoOL	Country of Origin Labelling
DFM	Direct Fed Microbials
DNA	Deoxyribonucleic Acid
EBV	Estimated Breeding Value
EPD	Expected Progeny Differences
EU	European Union
FSANZ	Food Standards Australia New Zealand
FSC	Food Standards Code
FSIS	USDA Food Safety Inspection Service
GAP	Global Animal Partnership
GFP	Global Focus Program
GMO	Genetically Modified Organism
HGP	Hormone Growth Promotant
ICAR	International Committee for Animal Recording
ICBF	Irish Cattle Breeders Federation
MBV	Molecular breeding values
MLA	Meat and Livestock Australia
NFAS	National Feedlot Accreditation System
PCAS	Pasturefed Cattle Assurance System
SNP	Single-Nucleotide Polymorphism
USDA	United States Department of Agriculture
WHO	World Health Organisation

Objectives

This report aims to:

- Determine alternative options to in-feed ionophores for use in the Australian feedlot industry, including the identification of production issues surrounding the deletion of ionophores from a lot-fed cattle production system.
- Identify antibiotic resistance issues pertaining to antibiotic use in the feedlot industry and outline the issues relating to their continued use.
- Identify the market opportunities, including labelling options for antibiotic-free beef utilising customer perception of meat and meat products.
- Define and identify the merit in nutrigenomics and genomic approaches to genetic advancement in beef cattle.

Chapter 1: Introduction

The beef cattle industry is one of Australia's major agricultural industries and is extremely diverse with a vast difference in production systems, quantity and quality of product. Australia has a total of 27.4 million head of cattle, as at June 30, 2015. The Australian beef industry was the world's largest exporter of beef in 2015, supplying 4% of the world's beef supply, primarily exporting to Japan and the U.S. (USDA, 2017). A total of 2.9 million head (ALFA, 2016) of cattle were grainfed in 2015, equalling 30% of the total Australian beef production (ALFA, 2015), with 267,578 tonnes shipped weight (swt) exported in 2015-16, a record volume of grainfed beef exports (MLA, 2017).

The majority of production growth in the Australian beef industry over the last ten years was due to the feedlot sector. The feedlot sector has recognised the importance of monitoring antibiotic residue and has shown that 99.9% of samples tested comply with the Federal Government's antibiotic residue monitoring program (ALFA, 2015). Antibiotic residue levels are low in this sector, as evidenced by National Residue Survey data. Antimicrobial resistance in bacteria isolated from cattle, when measured by the standards set for human health and when compared with other countries is also low (Barlow R. , et al., 2015).

Antibiotics are used in feedlot cattle in three distinct ways; therapeutically to treat sick animals, prophylactically to prevent infection and as growth promotants to improve feed efficiency and increase meat yield. Ionophores are intended to be fed at sub-therapeutic levels, affecting only the rumen and digestive tract.

It is not widely known that anti-microbial (bacteria, fungi, protozoa, virus) resistance is a naturally occurring phenomenon, driven by environmental, animal and human factors. Antibiotic resistance, in simple terms, is due to bacteria building resistance to anything that endangers their survival and they are extremely adept at change. Bacteria have the ability to respond rapidly and change according to evolutionary pressure. When antibiotics are administered they target the destruction of 'bad' bacteria, but 'good' bacteria are also harmed.

The Joint Expert Technical Advisory Committee on Antibiotic Resistance (JETACAR), including some of Australia's leading microbiologists, has called for appropriate regulatory controls deemed essential to manage antibiotic resistance (JETACAR, 1999). This body reports the increase of antibiotic resistance in humans is largely as a result of human misuse and overuse of prescription medicine; third world countries are at greatest fault due to the lack of governing bodies controlling antibiotic use. Human use of antibiotics is affecting antibiotic resistance at a greater rate than antibiotics used in animal production, primarily due to incorrect usage where an estimated 30% of human prescriptions in Australia for antibiotics are inappropriate (AURA, 2014). It has been estimated that 50% of human prescriptions and 80% of veterinary prescriptions in the U.S. could be eliminated without adverse results. Preservation of antibiotic effectiveness is unquestionably necessary and it is vital to maintain the continued use of ionophores for the foreseeable future. Antibiotic stewardship is of fundamental importance to the beef industry and in human medicine to control the chance of shared-class antibiotics, used in both human health and animal production, increasing the chance of antibiotic resistance.

The Australian One Health Antimicrobial Colloquium (2013) report states that Australia is regarded as having one of the world's most conservative approaches to antibiotic approval for use in livestock production. The report states in 2010, 359 tonnes of antibiotics were used in food-producing animals in Australia and that Australia has one of the lowest non-human uses of antibiotics in the world (One Health, 2013). This is regulated by the Australian Pesticides and Veterinary Medicine Authority (APVMA).

The organic movement is gaining traction in first world countries and a consumer option that sits between conventionally produced and organic markets will benefit the industry as a whole. The placement of an artificial product into the massive Chinese market, which has the consistency of grainfed beef, with the perceived health advantages of being antibiotic-free, will help capitalise on an already growing market share. Grainfed exports to China almost doubled during 2015-16, up 83% to 23,950 tonnes swt (MLA, 2017), largely due to the reduced tariffs and demand increasing, especially for Australian beef. This shift in consumption in China accounts for 9% of Australian grainfed beef volumes shipped during 2015-16 (MLA, 2017). The ability to capitalise on the Chinese market is vitally important to the Australian industry due to the potential financial benefits of expanding consumption in China.

China is not the only country looking for alternative perceived 'healthier' options. It was evident in the U.S. that consumers were looking for more choice. The organic movement with American consumers has been in double digit growth for over a decade with nearly 75% of U.S. supermarkets stocking organic products (USDA, 2017). The share of total agricultural area under organic cultivation in the European Union (EU) has risen by 42.5% in the short period between 2007 and 2012 (EuroStat, 2017). Cargill's (U.S) 'Feed for Thought' survey of more than 2,000 people in Brazil and the U.S. discovered that the majority of Brazilian (69%) and American (54%) consumers are more likely to purchase antibiotic-free beef, but only 35% in both countries were prepared to pay extra for antibiotic-free product. The survey identified that, as the population ages, beef products will need to reflect the growing demand for food produced in a more natural way. Cargill has recognised consumer trends and has started to reduce the use of shared-class antibiotics, which are used in both human medicine and animal production. Cargill has achieved a reduction in the use of shared-class antibiotics by 20%, which equates to a turn off of approximately 1.2 million head annually.

While there are concerns with the use of medically-relevant antibiotics, which may be extended to ionophores in intensive feedlot systems, ionophore resistance is not considered a widespread problem threatening the fate of the feedlot or cattle industry, but it may be difficult, in consumers' eyes, to explain the use of ionophores as a management and prevention tool. Correct antibiotic use in the beef industry is necessary to treat animals that become sick and the feedlot industry has a 99.9% compliance rate with samples tested by the Federal Government's antibiotic residue monitoring program (ALFA, 2015).

Consumer awareness of antibiotic resistance in feed animals is rising and a demand for correctly labelled products is increasing, in response to claims of contamination of animals and animal products (Figure 2). Other animal production sectors have identified customer perception issues and have had successful targeted approaches to changing purchaser product interaction.

***Figure 2: Brazilian and American consumers are more likely to purchase antibiotic free beef. Source: Cargill Animal Nutrition – Feed for Thought survey,* 2016 (Cargill, 2016).**

Chapter 2: Understanding Ionophores

2.1 What are they?

Ionophores, an animal production-enhancing antibiotic feed additive, have beneficial effects on animal production through the alteration of ruminal flora, resulting in changes in the proportions of volatile fatty acids produced during ruminant digestion. Ionophores meet the definition of both an antibiotic and an anticoccidial agent. Ionophores improve production efficiency of healthy animals and are fed at sub-therapeutic levels, affecting only the rumen and digestive tract, not the whole animal as use at a therapeutic level would achieve.

Ionophores used in the feedlot industry are currently not in use in human medicine and there is no known ability to select for resistances of public health significance (Lean, Page, Rabiee, & Williams, 2013). The World Health Organisation (WHO) has classified ionophores as not important to human medicine (WHO, 2011), as there is no obvious relationship between ionophore use in livestock production and the relationship between bacterial resistance to antimicrobial compounds in human medicine. To group all antibiotics together to evaluate the risk of their use is an overly simplistic approach.

2.2 Why are they used?

Ionophores are primarily used in the feedlot industry to prevent disease but also have a number of other benefits. Ionophores modify the rumen microflora decreasing methane and acetate production, the incidence of bloat, prevent coccidiosis and improves nitrogen utilisation, dry matter digestibility, feed efficiency and growth rates. Utilising ionophores in the feedlot industry results in 2%–10% improvement in liveweight gain in animals on a high-roughage diet, gives a 3%–7% increase in feed conversion efficiency, and up to a 6% decrease in food consumption (Reinhardt, 2016). The mortality rate also decreases with the use of ionophores and mortality levels are lower in feedlot cattle than in extensive grazing systems (ALFA, 2015). In effect, the use of ionophores in a feedlot has a positive effect on productivity and profitability of the feedlot as well as causing an improvement in animal health and welfare.

Animal welfare is considered the most important issue in the Australian feedlot industry and is highly regulated through the National Feedlot Accreditation System (NFAS). The feedlot industry is continually improving animal welfare performance statistics which are underpinned by world-leading animal husbandry practices. Pen management is also easier as there is less requirement to clean the pens due to decreased faecal matter. Livestock waste is a major source of greenhouse gases due to the production of methane, ammonia, carbon dioxide as well as starch gasses.

The difference in antibiotic resistance between Australian extensive and intensive beef production is also negligible, as reported in MLA research (Lean, et al., 2013). Ionophores, as feed additives used in cattle diets, increase feed efficiency and body weight gain by as much as 10% (Russell & Houlihan, 2003) and reduce the mortality rate of feedlot cattle. A 10% improvement in feed efficiency has twice the impact on profit than a 10% increase in weight gain, during both the growth and finishing stages of feedlot production (Fox, Tedeschi, & Guiroy, 2001).

2.3 Future Use

Ionophores are currently an important part of the Australian feedlotting industry and for the beef industry as a whole. Ionophores allow feedlots to maximise production, minimise inputs and obtain high standards of animal welfare by promoting animal health including effective rumen function.

U.S. research has shown that there continues to be a large gap between livestock producers and consumers regarding antibiotic use in animal care and welfare. The introduction of ‘Never Ever 3’ program supplying antibiotic-free, HGP free and animal by-product free beef in the U.S. in the early 2000’s saw many U.S. feed yards adopt the production method and marketing ploy. Since the global financial crisis in 2008, a number of feed yards have ceased feeding cattle for the program as production loss was too great, and there was a lack of consumer demand for the product.

The Global Animal Partnership (GAP) was developed by IMI Global (Castle Rock, Colorado, USA) for Whole Foods Market stores across the U.S. and is an independently monitored certification program. IMI Global audit the GAP assurance program, which is targeting farm animal welfare in a five-step program, which includes a preference for pasture raised livestock, given enhanced outdoor access and with full traceability. The GAP program allows the use of coccidiostats, anti-inflammatories, probiotics and some microbials, but disallows ionophores, growth hormones, animal by-products, beta-agonists and reproductive products (including prostaglandin and some insecticides) (IMI Global, 2016). This allows Whole Foods Markets to promote a product that satisfies customer requirements with animal welfare issues being addressed, while still providing the perceived health benefits to consumers of antibiotic-free animal products. IMI Global also facilitates the Non-GMO Project Verification for Whole Foods Market, using the 5-step Animal Welfare Ratings (Figure 3).

Figure 3: The 5 Step Animal Welfare Labels from the Global Animal Partnership. Source: 5-Step® Animal Welfare Program, Global Animal Partnership, 2016 (Global Animal Partnership, 2016).

In March 2015, McDonalds Corporation in the U.S. released their vision for antimicrobial stewardship in food animal production, which they identify as beef, pork, poultry, dairy and eggs (McDonald's Corporation, 2015). This vision was built on the McDonald’s 2003 global policy on antibiotic use, which saw the company in 2016 announce it required suppliers to phase out antibiotic use with the notable exception of ionophores. The reason cited was that the WHO did not consider ionophores, such as monensin, as medically important to human medicine. The fast-food chain did identify that judicious use of ionophores is an integral part of animal health and welfare. Most industry groups, veterinarians and food safety advocates believed the vision was a sensible compromise, one that identified and addressed consumer concerns, but allowed producers to maintain good animal health and welfare.

From these two corporate examples, we can see two different stances on ionophore use and how these companies are defining their positions in consumers' minds. Companies calling for livestock production changes have been driven by a growing call for food transparency, defined by the continued growth of terms like 'natural', 'local', 'pasture raised', 'hormone free' and 'antibiotic free'. The United States Department of Agriculture (USDA) reports consumption of conventionally bred and grown meat between 2011 and 2015 grew by 4.6% compared to meat labelled as 'natural', which grew by 14.6% (2017). This compares with products labelled as 'antibiotic free', which grew 28.7% and organic meat sales grew 44% (USDA, 2017). Products with 'natural', 'antibiotic-free' and 'organic' labels account for a small percentage of the total market share of more than US$50 billion in meat sales, and this needs to be considered when assessing growth rates (USDA, 2017). In 2015, 6% of meat products were labelled 'natural' with 3% being 'antibiotic free' (USDA, 2017). The rapid sales growth of products with a 'clean' label claim is quickly changing production focus (Figure 4).

Stakeholders in the Australian feedlot industry will need to consider the growth in market space other than the conventional, ionophore-based production system currently in place. There is market space and consumer demand for both products and for the beef industry not to take advantage of a growing market and to appease consumer awareness and demand would be disadvantageous to growing beef consumption, both domestically and globally.

THE RISE OF CLEAN MEAT LABELING

SNAPSHOT: U.S. BEEF SALES

HEALTH CLAIM	A TOTAL DOLLAR SALES (52 WEEKS ENDING 8/29/15)	TOTAL DOLLAR SALES (52 WEEKS ENDING 8/27/16)	DOLLAR SALES % CHG. VS. YA (52 WEEKS ENDING 8/27/16)	AVG. RETAIL PRICE (52 WEEKS ENDING 8/29/15)	AVG. RETAIL PRICE (LATEST 52 WEEKS ENDING 8/27/16)	AVG. RETAIL PRICE (% CHANGE VS YA)
CONVENTIONAL	$16 BILLION	$15 BILLION	-3.30%	$5.28	$4.85	-8%
NATURAL	$831 MILLION	$737 MILLION	-11.30%	$5.02	$4.48	-11%
ANTIBIOTIC-FREE	$310 MILLION	$321 MILLION	3.60%	$7.34	$7.25	-1%
MINIMALLY PROCESSED	$849 MILLION	$939 MILLION	10.60%	$4.71	$3.92	-17%

Source: Nielsen FreshFacts(R)

Figure 4: The rise of clean meat labelling systems; a snapshot of the growth of the antibiotic-free market space in US beef sales. Source: Nielsen, 2016 (Nielsen, 2016)

Chapter 3: Ionophore Alternatives

Alternative ways to feed cattle are available to achieve a similar result to using the conventional ionophore approach. Programs that cease the use of ionophores need to be nutritionally customised to fit the specific life stages of feedlot cattle. There has been some work done on probiotic and prebiotic use, mainly in the US and mostly in the dairy industry on young cattle, to increase gut function without the use of antibiotic feed-based additives.

The microbial cells in and on the bodies of living organisms outnumber the physiological cells of the body by up to ten to one (Knight, 2015). Knight (2015) indicates the digestive tracts of living animals generally has the largest microbial community.

The European Union (EU) Commission banned the use of antibiotics, including ionophores, in January 2006 (European Commission, 2005). This has led countries in the EU to look for alternative ways to gain efficiency in animal production, keeping productivity, profitability and animal welfare at the forefront of their production systems. As a result, many breeding and finishing programs to advantage of the short-term gain from using Continental breeds of cattle. The decision to utilise high muscle content breeds stemmed from the current EU beef grading system placing a larger weighting on muscle content rather than on a balance with external or intramuscular fat. Finishing programs have therefore required cattle to be fed for additional time to obtain carcase fat and eating quality, making feed efficiency even more important in reducing costs

3.1 Direct-fed microbials

Probiotics and prebiotics have the ability to control the balance and actions of the gastro-intestinal microbiota and are considered valuable to the host animal. Synbiotics is the effective use of both probiotic and prebiotic together to aid effective rumination. Direct-fed microbials are available commercially with a variety of bacteria strains being produced in a variation of products.

Probiotics

Probiotics are non-digestible sugars that play a beneficial role in promoting ‘good’ microbes and aid protection from ‘bad’ microbes in an animal’s digestive system. The use of probiotics in animal feeds has shown benefits in digestion, feed efficiency, performance and are immune enhancing. There are thousands of diverse types of bacteria strains and each can have a different effect on the digestive tract and each responds differently to specific probiotics (Alltech, 2017).

Prebiotics

Prebiotics are a specialised form of dietary fibre that acts as a fertiliser for the 'good' bacteria in the gut and improves the good-to-bad bacteria ratio benefiting health and digestion. Essentially, these tiny fibres are promoting the effect of the probiotics and healthy gut microbes; they are not actually digested by the rumen but rather by the bacteria in the rumen (Alltech, 2015).

Synbiotics

Synbiotics is the combination of probiotic and prebiotic strategies. They are considered a beneficial substitute to ionophore use and evidence has shown they can be an effective alternative to achieve health benefits in ruminant digestion. The term symbiotic should only be used when the prebiotic compounds selectively favour the probiotic organisms and work synergistically.

3.2 DHA Omega 3

Docosahexaenoic acid (DHA) is an omega-3 fatty acid that is naturally found in some species of plankton, algae and fatty fish. When used in animal diets DHA has numerous benefits; adding DHA to an animal's diet adds to the health and well-being of the animal and has positive flow-on effects to the omega-3 nutrient level in beef products when consumed.

3.3 Yeasts

Yeasts can be beneficial to intensive beef cattle feedlotting by breaking down fibre and making it more easily digestible. Yeasts are valuable in cattle diets due to their ability to regulate rumen pH and improve fibre digestion, which in turn increases feed efficiency and has a positive effect on rumen health, leading to better liveweight gain. Yeasts are usually used in combination with prebiotics and probiotics.

3.4 Essential oils

Essential oils are compounds extracted from specific plants or plant parts, and have been used therapeutically around the world for thousands of years. The poultry industry has trialled the use of essential oils to gain feed efficiency and increase bird health. Essential oils are use in treatment and prevention of liver abscess, along with having benefits for carcase quality, net feed intake and rumen function (Meyer, et al., 2014). Some research has shown that thyme and cinnamon oils maybe an alternative to monensin use, although commercial trials have not been undertaken.

3.5 Organic Acids

An alternative to ionophores may be organic acids, such as fumarate and malate. Castello et al., (2004) states that these substances in the rumen can stimulate lactate uptake, where malate gives the greatest response in preventing or correcting a drop in ruminal pH (associated with ruminal acidosis). Fumarate gives the greatest response in reducing methane production. Ruminal fermentation is enhanced by both malate and fumarate and they may be considered an alternative to ionophores in livestock production, particularly as the EU Commission has no limits or bans on the use of these organic acids in animals (Castillo, et al., 2004).

Chapter 4: Antibiotic Resistance

Antibiotic resistance in disease-causing bacteria is a major health concern for the world's population. The bacteria that antibiotics target are adept at dealing with antibiotics and are masters of the process of building resistance to anything that jeopardises their survival. All antibiotics used in both human and animal administration are therefore important to the ongoing battle against resistance, linking the use of antibiotics in animal production and antibiotic resistance in human pathogens. There is evidence that antibiotic resistant bacteria can transfer from animals to humans via the food chain (Barton, 2001).

Professor Mary Barton, School of Pharmacy and Medical Science, University of South Australia, agrees with the WHO's statement that antibiotic resistance is becoming a critical global health issue and is concerned about the contribution made by antibiotic use in animals (Barton, 2001). Much of the blame for antibiotic resistance is attached to misuse or over-use, whereas any use of antibiotics will lead to the emergence of resistant strains of bacteria (AURA, 2014) and this is a naturally occurring phenomenon that has occurred for thousands of years (D'Costa, et al., 2011). Australia is one of the highest users of antibiotics for humans in the developed world (WHO, 2011). A judicious approach is required to kerb antibiotic resistance.

While ionophores are not used in human medicine they should not be considered irrelevant to antibiotic resistance as their mode of action in the intestinal tract at low doses creates an ideal environment for resistance development (Barton, 2001). Australia has been proactive in a targeted approach to antibiotic resistance when, as a result of the Swann Report, antibiotics important in human medicine were removed from animal feeds (Swann, 1965).

The impact on human health from antibiotic use in food producing animals has been under scrutiny since the Swann (1965) report was published. A considerable concern is antibiotic resistance in intestinal bacteria, including E. coli and Salmonella spp., which are known pathogens in both animals and humans. These food-borne pathogens, evolving from intestinal bacteria in animals, can get into the food chain and are of concern to the feedlot industry (Barton, 2001). Soon after antibiotics were introduced as animal feed supplements, antibiotic resistance was detected (Barton, 2001). Published literature has identified that resistance to antibiotics is common in some E. coli strains which have evolved since the introduction of in-feed antibiotics 50 years ago (Langlois, Dawson, Leak, & Aaron, 1988). A more disturbing detail is that published studies have identified that resistance to more than one class of antibiotic is the rule rather than the exception (Barton, 2001). However, more recent, comprehensive studies have found very low levels of resistance in bacteria isolated from Australian cattle (Barlow et. al., 2015 and Barlow et al., 2017)

The global increase in antibiotic resistance is an ongoing issue for human health. Antibiotic stewardship programs are designed to facilitate awareness to the appropriate use of antibiotics, decrease inappropriate usage and improve the effectiveness of their use; primarily programs are aimed at reducing resistance through these measures. Stewardship of antibiotics is of major importance, as the development of new antibiotics has almost completely ceased and the preservation of the effectiveness of current antibiotics is vital due to the inevitability of resistance.

The ethical responsibility of the feedlot sector to maintain animal welfare at the current, highly compliant level and balance this with the perceived necessity of ionophores to maintain welfare is a difficult task. The risk of shared-class antibiotic resistance developing from the continued use of all antibiotics in food-producing animals, both therapeutically and sub-therapeutically, will continue to be a debate for industry and governing bodies.

Chapter 5: Nutrigenomics

Nutrigenomics, an emerging science based on epigenetics, is the study of the interaction between nutrition and gene expression, especially with regard to the prevention of disease and has potentially positive implications for the feedlot industry. Its rise in the scientific world largely came from the inability to identify why individuals with identical genes would display completely different traits. To date, this has been explained by the genetic interaction with nutrition, or how environmental factors will affect animal cells from conception to death. Basically, some nutrients have the ability to switch on or switch off gene expression in response to environment factors.

Epigenetics studies changes in organisms caused by modification of gene expression rather than alteration of the genetic code and this is the basis of nutrigenomics. Epigenetic changes also allow these modified gene or genes to transfer nutritional and environmental inheritance information from one generation to the next. Multi-generational studies in humans have shown that epigenetic effects can be passed on for up to two generations. Epigenetic inheritance is helping to explain why cancer is linked to bad health choices. The nutritional performance of animals is not solely related to an animal's direct environment and how they have been treated but also how their sire, dam or possibly their grandparents were treated.

Dr Karl Dawson, Vice President and Chief Scientific Officer of Research at Alltech (Lexington, Kentucky, USA), believes that agriculture is in a rapidly changing phase, where more output is required with increased efficiency from a smaller carbon footprint. Alltech's (2017) cutting-edge nutrigenomic technology has enabled scientists to make significant strides, by analysing how diet and health interact from one generation to the next and how nutrition affects an animal at the genetic level. A better understanding of nutrigenomics in lot-fed cattle has identified the ability to improve feed efficiency, growth rates and other important traits through the use of probiotics, prebiotics, trace minerals and vitamins, while excluding conventional ionophore and growth hormone usage.

Conventional beef cattle genetic selection is a slow and unpredictable method of progression. Nutrigenomics is fast paced, producing change almost immediately, and information can be gathered while cattle are still alive. Alltech uses a specialised gene chip, or Single-Nucleotide

Polymorphism (SNP) chip, that analyses tissue samples to show how a change in diet or environment can affect gene expression and this can happen almost instantaneously. The SNP chip has more than 22,000 data points that show if a specific gene is turned on or turned off. Nutrigenomics can be perceived as 'fine-tuning' the metabolism to help the animal to better adapt to stressful periods, such as a change in environment or diet. Specialised software is used to analyse the high volume of data so researchers are able to identify the pathways that have been most affected by the dietary or environmental change. The dramatic decrease in time needed to conduct and evaluate this research allows nutrigenomics to fast-track alternative intensive animal production systems and produce genetic gain.

The science of nutrigenomics has identified the specific feed additives necessary to optimise lean tissue deposition in beef cattle being fed under intensive systems. Lean muscle tissue volume is a key performance indicator in feedlot cattle. Nutrigenomic research has discovered both what has changed (i.e. increased weight gain) and why it has changed (i.e. improvements in energy metabolism), with the identification of metabolic pathways which are crucial to muscle growth.

EPNIX, developed by Alltech research, certified by IMI Global, is a two-stage feedlot technology program targeting the introductory and finishing stages of lot-fed cattle and is 100% organic, designed without the need to use antibiotics, antimicrobials or beta-agonists. The EPNIX formulation utilises probiotics, trace minerals, algae and yeast formulated to optimise rumen function and metabolism, bringing innovation and value to feedlot production. Repeatable, large-pen studies have been conducted where EPNIX has demonstrated improvements in overall performance, including dressing percentage, while maintaining carcass weights (Alltech, 2015). The supplement is registered for use in U.S. raising claim (a trade description claim specifically relating to animal husbandry conditions including feeding, handling, drug treatments and/or geographical references) and labelling systems including the Never Ever 3 program.

Chapter 6: Labelling Systems

In 2016, the Australian Government introduced new requirements, making labelling of food clearer, including where products are grown, processed, made or packed with a mandatory country of origin labelling (CoOL) system. The new system includes the familiar triangular green and gold kangaroo logo, with bar charts indicating the origin of products. Food Standards Australia and New Zealand (FSANZ) are the governing body for the Food Standards Code (FSC), the labelling system used in Australia. The FSC includes general labelling requirements, as well as the information requirements relevant to varying food products. FSANZ, in addition to the FSC, requires that all food claims abide by fair trading laws, food quality laws and do not contain any misleading or deceptive information.

In 2014, the MLA and Australian Meat Processor Corporation (AMPC) were requested by ALFA, the Cattle Council of Australia (CCA) and the Australian Meat Industry Council (AMIC), to commission a White Paper on the future of the language used in the Australian beef industry, because the last formal review was done when AUS-MEAT was formed in 1980. The White Paper recommendations will be used to modernise the industry, to ensure greater consistency and to better reflect the requirements of consumers (Biddle, et al., 2016). The outcome of the paper represents a whole-of-chain approach to delivering requirements of both international and domestic customers and consumers. The White Paper further specifies the industry language necessary to explore the potential new objective and list subjective descriptors for each stage (production, processing, wholesaling, retailing and consumer) in the red meat value chain (Biddle, et al., 2016).

Australian consumers identified that price was the most important aspect of food selection across four differently processed food types, including fresh food and highly processed food. CoOL ranked third overall with an average of 20% of consumers concerned with CoOL (Department of Industry and Science, 2015). Increasingly, consumers want to make food choices that are perceived to be more natural. Consumer's increased awareness of an antibiotic-free option, among other 'free' options, is spurred by reports of antibiotic resistant super bugs and antibiotic residues in meats. Companies like Subway and McDonalds have reported that they will cease selling meat products, within the next few years, that are not antibiotic-free. But questions remain, including the feasibility and sustainability of raising livestock in an antibiotic-free environment in sufficient numbers to feed an ever-growing population of meat eaters and what this means in added cost to consumers. If such claims are being made by large processed food corporations, the industry needs to have a third party certification system in place to guarantee consumer trust.

Figure 5:Whole Foods Market poster displayed in the meat section identifying antibiotic and growth hormone free products, September 2016 (Global Animal Partnership, 2016). Source: Author

The beef industry is the largest Australian agriculture industry, with the feedlot sector playing a major role. Chicken is the most consumed meat domestically; this dominance has been helped by their industry governing bodies creating certification programs to produce RSPCA approved, free range, antibiotic and hormone-free products. The Australian beef industry finds itself in the same space the egg industry was a number of years ago, in regards to raising claims for the status of animals. While there is a clearly defined space in the Australian industry for grain fed cattle, where a third party auditing system is in place, there is an emerging requirement for an equivalent claim for 'natural', grain-assisted and antibiotic-free product claims. There is a vast proportion of the Australian market that falls somewhere between the two (pasture-fed and grain fed) product claims. Grain fed beef can increase market share, in both the domestic and export markets, by producing equivalent antibiotic-free beef products and capitalise internationally on Australia's existing 'clean, green' image.

With 74% of Australian beef exported (MLA, 2016) and Australia's legislation stating that any trade description applied to a product must be true and accurate and include these claims on the label or attached to the product. AUS-MEAT is Australia's national industry body that is responsible for establishing and maintaining a uniform trade language for meat and livestock, providing accurate descriptions associated to the export of meat. The counterfeiting of meat and other foodstuffs, especially in export markets like China, is a multi-billion-dollar per year industry. There are cases where well-established beef brands will not sell into the Chinese market, due to the lack of perceived brand integrity because of the ability and willingness to counterfeit vacuum packaging and carton labels. Substitutions are not always in beef products. It is expected that, due to the increase in the rising price of beef, the counterfeiting issues faced by Australian beef exporters will increase. Companies are looking to developing technologies to counteract the problem with invisible, inorganic, trace mineral identification.

The industry language describing these types of raising claims descriptions for cattle is a current issue for the sector (AUS-MEAT Limited, 2017). Terminologies and standards need to be more representative of the existing industry and all the production systems that are in place. The requirement to change the existing system and to include other claims was highlighted by a 2016 incident, where a prominent national grassfed carcase competition was won by animals that were known to have received a grain-based supplement in a paddock situation, thus being grain-assisted (Condon, 2016).

The current Pasture-fed Cattle Assurance System (PCAS) may confuse the issue somewhat, with the assumption that it is a verifiable raising claim; although it is an assurance program, it is not a recognised claim implemented by the AUS-MEAT language and standards committee (AUS-MEAT Limited, 2017). PCAS is owned and managed by the CCA with the support of MLA, who are responsible for the standards and management of the producer database and certification requirements. AUS-MEAT, however, have developed an animal raising claim identification framework suitable for all aspects of Australian production systems (AUS-MEAT Limited, 2017).

AUS-MEAT industry-based raising claim descriptors (AUS-MEAT Limited, 2017) include:

- Organic
- Free range
- Pasture fed
- Grain fed
- Fodder fed
- Raised without hormonal growth promotants
- Raised without antibiotics
- Raised without sub-therapeutic antibiotics
- Never Ever 3 (no HGP, no antibiotics, whole of life)
- Natural

Organic, free range, pasture fed, grain fed and HGP free claims are easily describable where a pre-set, clear, definable set of requirements can be established. "Raised without antibiotics" and "Never Ever 3" are more difficult to describe clearly and to certify. As stated by Mr Allan Bloxsom, Chairman of AUS-MEAT language and standards committee, these raising claims are only applicable to export products, as there is no AUS-MEAT jurisdiction in domestic trade (Condon, 2016). Industry bodies have expressed a desire to have both domestic and export trades utilising the same set of descriptors for raising claim frameworks.

In the U.S. food labelling changes started in the 1970's, which highlighted a fundamental shift in the regulatory protocols to aid consumer understanding of products. The USDA now has over 750 product label claim requirements. The USDA defines the meat label claims for U.S. meat products as (USDA, 2005):

- Natural: a product not containing artificial, chemical or synthetic ingredients and has not been more than minimally processed. It is not a raising claim.
- Organic: any product that contains a minimum of 95% organic ingredients (excluding salt and water); up to 5% of the ingredients may be non-organic agricultural products that are not commercially available in an organic form.

- No Antibiotics Added: documentation is required demonstrating animals were raised without antibiotics, which is provided to the USDA's Food Safety Inspection Service (FSIS).
- No Hormones Added: producer documentation is required and is provided to the FSIS, showing that hormones were not used in raising the livestock.
- Never Ever 3: a bundled marketing claim associated with a verification program claiming no antibiotics, no hormones and no animal by-products fed at any point in the animal's life. FSIS documentation is required.

Conventional meat still dominates retail sales in the U.S., but the rapid sales growth of products with 'free' or 'natural' claims is rapidly changing. More suppliers and fast-food restaurants are changing to antibiotic-free inputs, or have plans to do so in the near future, and the growth of products with these label claims demonstrates no signs of slowing.

Chapter 7: Research Outcomes for Ionophore-Free Feedlotting Systems

Case study 1: Alltech conducted commercial trial

Alltech, a privately owned, non-pharmaceutical company, that has been certified by IMI Global, have developed a management program utilising nutrients and nutrient strategies to maximise the animal's ability to express its genetic potential. The program can achieve better health, improved performance and increased profitability and has been through a rigorous testing program in feedlot trials.

Alltech's programmed nutrition feedlot additive, EPNIX, consists of 100% organic minerals, contains no antibiotics, antimicrobials or beta-agonists and was trialled at the Wrangler Feedyard, Cactus Feeders, Texas. The trial consisted of 1,928 head on feed for 169 days where the Alltech products were compared to conventional trace mineral sources which included ionophores (Alltech, 2015). The trial showed cattle fed the Alltech additives showed an increase in carcase weight of 6.4 kg, an increase of dressing yields of 4.6% and an increase in rib eye area of 1.5 cm^2 (Alltech, 2015). The benefits for cattle fed the Alltech additives increased their profit by $18 per head. When coupled with a 5% increase in carcass premium (for being antibiotic-free), this would increase profit by $155 per head (Alltech, 2015).

Although Alltech is the only company that gave the author access to the results from ionophore-free research, there are other companies exploring the options of ionophore-free feedlot rations.

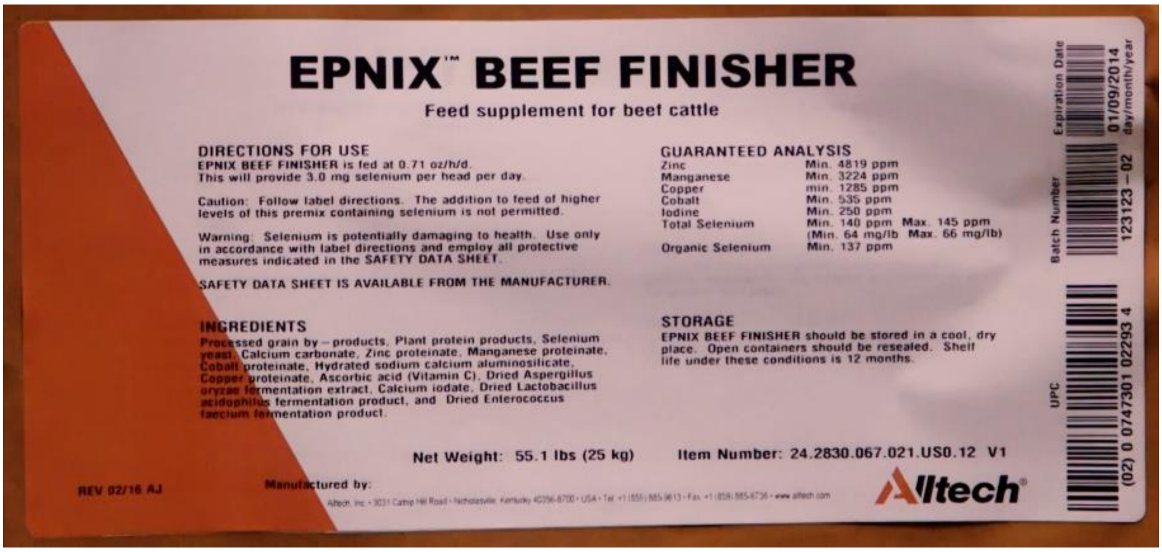

Figure 6: Alltech's EPNIX Beef Finisher product label showing ingredients, composition and directions for use. Source: Alltech product label

Case study 2: Small commercial trial on the author's farm

A small feedlot trial has been conducted at the Manchee Agriculture feedlot, incorporating a group of mixed-sex, Shorthorn weaners, comparing a conventional ionophore and trace mineral ration to an equivalent ration utilising Alltech's Blueprint Beef Up™ concentrate, which is ionophore-free.

Two pens consisting of 85 mixed sex weaners with the same male to female ratio, were fed for 60 days. All weaners were bred on property and came from a single management group. The weaners were weaned at an average of six months and introduced to feed on the 8th February 2017 with the final weight date of the 10th April 2017. All animals were treated in the same manner and went through the same production cycle and were not treated with an HGP. The ration fed to the weaners is considered a grower ration rather than a fattening or finishing ration (as the cattle being fed are to be retained as breeders) and does not meet the minimum standards for grain-fed certification. The feed analysis ration report (Feed Central, 2017) analysed fibre at 49%, energy at 9.4MJ and protein at 12.7%.

Both rations were equivalent in their content, except for the feedlot additives, both added at 2%. The conventional ration containing ionophores and trace elements included 2% of BEC 2% Beef Feedlot mix, which contains the ionophore monensin. The ionophore-free ration additive was Lienert Blueprint Beef Up, an Alltech product produced by their Australian company, Lienert, which is a vitamin and mineral concentrate containing probiotics, rumen buffers, yeast and is based on Alltech's nutrigenomic research.

The trial showed evidence of better weight gain and feed intake in the pen of cattle that received the ionophore-free Beef Up feed ration. Weight gain was 7% better in this pen when compared to the animals that received the BEC ration (Figure 7). The largest improvement was in net feed intake in the Beef Up fed pen being 22% better than the BEC pen of weaners. A substantial difference in intake was noticeable as the trial progressed, with a 161 kg difference in the quantity of feed being fed per day, totalling approximately 9,660 kg more feed being fed to the BEC pen of weaners over this period of the trial (Figure 8). This equates to a total of $937 more spent on fodder for the BEC pen where the base cost per tonne of feed is $97 (excluding supplementary additives).

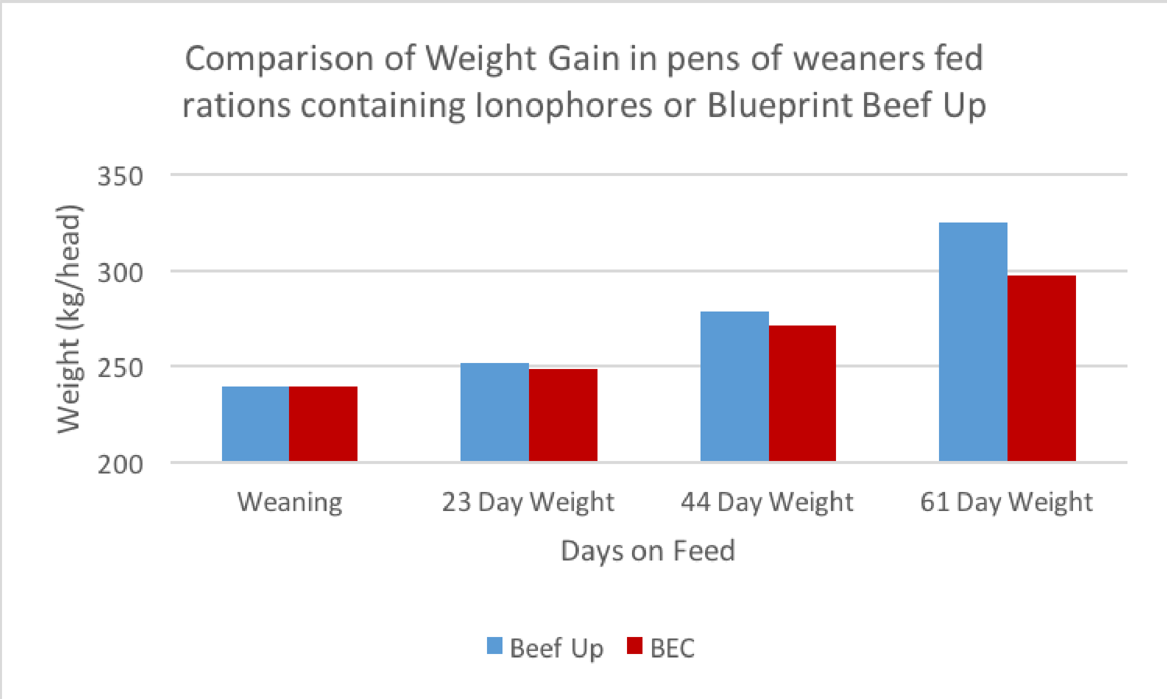

Figure 7: Results of a trial conducted at Manchee Agriculture, comparing weight gain of animals when fed a conventional feedlot ration utilising ionophores and a ration containing Blueprint Beef Up

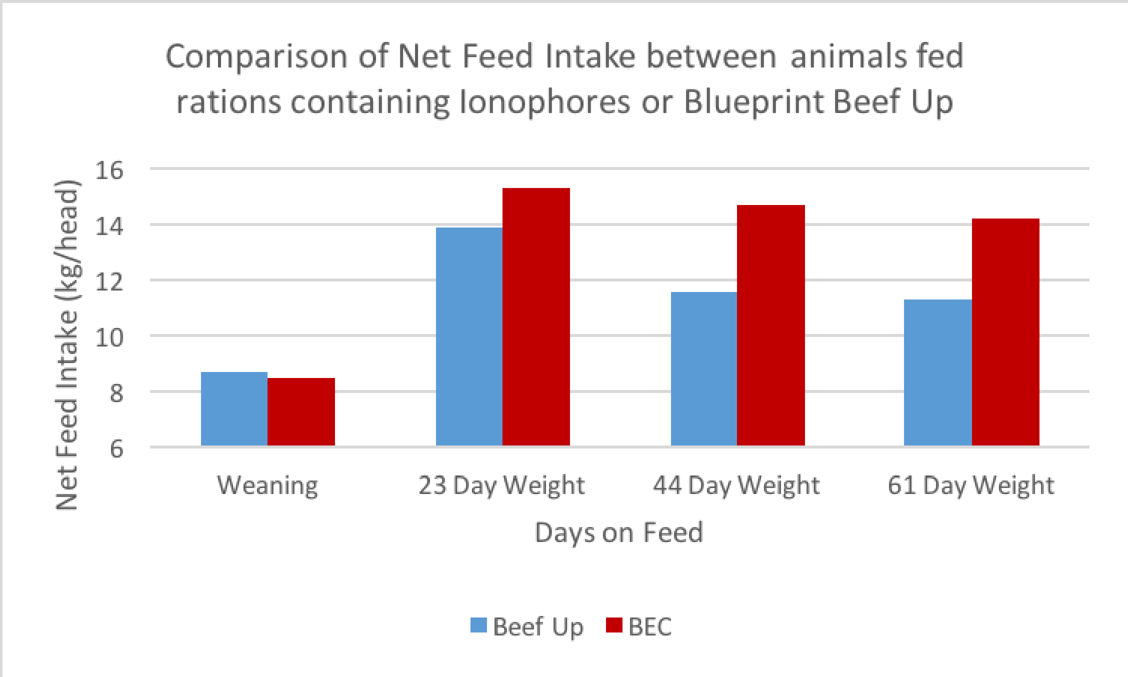

Figure 8: Results of a trial conducted at Manchee Agriculture comparing Net Feed Intake of animals when fed a conventional feedlot ration utilising ionophores and a ration containing Blueprint Beef Up

Although there is a considerable cost difference between the BEC product at 0.27 cents per head per day compared to the Beef Up product at 0.89 cents per head per day the cost per kilogram of liveweight gain per head was in reverse. The BEC product cost $1.36 to gain one kilogram of liveweight verses the Beef Up product cost was $1.29 for one kilogram of liveweight. Therefore, the cost saving on the ration content and the added live weight gain has made the Beef Up ration the preferable option.

There were some visual (subjective) differences in observations of the two pens of animals. The pen of weaners on the Beef Up ration were more content and less active, consumed less feed, had less nasal discharge over time and there were fewer animals treated for respiratory issues. The pen fed the BEC ration appeared fuller and better in the coat. Both pens appeared to utilise the available feed similarly. There were three animals treated for respiratory issues in the conventionally fed pen and one animal treated in the pen fed Beef Up. With the added input of fibre, the faecal matter output was greater and visually noticeable, in the BEC pen of weaners.

This trial gives a real-world example of both products used in a realistic producer based program. It was evident the weaners fed the Beef Up ration did better whilst consuming less over the course of the 61 days. Replication of this trial would be necessary at various times of the year to identify the consistency and accuracy of the results. This trial has not taken into account the premium an antibiotic-free product would attract commercially. Overall the trial showed evidence that antibiotic-free alternatives are available and can make an economic difference to the bottom line profit.

Conclusion

Antibiotic resistance in bacteria has serious implications for human medicine and is a major concern globally. Although misuse of antibiotics is primarily an issue in human medicine, caused by the mis-management and over-use of prescriptions, animal production systems need to recognise that the use of antibiotics is a contributing factor to resistance. The WHO is concerned that, due to the lack of development of new antibiotics, it is increasingly difficult to justify antibiotic use in feedlot production as a preventative measure (Iredell, et al., 2016). Feedlot production systems, as the end-user of antibiotics, must be made aware of the antibiotic resistance issue that exists with both the use of therapeutic and sub-therapeutic antibiotics. However, having antibiotics available for therapeutic use in feedlots to treat sick animals is important to maintain good animal welfare practices.

The technological advancement in nutrition, nutrigenomics and genomics will continue to be important to the beef industry as a whole and the benefits will be utilised by the feedlot industry. To maximise these new systems and technologies, the need to continue early adoption of proven methods is vital. Although ionophores are not used in human medicine, and the WHO does not identify ionophores as medically important, the potential of increased antibiotic resistance will always be a potential risk through their continued use (Iredell, et al., 2016). The WHO identifies that antibiotic resistance is a critical global health issue.

The exploration of alternative rumen antimicrobial agents for use in the feedlot industry is important. The current alternatives to ionophores includes alternative ration formulation including the use of rumen pathogen binders, management systems, pen/housing systems and the development of vaccines. For the foreseeable future, ionophores have a place within the industry, primarily in cattle that have low feed conversion efficiency, or where the cost of production needs to be minimised to allow profitable sale of lesser quality meat. Ionophore use in the industry will remain relevant for as long as the WHO continue to consider them unimportant, Minimising ionophore use may be beneficial in the longer term. Commercial trials have been conducted demonstrating clear benefits for some alternatives to ionophore use.

The industry has the capability to find a balance between conventional feedlotting and an ionophore-free alternative and this, in turn, will provide greater opportunities for producers to meet customer demands for antibiotic-free products. If consumer-driven requirements for antibiotic-free systems increases overall consumption, the implementation of a certified system for raising claims that functions effectively for both producers and consumers will benefit the industry's growth.

It is crucial that quality assurance programs pertaining to antibiotic stewardship are implemented to address responsible use of antibiotics, increase awareness of the correct usage, minimise tissue residue and limit development of further resistance to important human antibiotics.

The complexities of the ongoing use of, or the removal of ionophores, in the Australian feedlot sector is a difficult one to navigate. However, it is unclear if the use of antibiotics as a preventative measure increases the chance of antibiotic resistance (Barton, 2001), coupled with the understanding that ionophores are not considered important in human medicine (WHO, 2011), only complicates the issue. Consumer awareness and purchasing habits are also adapting, requiring more product detail and raising claim information on the label. Explaining the difference between the use of ionophores and other antibiotics may be difficult. The industry might take a proactive move towards implementation of an alternative system as a method of moving seamlessly away from the continued use of ionophores over a period of time. Continued research and development in newly emerging fields may help sustain the industry into the future.

The ethical responsibility held by food-producers in animal production to curb resistance whilst maintain animal welfare is a tight line to walk, especially when the current production system is resulting in good animal welfare and ionophore use is considered an acceptable practice by medical bodies, governing bodies and industry. The feedlot industry needs to consider how systems of production will develop, taking in mind the ethical dilemma of how the use of ionophores will impact society and to raise, confront and enact some difficult ethical decisions regarding their use.

Recommendations

In future the Australian beef cattle industry should:

- Research, develop and implement antibiotic-free feedlot systems to find a balance between conventional feedlot production and an antibiotic-free system.
- Carry out research and development in nutrigenomics, with the implementation of knowledge gained to be trialled in an existing feedlot production system for further commercial development.
- Further develop antibiotic residue and assurance programs to limit the possibility of additional pathogen transfer between cattle and humans.
- Develop a raising claim scheme which includes a certification system for both domestic and export product claims, working in parallel with the existing beef production systems.
- Educate beef producers about the effect of misuse of all classes of antibiotics in production systems.
- Work with industry partners to kerb the counterfeiting of Australian beef in export markets.
- Encourage the adoption of the use of the ICAR animal identification system for databases with the intention of utilising multi-breed genomics.

Appendices

Glossary

Anticoccidial - prevention and control of coccidial infections.

Anti-inflammatory - medication designed to reduce inflammation.

Antimicrobial - products which inhibit or destroy the growth of microorganisms, bacteria, fungi, protozoa and viruses.

Antimicrobial stewardship - coordinated interventions promoting the appropriate use of antimicrobials to decrease the potential development of multidrug-resistant organisms.

Beta-Agonists - drugs that combine with and activate a beta-receptor, used to improve muscle deposition, growth rate, feed efficiency and carcass leanness.

Bloat - a digestive disorder due to the accumulation of gas in the rumen which causes swelling on the left side of the animal and can cause death.

Coccidiosis - a disease that affects the intestines caused by coccidian protozoa.

Docosahexaenoic acid - an omega-3 fatty acid essential for brain function.

Epigenetics - the modification of gene expression that does not involve changes to the genetic code in response to nutritional or environmental factors, resulting in changes in individual gene activity.

Genetics - the study of heritability of a genetic trait, how they vary from subject to subject and quantifying how they are passed onto subsequent generations.

Genes - instructions written in DNA sequence for making the proteins that carry out all biological functions.

Genome - a collective term for all genes and DNA present in an organism.

Genomics - a genetic field that studies and analyses the genome sequence.

Ionophore - an antimicrobial (antibiotic) that improves nutrient availability, used to improve feed efficiency and weight gain and to reduce the instance of bloat, acidosis and coccidiosis.

Microbe - a single-celled organism which includes bacteria, archaea, fungi and protozoans.

Nutrigenetics - the study of how genetic variations affect responses to nutritional changes.

Nutrigenomics - The study of how nutrients affect gene expression. Nutrigenomics is a branch of epigenetics whilst, technically, nutrigenetics is not.

Prebiotic - a substance that promotes the growth of beneficial intestinal microorganisms, particularly beneficial to promoting probiotic activity.

Probiotic - a substance that stimulates the growth of microorganisms, particularly beneficial to intestinal flora.

Prophylactic – a substance or device used for preventing disease.

Prostaglandin - a group of hormones used in artificial breeding programs.

Raising Claim - a claim made in the trade description or export documentation about the animal or supply chain specifically relating to animal husbandry conditions, feeding, handling, drug treatments and/or geographical references.

Sub-therapeutic - a dosage below a therapeutic level.

Synbiotic - a product containing both prebiotics and probiotics.

Therapeutic - have a healing effect on the body as a whole.

Interviews

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Plain English Compendium Summary

Project Title:	Alternative use to Ionophores in the Feedlot Industry
Nuffield Australia Project No.:	1604
Scholar: Organisation: Phone: Email:	Liz Manchee Wallah, Narrabri, NSW 2390 0427 936213 liz@manchee.com.au
Objectives	Determine alternative options to in-feed ionophores for use in the Australian feedlot industry and defining production issues which may arise from ionophore-free rations. Identify antibiotic resistance issues pertaining to the use of ionophores in the feedlot industry and outline issues with their continued use. Explore the benefit to the beef industry that genomic and nutrigenomic advancement can have.
Background	Consumer awareness and demand is changing food production methods, as perception is evolving towards more 'natural', 'clean' and 'free' products. The continued use of ionophores in the industry may be short-lived and alternatives needed to be explored.
Research	Participation in the Contemporary Scholars Program and the Global Focus Program, along with eight weeks personal travel, visiting research stations, businesses, scientific departments and universities in Ireland, United Kingdom, France, Italy, Slovenia, Croatia, America, Mexico, Brazil, New Zealand and Australia.
Outcomes	The feedlot industry needs to be proactive in research and development in a move to reduce the reliance on ionophore use. Antibiotic stewardship needs to be implemented in the beef feedlot industry, which needs to be educated in the alternatives to antibiotic use.
Implications	Ethical responsibility for antibiotic use in animal production, to reduce antibiotic resistance and maintain animal welfare, is a difficult goal for the industry. Antibiotic resistance is a serious human health issue that needs to be addressed.