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Declarations of interest

All experts and resource people were asked to complete a declaration of interest form before participating in this meeting. These were reviewed by the FAO Secretariat for potential conflicts of interest. Many experts declared to be involved in activities related to this meeting; however, none of the interests declared was considered to present a specific conflict of interest. Four experts indicated specific interests and private sector activities that could represent a conflict of interest: Barbara Brutsaert, Jules Taylor-Pickard, Lea Pallaroni and Roopa Krishan Reddy. Due to their specific knowledge and the importance of expertise, the Secretariat was of the opinion that the interests declared by these experts should not prevent them from participating in the meeting as resource persons and contributing to the discussions - including the formulation of conclusions and recommendations.
Abbreviations and acronyms

AGP  antimicrobial growth promoter
AMP  antimicrobials peptide
AMR  antimicrobial resistance
DFM  directly fed microbials
FOS  fructo-oligosaccharides
GOS  galacto-oligosaccharides
GRAS  generally recognized as safe
LAB  *Lactobacillus* and *Bifidobacteria*
MCFA medium chain fatty acids
MOS  mannan oligosaccharides
SCFA  short-chain fatty acids
TCM  Traditional Chinese Medicine
TEM  Traditional European Medicine
TIM  Traditional Indian Medicine
TMR  total mixed ration
TNA  total nutritional approach
WHO  World Health Organization
WOAH  World Organisation for Animal Health
XOS  xylo-oligosaccharides

Definitions

**Advanced and alternative feeding practice:** a combination of precision feeding (optimal macro and micro-nutrients and optimal feed practice) and feed additives increasing feed efficiency, animal health and productivity.

**Feed (Feeding stuff):** Any single or multiple materials, whether processed, semi-processed or raw, which is intended to be fed directly to food producing animals (FAO, WHO, 2008).

**Feed ingredient:** A component, part or constituent of any combination or mixture making up a feed, whether or not it has a nutritional value in the animal’s diet, including feed additives. Ingredients are of plant, animal or aquatic origin, or other organic or inorganic substances (FAO, WHO, 2008).

**Feed additive:** Any intentionally added ingredient not normally consumed as feed by itself, whether or not it has nutritional value, which affects the characteristics of feed or animal products (FAO, WHO, 2008). Micro-organisms, enzymes, acidity regulators, trace elements, vitamins and other products fall within the scope of this definition depending on the purpose of use and method of administration.
Executive summary

Multiple opportunities and examples for advanced feeding practices and functional feed additives were identified that allow for the safe and effective replacement of antimicrobial growth promoters (AGPs) and the overall reduction of the need to use antimicrobials in livestock systems.

The nature of these feeding strategies is diverse, allowing a tailored approach for individual animal species and age- and production groups. Moreover, feeding practices and sustainable livestock system rely heavily on the availability of feed and feed ingredients in each geographic region. The many alternatives identified in this report include the use of locally produced feed ingredients and feed additives as well as products originating from a circular economy. They consider also the incorporation of a total nutritional approach will support the withdrawal of antimicrobials as growth promoters and contribute to an overall reduction of the use of antimicrobials in livestock farming.

Feed additives and various functional feed ingredients improve gut health and the innate immune system by direct interaction with the gut microbiota, the main target of the previously used AGPs. The various feed additives described are also able to stimulate additional physiological functions of the intestines, such as the secretion of endogenous digestive enzyme and bile fluid and hence feed digestion. Moreover, a support of gut barrier integrity and intestinal immunological defense mechanism are common targets and biomarkers of efficiency as these parameters are related to the overall resilience of animals to infections and environmental stressors, thereby reducing the need to use antimicrobials for the maintenance of animal health and welfare.

Feed additives used in the replacement of AGPs are generally blends composed of different classes of feed additives to achieve optimal health benefits also under varying physiological and environmental stress conditions. Current limitation for the use of such blends can be lack of defined identity of all ingredients, standardization of composition and quality assurance, and regulatory hurdles in the evaluation of complex mixtures of natural ingredients, as well as cost-efficiency.

Many feed ingredients and additives improving gut health have a history of safe use in human and animal health care, and are generally considered as safe. Nevertheless, a major prerequisite for the ultimate use of feed additives in the replacement of AGPS is the setting of standard for a transparent pre-marketing authorization proves including the assessment of efficacy and safety for the target animal and within the food chain, including the safety and quality of animal-derived products such as milk, meat and eggs. Such transparent standards encourage feed and livestock producers to replace AGPs and to join others in their commitment to prevent the further spread of antimicrobial resistance, one of the major health hazards in the coming decades.
1. Introduction

1.1 Background

The global increase of resistance of microorganisms to antimicrobials essential in the treatment of infectious diseases in humans and animals demands a responsible and prudent use of all antimicrobial agents including the use in animal production and crop protection. As demanded by the World Health Organization (WHO, 2024) the responsible and prudent use of antimicrobials needs to be improved in all sectors - human, animal, plant/crop, and environment - to preserve their public health benefits. In particular, antimicrobials that are medically important for human medicine (WHO, 2024) need to be preserved by reducing their use in the non-human sectors. In addition, the availability of effective antimicrobials in diseased animals remains essential for animal health and welfare, and food security and have implications for food safety and public health.

Antimicrobial resistance (AMR) is an evolutionary process by which microorganisms adapt to their surrounding environment. It is exacerbated by an abundant antimicrobial use in human and animal healthcare and in the food and agriculture sectors. Transmission of multi-resistant microorganisms, particularly bacteria and their resistance genes occur via direct contact, but also via the environment and the entire food chain, emphasizing the need for a combined One Health Action Plan (FAO, UNEP, WHO and WOAH. 2022). Effectively addressing AMR requires the feed and livestock sector to join others in their commitment to implement practices that minimize the need to use antimicrobials in animals.

Antimicrobials have been used in the animal feed sector for about 70 years, not only in the prophylaxis, metaphylaxis and treatment of diseases but also to promote growth and performance, improve feed utilization, prevent infections and reduce mortality. Many of these substances used in agriculture belong to the same classes as the medically important antimicrobials as identified by the World Health Organization (WHO, 2024) and according to the World Organisation for Animal Health (WOAH, previously denoted OIE) are also of veterinary importance for animal health (WOAH, 2021).

As a result, concerns have arisen about the potential risk for the selection of resistant microbial populations and the transfer of resistant bacteria and fungi between animals and humans by direct contact or via the transmission of resistance genes and mobile elements along the food chain and in the environment. An overall reduction in the use of antimicrobials in animal production, especially limiting the use for growth promotion purposes, e.g. antimicrobial growth promoters (AGPs), is considered as an important risk mitigating measure. Subsequently the use of AGPs as feed additives for use in animal nutrition were banned in some countries already in 1999. Within the European Union (EU) the ban of AGPs as feed additives was implemented in 2006 following the amendment of REGULATION (EC) No 1831/2003 in September 2003. This European ban was strengthened recently by prescribing the compliance with the ban of AGPs as growth promoting agents as a prerequisite for the import of animal-derived products into the EU (DELEGATED REGULATION (EU) 2023/905 of 27 February 2023). This strategy is in the meanwhile endorsed and implanted by many important livestock producing countries such as the USA, Brazil, China and others. It should be noted that this delegated regulation applies only to the use of AGP as feed additives and not to antimicrobials used for therapeutic, metaphylactic and prophylactic purposes in animal health care.
The concern about the public health risk associated with the broad use of antimicrobial agents, particularly such antimicrobials that are important or even essential in human health care, has resulted in a re-evaluation of potential alternatives. Increasing insight in animal nutrition, improved animal husbandry and advanced feeding practices were found to allow the replacement of AGPs use in livestock production. These new insights into animal nutritional needs at different phases of life, nutritional physiology (the importance of gut health and microbiome management) and improvements in feed technology not only in rations for farm animals but also for diets for companion animals and aquatic species, is now contributing to a broad reduction of the global use of antimicrobials and other antimicrobials in animals, thereby further implementing the demand for a responsible and prudent use of antimicrobials.

For these reasons, the FAO Committee on Agriculture Sub-Committee on Livestock (the Sub-Committee) has requested FAO to collect scientific evidence on alternative feeding practices to replace the use of medically important antimicrobials used as growth promoters, their effectiveness and safety, and to conduct an inventory of these alternative feeding practices. In addition, the Sub-Committee has requested FAO to share successful experiences and good practices, including traditional knowledge (e.g. the use of traditional remedies to improve animal health and sustainability), to support its Members to reduce the need for antimicrobials, and to collect data on the impact of measures to phase out or ban the use of medically important antimicrobials used as AGPs on livestock production, health and welfare.

1.2. Objectives

The objectives of this document are:

- to provide science-based information on advanced and alternative feeding practices and their possible impact on the use of AGPs, and to reduce the overall need to use antimicrobials in farm animals, considering the effectiveness and safety of those practices;
- to present successful experiences, advanced technologies and good practices, including traditional knowledge (e.g. the use of traditional remedies and natural products enhancing feed efficiency and animal productivity) to reduce the need for antimicrobial use in animal production;
- to make an inventory of these alternative and advanced feeding practices; and
- to collect information on measures to phase out or ban the use of AGPs and their impact on animal health, welfare and productivity; and food safety.
2. General principles of advanced and alternative feeding practices

Successful livestock production depends largely on good farming practice and animal nutrition as prerequisites for animal health and productivity. Additional benefits can be achieved by selective animal genetics, biosecurity and hygiene measures, improved disease control through vaccination, as well as targeted nutrition and optimization of feed quality. These measures and requirements are specific for each animal species and production group and need to be monitored and accompanied by data-recording, diagnostic measures and veterinary oversight to monitor animal productivity, health and animal welfare under normal conditions and in situations of physiological and environmental stress. With the global emergence of antimicrobial resistance, monitoring of the use of antimicrobials and the distribution and spread of resistant bacterial isolated have been added to the demands for a sustainable animal production (FAO, 2021).

2.1. Advanced feeding techniques and the role of the Total Nutritional Approach (TNA)

The objective of a Total Nutritional Approach is to meet the nutritional demands of an animal at a defined production level and/or physiological status and under different environmental conditions. Animals should receive a balanced diet containing the required energy, protein, minerals, and vitamins as well as water and all essential micronutrients. In addition, advanced techniques in feed processing to retain the nutritional value of (heat-) sensitive feed components, and measures to prevent feed spoilage and oxidation and to improve feed palatability, digestibility and utilization are targets of TNA.

Table 1. Elements to consider in a Total Nutritional Approach.

<table>
<thead>
<tr>
<th>Basic nutritional requirements of the animal</th>
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<tbody>
<tr>
<td>Precision feeding for various stages such as</td>
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<td>- Early life nutrition</td>
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<tr>
<td>- Transition phases</td>
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<tr>
<td>- Production stages</td>
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<tr>
<td>- Stress (physiological, environmental)</td>
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<tr>
<td>Feed processing technology</td>
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<td>- Feed presentation (pellets, mash, particle size) production technology</td>
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<tr>
<td>- Diet formulation and mixing</td>
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<td>- Extrusion methodology and vacuum coating</td>
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<td>Feed and feed ingredients</td>
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<tr>
<td>- Safety (biological, chemical, physical)</td>
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<td>- Nutritional value and digestibility of ingredients</td>
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<td>- Resources and grazing systems</td>
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<tr>
<td>- Sustainable and alternative feed sources in different geographic regions</td>
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The contribution of animal nutrition as a strategy to reduce the need for the use of antimicrobials has been already addressed in another FAO publication (Smits, C.H.M., Li, D., Patience, J.F. and den Hartog, L.A., 2021). This publication addresses among others the general principles of gastrointestinal digestion and defense mechanisms, the development of the defense system in young animals and the dietary toolbox to support gastrointestinal defense, water allowance and water quality, feed safety and quality, feeding level and feed form and particle size, and the nutritional value and needs of protein, starch and sugars, dietary fiber, calcium, phosphorus and sodium, copper, zinc and vitamins. These feed ingredients were related to an optimal dietary strategy for swine and poultry of different age groups, and ruminants. In the conclusions, this report stated that functional nutrition to promote animal health is one of the tools available to decrease the need for antimicrobials in animal production, as nutrition affects the critical functions required for host defense and disease resistance. Advanced animal nutrition strategies should therefore aim to support these host defense systems and reduce the risk of the presence in feed and water of potentially harmful substances, such as mycotoxins, anti-nutritional factors and pathogenic bacteria and other harmful microbes. The targeted use of a combination of feed additives and feed ingredients to stabilize the intestinal microbiota and support mucosal barrier function is a key element in animal health, disease resilience, and productivity. These measures and knowledge could be used to establish best practices in animal nutrition and could allow to reduce the need for antimicrobials, including antimicrobial growth promoters thereby contributing to the containment of antimicrobial resistance.

In line with these conclusions, the current report focusses on the description of functional ingredients and feed additives that improve feed quality and safety and support animal health and productivity.

2.2. Objectives of advanced feeding techniques and the use of feed additives to improve animal health and possibly replace AGPs

The current objectives of advanced feeding techniques include:

- increase nutrient utilization and feed efficiency;
- reduce the impact of environmental and physiological stressors thereby improving animal health and welfare;
- reduce undigested nutrient excretion (cost-effectivity) and the adverse impact of livestock production on the environment (nitrogen and phosphorus excretion, methane and other undesirable emissions);
- promote feed safety, by advanced sanitation techniques and functional feed additives mitigating the risk of exposure to common environmental pollutants, as well biological, chemical and physical contaminants;
- promote the quality of animal sourced food, such as milk, meat, and eggs; and
- stimulate a sustainable and circular livestock production.

Finally, and as result of the globally increasing demand for animal feed, and hence the increase in the market value for common feed ingredients, it becomes important to use locally produced feed and feed ingredients, and to improve their nutritional quality by advanced and tailor-made feed technologies and the targeted use of advanced sanitation techniques which contribute to feed security and safety (Balehegn, M., Duncan, A., Tolera, A., Ayantunde, A. A., Issa, S., Karimou, M., Zampaligré, N., André, K., Gnanda, I., Varijakshapanicker, P., Kebreab, E., Dubeu, J., Boote, K., Minta, M., Feyissa, F., and Adesogan, A. A., 2020).
3. Alternative and advanced feeding practices and functional feed ingredients

Animal nutrition practice and research have focussed for decennia on the understanding of the physiological processes underlying the digestion of feed ingredients taking into account the species differences in the anatomy and physiology of the digestive tract. The research was able to identify and describe the different enzymes and physio-biochemical processes involved in feed utilization and absorption of nutrients and water. The overall objective of animal nutrition concepts is to compose diets that supply the animal with an appropriate balance of proteins, carbohydrates, fats, vitamins and minerals, thereby promoting health, productivity, and well-being.

The nutritional needs of an animal vary with different production stages and feed utilization is influenced by physiological (early life maturation of the intestines, life-cycle related changes and environmental (temperature, heat) stress factors.

One of the most simple but important strategies to improve the health status of young mammalians is related to colostrum intake. Colostrum supply is important because it is the first energy source for thermoregulation, provides immunoglobulins as well as oligosaccharides promoting the development of beneficial microbiota that enhance immunity and gut health, and increases the resilience against infectious diseases. Early life nutrition and physiological stress conditions like weaning require highly digestible proteins like animal proteins (plasma, egg protein) or processed plant proteins (fermented soybean and concentrate proteins) to provide animals with a balanced supply of essential amino acids.

In consideration of the variability in nutritional requirements, precision feeding programs (tailor-made diets for individual age groups and production stages) also known as smart feeding practices have been developed and implemented for poultry (all categories), pigs, with special emphasis on early life nutrition and weaning, cattle (early life nutrition in calves, dairy cows, different production stages) and are part of advice given by nutritionist and veterinarian at a farm.

Many precision feeding programs include and apply very practical and experience-based knowledge. A typical example is the functional use of high-fiber diets to stimulate gastrointestinal secretions and motility (for example in sows around parturition) or to lower the protein content of diets to avoid excessive protein fermentation in the hindgut. High protein (insect-rich) diets are traditionally used for young chickens and non-digestible oligosaccharides from plants or yeasts are added to the diet of piglets prior to weaning. Special weaner diets often contain aromatic feed additives to mitigate the metabolic and social stress related to weaning and regrouping. Other examples are special feeding programs for calves supporting the transition from the pre-ruminant stage in early life to a functional rumen development, and for dairy cows in the transition phase before and after calving.

Depending on local resources and often based on the concomitant use of traditional feed preservation techniques and the use of herbal remedies (ethnoveterinary medicine) traditional feeding practices should be re-assessed and standardized as they can provide a valuable, and economically viable alternative to the standard programs used in large (industrial) livestock operations. Traditional feeding practices often use feed ingredients (such as fermented feed) and feed additives that are now considered as tools to improve gut health and overall
resilience to infectious disease and hence can reduce the use of antimicrobials and especially AGPs. A compromising factor is the traditional feeding practices are often labour-intensive and that traditional remedies are insufficiently standardized to allow large-scale use. Stimulating a bi-directional knowledge transfer resulted already in increased production and use of feed additives, based on traditional herbal products and spices in the last decade. These products are well standardized employing potent analytical techniques and making use of advanced feed technology such as the application of coatings and related pharmaceutical techniques to guarantee stability and easy applicability in feed or drinking water.

Modern feeding practices are invited to consider also other objectives including the reduction of feed and water spoilage (cost-effectiveness) and the adverse impact of livestock production on the environment (undesirable emissions, nitrogen excretion, emission of greenhouse gases), as well as the global ecological impact associated with the sourcing of feed and feed ingredients. While these aspects are important prerequisites for sustainable livestock production, they do not have an immediate effect on the use of antimicrobials in livestock farming, and hence remain beyond the scope of this document.

In conclusion, revisiting feeding practices based on locally produced crops/plants, and reconsidering experience-based feeding concepts including the use of functional feed ingredients and feed additives could significantly contribute to the improvement of feed security and contribute to the overall sustainability of livestock production. These goals can be achieved with the active involvement of animal nutritionists and veterinarians working in collaboration with farm managers. This objective can be supported by the translation of experience-based practices into modern concepts which are less labour-intensive and better standardizable and reproducible. Knowledge and practical information are keys to achieving this goal resulting in the improvement of animal productivity, health and welfare and ultimately to increased resilience of farm animals to infectious diseases and thereby reduce the need to used antimicrobial agents.
4. Measures and strategies to reduce the need for the use of antimicrobials in farm animals

4.1. Feed ingredients supporting animal health

Nutrition aims to deliver essential micro- and macro-nutrients to the animal but assist and determines endurance and resilience to stress factors. Nutrition supports the innate immune system by supporting the development of the intestinal (and rumen) microbiome, the gut integrity and functionality, and the physiological and immune functions via the gut-associated immune system. This nutritional approach to health promotion, designated as adequate nutrition (Figure 1), reduces reliance on use of antimicrobials. The role of adequate nutrition together with hygiene and health management (vaccination programs) is well established for humans and can be easily translated to animals and livestock farming.

![Figure 1](image)

4.2. Feed additives

The efficacy of feed additives promoted as replacement for AGPs was initially driven by the search for substances that have an antimicrobial effect but did not belong to classes of medically important antimicrobials. The rationale for this approach was the assumption that AGPs, when given at the licensed subtherapeutic doses over longer periods of time, modulate the intestinal microbiota thereby influencing feed conversion and growth rate. The actual benefits of AGPs vary and are related to the herd health status, feed safety and quality, hygiene and farm management practices. At the time of the introduction of AGPs they were an important instrument in the scaling-up of poultry and pig intensive production. Currently, the above-mentioned increasing insight in animal physiology and the nutritional needs of animals at different production stages, has largely decreased the apparent beneficial effect of AGPs. More importantly, the use of antimicrobial agents at subtherapeutic levels increases the selective pressure in the intestinal microbiota of treated animals for resistant bacteria thereby promoting the development and transmission of AMR in bacteria and genes in the animal population and the environment. In consideration of the public health risks associated with AMR, alternatives to the use of AGPs have been developed and are described below.

4.2.1. Bacteriophages and their enzymes

Due to their specificity bacteriophages are gaining increasing interests as potential feed additives particularly against food-borne pathogens such as *Salmonella spp*, *Campylobacter spp*, *Listeria spp* and *Escherichia coli*. An unresolved concern in the use of reproducible bacteriophages is their ability to acquire and transfer bacterial resistance genes. Hence, most applications focus currently on the use of lytic enzymes derived from bacteriophages, as these
have a better safety profile and retain (via a selection of bacteriophages used in the process) the defined spectrum of bactericidal effect without adverse effects on the desirable (commensal) population of gut microbiota. Bacteriophages as such, have been considered by some national regulatory authorities as generally recognized as safe (GRAS) and approved for use in food packaging and preservation under defined conditions ensuring that no reproducible phages reach the consumers.

4.2.2 Antimicrobial peptides

Antimicrobial peptides (AMPs) are cationic peptides that are produced by a wide range of species, as part of tier innate immune system (Huan, Y., Kong, Q., Mou, H. and Yi, H., 2020.). Currently more than 3000 different AMPs have been identified originating from bacteria, insects and mammals (including typical defensins and cathelicidines from livestock species such as sheep pigs and cattle). Their efficacy to affect the integrity and viability of bacteria, viruses, fungi, yeasts and even small parasites have been convincingly demonstrated in *in vitro* experiments. These broad activities and the fact that antimicrobial resistance has never been observed due to their detergent-like effect that differs entirely from the mechanism of action of common antimicrobials, makes them an attractive class of compounds to be used as feed additive in animal feed. Current limitations include high costs in the production of AMPs, the limited stability in feed processing technologies and their potential toxicity in target animal species.

4.2.3. Beneficial microorganisms and their metabolites used to possibly replace AGPs

Beneficial microorganisms, such as Lactobacilli are used for centuries in human nutrition to stabilize intestinal microbiota and to improve gut health. They measurable improved colonization resistance and resilience to enteric pathogens such as *Clostridium perfringens* and *Escherichia coli*, but also suppress zoonotic pathogens like *Salmonella* and *Campylobacter* spp. in line with the concept of competitive exclusion. Suppression of enteropathogenic bacteria was considered as a typical beneficial effect associated with the use of AGPs and the use of protective bacteria (probiotics) and supportive substances (prebiotics) were considered as one of the first alternative strategies to replace AGPs.

4.2.3.1. Probiotics

Probiotics are defined as live microorganisms which when administered in adequate amounts, confer health benefits on the host (Pineiro, M., Asp, N.G., Reid, G., Macfarlane, S., Morelli, L., Brunser, O., Tuohy, K., and J Clin, J. 2008.). This definition was coined originally for human applications, and feed legislation often describes them as directly fed microbials (DFM). The US Food and Drugs Administration broadly defines DFM as “products that are purported to contain live microorganisms.” DFM including bacteria and fungi are currently fed to animals. Bacterial DFM can come from a variety of taxa, although they frequently come from *Lactobacillus*, *Propionibacterium*, *Enterococcus*, and *Megasphaera*. Common fungal DFM is yeast, specifically *Saccharomyces cerevisiae*. Although DFMs and probiotic terminology are frequently used interchangeably, they are not the same entity in actual usage. Most common probiotics belong to LAB (*Lactobacillus* and *Bifidobacteria*) originating from traditional fermented food, including dairy products, which are used primarily in humans. Probiotics used in animal feed are also being isolated from the microbiota of different
livestock species including poultry, swine, and calves. Typical examples of probiotics currently used in animal feed (DFM) belong to the phyla Firmicutes (*Lactobacillus, Streptococcus, Bacillus*), Actinobacteria (*Bifidobacterium*) and yeasts (*Saccharomyces cerevisiae*). The main target and mechanism of action is the modulation and stabilisation of the intestinal microbiota, following the concept of competitive exclusion (of undesirable microorganisms) directly or by an increased production of short-chain fatty acids combined with a reduction in pH. Modern biotechnological techniques (such as 16S rRNA gene and genome sequencing analysis) allow for the investigation of microbial diversity (α- and β-) in healthy and diseased animals across all age categories. They serve as indicators of a positive health effect in the development of probiotics to demonstrate efficacy and to select the dose based on colony-forming units (CFUs) when added to feed.

Production of probiotics (and postbiotics) requires advanced technical knowledge and regular control measures are needed to monitor any undesirable contamination of the fermentation broth used in the production process. In addition, guidance documents for market authorization should be developed to prevent the risk of acquiring and multiplying resistance and virulence genes via plasmids or other mobile elements.

### 4.2.3.2 Prebiotics

Prebiotics are a non-viable food component that confers a health benefit on the host associated with a modulation of the microbiota (Pineiro, M., Asp, N.G., Reid, G., Macfarlane, S., Morelli, L., Brunser, O., Tuohy, K., and J Clin, J. 2008.). They are used to stimulate health and balance the intestinal microbiota. The most prominent class of prebiotics are non-digestible oligosaccharides that selectively stimulate the growth and/or activity of target microbiota in the colon thereby depressing dysbacteriosis and maldigestion. Examples of commonly used prebiotics in animal nutrition are manno-oligosaccharides (MOS) present in the cell wall of yeasts (*Saccharomyces spp.*), fructo-oligosaccharides (FOS) and inulin which can be obtained from various plants, and xylo-oligosaccharides (XOS), polymers of the sugar xylose obtained by controlled fermentation of plant fibres. The beneficial health effects of prebiotics are quantifiable by typical makers of gut health, including microbiota diversity (and increases in *Lactobacilli* and *Bifidobacterium*) and improved feed utilization, weight gain and reduced vulnerability to stress. While oligosaccharides obtained from plants and yeast have been traditionally used as food and feed additives, the identification of galacto-oligosaccharides (GOS) as a major component of colostrum and early lactation milk from humans and animals has convincingly demonstrated the beneficial health effects in neonates and infants. GOS is increasingly used as a feed additive in diets for young animals and animals with disturbances of the large intestine and dysbacteriosis.

### 4.2.3.3 Postbiotics, Paraprobiotics and Synbiotics

Postbiotics have recently developed as feed additives and are described as preparations of inanimate (non-viable) microorganisms and all their components, often including the entire fermentation broth used for microbial cultures. A postbiotic product can contain various biologically active substances such as fatty acids, proteins, small peptides, bacteriocins, oligosaccharides, vitamins, minerals, enzymes, and various (cellular) growth factors. Given to animals these products exert a measurable improvement of gut health, resulting in increased animal productivity and resilience to infectious diseases. Postbiotics provide all the
benefits associated with probiotics but without the risk to acquire and transmit AMR genes. Examples of postbiotics currently available are products derived from *Lactobacillus*, *Streptococcus* and *Saccharomyces cerevisiae*.

Paraprobiotics constitute inactivated/lysed/non-viable microbial cells of probiotics as intact or ruptured cells. They contain all cell components of the original probiotic cells such as teichoic acids, peptidoglycan-derived muropeptides, surface protruding molecules (pili, fimbriae, flagella), polysaccharides like exopolysaccharides, cell surface-associated proteins, cell wall-bound biosurfactants, and basic molecules such as proteins, lipids and vitamins. The use of postbiotics or para-probiotics allows for the prevention of a number of challenges associated with the use of live cells, particularly in the manufacturing and storage of cells that must be alive when given to the target animals. Because they promote gut health, gastrointestinal functions, and exert immunomodulatory activity, as demonstrated by research and commercial use in humans, postbiotics or para-probiotics are finding growing applications in animal production.

Synbiotics are defined as ‘mixtures of probiotics and prebiotics that beneficially affect the host by improving the survival and implantation of live microbial dietary supplements in the gastrointestinal tract of the host’ (FAO, 2006).

4.2.3.4. Microalgae, seaweeds and other algae

Microalgae are attractive as feed additives due to their nutritional value associated with the abundance of proteins, vitamins, carbohydrates, lipids, antioxidants and other functional components. The most common algae for animal feed that can be currently used are *spirulina* and *chlorella*. Actual properties are specific to the strains used and observed benefits include enrichment of meat, milk and eggs with omega-3 fatty acids, including docosahexaenoic acid (DHA) and eicosapentaenoic acid (EPA). In consideration of sustainable feed production, the fact that algae require very few resources, primarily sun, water and carbon dioxide, makes algae one of the most sustainable raw materials. Subsequently, algae have recently received the attention of the global scientific community as a novel source of nutritional elements. Although algae differ in composition from those of terrestrial plants they contain various bioactive molecules with diverse health benefits, and their use in animal diets is increasing globally.

The marine plants and algae that are used to make seaweed are grown in rivers, oceans, and other water bodies. Seaweeds might be green, red, or brown, but all varieties contain an abundance of bioactive compounds like carotenoids, dietary fibre, protein, vital fatty acids, vitamins, and minerals. Compared to brown seaweeds, green and red seaweeds have more protein, but fewer additional nutrients. Seaweeds have long been employed in both human and animal diets as a source of structurally diverse and biologically active secondary metabolites. The majority of the secondary metabolites produced by seaweeds exert bactericidal or antibacterial effects. Due to the very large number of microminerals present in some algae, seaweed extract is now widely employed in livestock and human nutrition.

4.2.3.5. Organic acids

Organic acids, comprising short-chain, medium-chain, and long-chain organic acids, are widely used in feed and drinking water as an hygienic measure and beneficial effects in animals. Organic acids are beneficial in supporting the first barrier against invading
pathogens in the animal digestive tract by lowering the pH and improving digestion. For example, they improve the crop barrier in poultry and the gastric barrier in pigs by lowering the pH in the presence of feed ingredients, which often have a high buffering capacity. Lowering the pH in the crop and stomach reduces the transfer of undesirable bacteria such as E. coli, Salmonella spp. and other enteropathogenic bacteria into the gastrointestinal tract. Commercial products are blends of different organic acids to ensure that under variable pH conditions, an optimal balance between dissociated (pH lowering) and non-dissociated (direct antimicrobial) effects is achieved. Many short-chain fatty acids (SCFA), and their salts, such as acetic acid (C2), propionic acid (C3), and butyrate (C4), are physiologically produced by intestinal microbiota in the large intestines of monogastric species and the rumen of herbivores. They serve as energy sources for other microorganisms thereby stimulating the digestive process and hence feed utilization. SCFAs and medium-chain fatty acids (MCFAs) exert beneficial effects on the intestinal microbiome by increasing microbial diversity.

Butyric acid and butyrate are especially recognized for their dual function in serving as energy sources for microbiota and enterocytes. Butyric acid is the basis for sodium and calcium butyrates and butyrins (esters of butyric acids), recommended as feed additives. Butyric acid is produced in healthy individuals in the large intestines by the endogenous (commensal) microbiota, where it contributes also to the protection of the mucus layer against invading pathogens due to its antimicrobial effect.

MCFAs are a family of fatty acids with a chain length of C6 to C12. The most prominent MCFAs are caproic acid (C6) and caprylic acid(C8). MCFAs exert an antimicrobial activity by direct disturbance of the bacterial cell wall, and there is a clear synergetic effect when combined with SCFA. This mechanism is entirely different from the common mechanism of action of therapeutic antimicrobials but is very effective in the reduction of pathogens. Glycerides or esterified forms of MCFAs (monoglycerides or triglycerides), are rapidly absorbed and metabolized, serving as a valuable energy source. MCFAs also improve rumen fermentation by reducing methanogenic bacteria.

Long-chain fatty acids (LCFAs) comprise a diverse group of saturated and unsaturated fatty acids containing more than 12 carbon ions including omega 3 and 6 fatty acids. Widely used feed ingredients are oleic, linoleic, and palmitic acid. They serve as energy sources, but also have well-recognised anti-inflammatory and immunostimulatory properties, and therefore are used as feed and food additives.

In conclusion, beneficial microorganisms and their products, such as prebiotics, paraprobiotics and organic acids are widely used as a replacement for AGPs due to their multiple beneficial effects. Their desirable effect on the intestinal microbiota and gut health as well as the sanitizing effects of organic acids in feed and drinking water is well documented for monogastric and ruminant species. A stable and balanced composition of microbiota suppresses the proliferation and virulence of invading pathogens and supports feed digestion and utilization and hence animal growth and productivity.

4.2.4. Plant-derived products and extracts (Phytogenics) used as alternative to AGPs

The use of medicinal plants has a long tradition on all continents. The plant species used traditionally for therapeutic purposes (ethno-veterinary medicine) vary depending on the local vegetation and geographic and climatic conditions. Traditional remedies may consist of fresh or dried whole plant, flowers and fruits, leaves, roots or barks or extracts thereof including
water and alcohol extracts of non-water-soluble organic compounds like essential oils. Their preparations and extract contain an array of bioactive, secondary plant metabolites, produced by plants in defense of invading phytopathogens and in support of physiological functions, growth and reproduction. It is estimated that approximately 70% of all pharmaceuticals currently in clinical use in human and veterinary medicine originate from plants or were used directly after purification or after modifications particularly to improve the kinetic properties of plant-derived pharmaceutical products. With the increasing concerns about the global increase of antimicrobial resistance and to reduce the use of antimicrobials in livestock, many of the traditional remedies are currently re-evaluated and their value in the treatment of chronic and biofilm-related infections is increasingly recognized. Advances in analytical techniques and pharmaceutical technology overcome previous concerns about identity, reproducibility of extracts and stability of plant-derived products. Prominent research activities and multiple publications address remedies from Traditional Chinese Medicine (TCM), Traditional Indian Medicine (Ayurveda or TIM) and Traditional European Medicine (TEM). In addition, numerous other collections of plant products used in ethno-veterinary medicine are published from other continents.

Phytotherapy is also used in veterinary medicine and phytogenic remedies are increasingly used in ecological production systems and traditional farming including small scale animal production in low- and medium-income countries. Traditional knowledge from phytotherapy has also initiated the development of phytogenic products in animal nutrition as feed additives, as many secondary plant metabolites exert antimicrobial and antiparasitic properties.

**Phytogenics feed additives to possibly replace AGPs**

Phytogenic feed additives (also denoted phytobiotics, plant feed additives (PFA), poly-herbal feed additive or simply botanicals) are used due to their antibacterial activity and their measurable effect on gut health, including anti-inflammatory and/or antioxidant effect resulting in increased immune competence. Like in traditional phytotherapy, phytogenic feed additives might be composed of whole plant powders and extracts, plant derived essential oils, oleoresins or pure extracts of defined parts of the plant such as flowers, fruits, leaves and roots. From the traditional use of herbs and spices in food preparation (such as oreganos, thyme, garlic, onions, red peppers, and turmeric) it is known that plants can produce a variety of secondary metabolites (PSM – plant secondary metabolites) that show potent antimicrobial activity. The underlying molecular mechanisms are different from those of common antimicrobials. Due to this alternative mechanism, phytogenic feed additives are also effective against resistant bacteria (such as MRSA, or ESBL-carrying bacterial isolates) and can prevent biofilm formation and the expression of virulence genes by interference with microbial quorum sensing. Phytogenic feed additives can modulate and stabilize the rumen microbiome, which results not only in an improved feed utilization but also offers the possibility to control the population of methanogenic bacteria and hence the ruminal methane production which is a contributing factor to improve sustainability of and reduce the adverse impact of livestock production.

Due to this array of effects, often improbable by using blends of different plant products together with minerals, animal health and performance is significantly improved and hence phytogenic products are now considered a promising tool to reduce the need to use antimicrobials and replace AGPs.
A prerequisite for the use of phytogenic feed additives is a clear definition of their botanical identity (to avoid insertion of toxic plant varieties), origin, nature (dried or extracts of part or whole plant) and quality control, excluding the presence of pesticides, persistent organic pollutants and heavy metals by appropriate and sensitive analytical methods. Toxicity and antinutritional factors of certain PSMs need to be considered when designing blends composed of multiple plant components as feed additive to avoid undesirable side effects in the anima. Moreover, the absence of sensory and nutritional changes of animal derived products such as milk, meat and eggs need to be demonstrated. Phytogenic feed additives require advanced processing technologies, for example vacuum coating, to allow their use in pelleted feeds, or solubility-enhancers if water application is considered for example for their use in poultry and swine production.

In conclusion, phytogenic feed additives are among the most promising alternatives to AGPs due to their multiple beneficial effect on animal health and productivity. Phytogenic feed additives are often based on traditionally used herbal remedies, and hence can be designed and produced also locally for small animal holders in low-and medium income countries to improve animal health and productivity. Major challenges to be met in the large-scale use of phytogenic feed additives in commercial farming are sourcing, standardization, pharmaceutical processing to guarantee stability during feed production, and ultimately cost efficiency as many of the production steps are cost-intensive.

4.2.5. Feed additives used to improve feed safety, feed utilization and animal performance thereby reducing the need to use antimicrobials, including AGPs

4.2.5.1. Clay mineral and phyllosilicates

Ultrafine granulated clay minerals such as bentonite (mainly consisting of sodium montmorillonite) and kaolin have been used traditionally in the treatment of diarrhoea due to their ability to adsorb large amounts of water. This improves faecal consistency and stimulates the reabsorption of water in the large intestines. Both clays are members of a large group of aluminium phyllosilicates which contain variable amounts of mono- and divalent ions (Na, K, Mg, Ca) and are found naturally in many geographic formations in all continents. Examples of products used in animal diets are bentonites, sepiolite, clinoptilolites, montmorillonite and other smectites.

Phyllosilicates are characterized by a complex layer structure which indeed can adsorb large quantities of water, but also natural toxins such as bacterial endotoxins (lipopolysaccharides) and various mycotoxins, particularly aflatoxins. This toxin binding capacity, which also includes several toxic plant metabolites, promoted their use in animal diets to mitigate the adverse effect of feed contamination and indirectly to improve food safety by reducing significantly the risk of contamination of dairy products with aflatoxin M1 following the exposure of dairy cows to aflatoxins in their daily feed. In monogastric animals, mineral clays are often combined with yeast-derived mannooligosaccharides (see prebiotics) to further mitigate the adverse effects of mycotoxins and to improve gut health.

In conclusion, mineral clays and phyllosilicates are widely used feed additives both in feed technology (as anticaking agents) as well as animal health products, to restore the water balance during dysbacteriosis and to prevent the the absorption and bioavailability of microbial toxins, such as bacterial toxins and mycotoxins. Their beneficial effect on gut health, reduced the need to use AGPs to stabilize intestinal functions and feed efficiency.
4.2.5.2. Specific enzymes improving the nutritional values of feed ingredients

Feed ingredients may contain anti-nutritive factors that affect the bioavailability of certain minerals and other nutrients from ingested plant material. The most prominent example is phytic acid which contains 40-90 percent of the phosphate present as phytate in plant tissues. This bound fraction is liberated in by the rumen flora in ruminating animals but limits the availability of phosphorous in monogastric animal species, such as poultry and pigs. The addition of phytase, the enzyme that converts phytate into inositol and free phosphorus is therefore an important feed additive in monogastric species and known to improve intestinal functions, and the intestinal immune system particularly in poultry. This results in a significant improvement of feed utilization and improved weight gain.

Other digestibility enhances such as fermentative NSP enzymes and proteases are also used in certain feeding programs. NSP enzymes improve digestibility of non-starch polysaccharides (e.g., xylans or beta glucans) and proteases improve the overall digestibility of proteins.

An entirely different group of enzymes concerns the very specific mycotoxin degrading enzymes, which inactivate *Fusarium* mycotoxin such as deoxynivalenol, fumonisines or zearalenone. These mycotoxins are poorly absorbed by the mineral clays used to prevent enteric absorption of aflatoxins and bacterial endotoxins. The use of mycotoxin-mitigating agents contributes significantly to feed safety and sustainability.

In conclusion, when added to feed, enzymes can improve feed digestibility and safety and prevent the impairment of intestinal integrity and intestinal inflammatory reactions thereby improving feed utilization and animal productivity. Hence the use of enzymes are a valuable part of advanced feeding practices decreasing indirectly the need to use AGPs.
5. Not recommended feed ingredients, additives and practices

Some heavy metals, such as copper and zinc, are added to animal feed as essential trace minerals and are required for animal health and growth. Another group of elements considered essential for the animals include chromium (Cr), vanadium (V), tin (Sn), nickel (Ni), and molybdenum (Mo). Given the limited knowledge about the actually required mineral concentrations, feed supplemented with these minerals often contains higher concentrations than may be necessary to ensure adequate nutrition.

In addition to these minerals that are intentionally added, animal feed can also be occasionally contaminated with toxic heavy metals such as cadmium (Cd), lead (Pb) and mercury (Hg). The heavy metals may accumulate in certain organs (liver, kidney) resulting in progressive tissue damage. Although these elements are naturally occurring in the environment, they can also be derived from anthropogenic sources.

Certain minerals, particularly copper and zinc, exhibit some antimicrobial effects and have been used as feed additives in food animal production:

Arsenicals
In some countries, an organic form of arsenic (3-nitro-4-hydroxyphenylarsonic acid, Roxarson) has been used in swine and particularly in poultry as growth promoting agents, and in the prevention of coccidiosis. It is withdrawn from the market in 2011 and totally banned by the US-FDA in 2013. This ban is implemented now almost globally. Organic arsenicals are less toxic than inorganic arsenic, but contribute to the overall burden of Arsenic in the food chain.

Copper
Copper (Cu) is supplemented in animal diets at levels higher than physiological requirements to promote growth and improve feed efficiency. However, its use has been associated with the co-selection of bacterial resistance to antimicrobials in the absence of antimicrobials selection pressure. This has been explained by the presence of a transferable copper resistance gene, tcrB, which confers resistance to copper, on a conjugative plasmid which also carries various genes for antimicrobial resistance e.g. vanA, erm(B) or tet(M) genes, encoding resistance to glycopeptides, macrolides and tetracyclines, respectively.

Zinc oxide
Zinc oxide (ZnO) given in pharmacologically active doses is one of the common practices to prevent intestinal infections and production losses in piglets during the weaning phase. The use of ZnO at pharmacologically active concentrations is criticized and banned in many countries as the abundant use of zinc and subsequently, its excretion with manure can contaminate soil and groundwater. More importantly, zinc may promote the selection of multi-drug resistant bacteria and particularly Enterobacteriaceae have shown an increase in the expression of resistance genes following the use of zinc as feed additive.

The increased expression of resistance genes in livestock by gut microbiota, and subsequent environmental spill-over, due to over-supplementation of zinc, copper and other metal ions such as iron, cobalt, and manganese, may lead to an increased selection pressure on environmental and pathogenic bacteria. Given this scientific evidence, the addition of heavy metals to animal diets should be restricted to levels that meet the nutritional requirements of an animal.
6. Assessment of the efficacy of feeding practices and feed additives intended to possibly replace AGPs

The efficacy of feed additives promoted as replacement for AGPs focused initially on compounds exerting an antimicrobial effect, such as organic acids and various essential oils derived from medical or aromatic plants. *In vitro* antimicrobial effects were compared with measurable increase in daily weight gain and feed conversion rate in field trials, often with inconsistent results, as previously also observed in field trials with AGPs. Following the hypothesis that successful AGPs modulated the intestinal microbiota, the changes induced by pre- and probiotics, organic acids and phytogenic compounds (and mixtures thereof) were measured and clearly visible differences were described. However, it remains difficult to relate these differences to production parameters such as weight gain and feed conversion rate when using different basic diets. As the effects on intestinal microbiota are closely related to gut health, other markers of effect are added to demonstrate efficacy and desirable animal health benefits. These additional markers of effect include next to the analysis of intestinal microbiota, digestive enzymes and fluids (bile), and markers of inflammation, all contributing to the maintenance of intestinal barrier integrity and digestive functions. These markers of gut health can be successfully related to animal performance parameters such as growth rate and feed efficiency. Moreover, the improvement of gut health is associated with animal health and welfare indicators such as the occurrence of dysbacteriosis (poultry, piglets, calves), reduced metabolic stress in physiological transition phases (weaning) and a decreasing prevalence of *Salmonella* spp., *Campylobacter* spp., pathogenic *E. coli* and protozoan (coccidia) infections. In ruminants, prevention of rumen acidosis, low somatic cell counts, hoof health and reduction of methane emission have been used to validate the efficacy of feed additives. In addition, a documented reduction of the use of antimicrobials needed for treatment are quantifiable markers of the beneficial effects of feed additives in replacing AGPs and reducing the overall need to use antimicrobials. Guidance documents for the evaluation of efficacy of feed additives during market authorization have been published by various national and supranational authorities for single compounds and may serve as a template for the (local) authorization and marketing of (blends of) natural products.
7. Safety assessment of advanced feed practices and feed additives used to replace AGPs

Premarketing safety assessment needs to include the assessment of the safety of a product for the target animal species at the recommended dosing level and for all products derived from the target animal such as milk, meat and eggs. Many of the natural products considered here as feed additive to replace AGPs have a history of safe use in human nutrition and therapy and are generally considered as safe at nutritional levels. Nevertheless, guidance documents need to be established informing the producer of feed additives about the documentation and additional experimental work and the quality controls that need to be conducted for marketing authorization. A global harmonization of such minimal requirements related to safety (and efficacy) assessment of feed additives would certainly improve their acceptance and stimulate the implementation of the alternatives for AGPs.

Feed additive manufacturers should follow good hygienic and good manufacturing practices and implement Hazard Analysis and Critical Control Points (HACCP) plans to prevent the introduction of microbiological, physical and chemical hazards into the feed additives during transportation, manufacturing and storage. Microbiological testing should be conducted according to recognised guidelines from international standard-setting committees. Target animal toxicity testing could be conducted as part of in vivo testing for efficacy (dose-range finding). Moreover, feed manufacturers should keep records of suppliers for traceability purposes. The local competent authorities are encouraged to issue guidelines defining the standards for good manufacturing practices (GMPs) and quality control measures for the production harvest and processing of natural feed additives (derived from microorganisms, plants or soils). Such measures will also ensure the safety of the animal sourced food such as milk, meat and eggs.

Feed additives should be used according to the manufacturers’ instructions and/or national legislation including the requirement set for use of PPE (personal protective equipment) by the producers. As mentioned above, most of the examples of feed additives given in the current document concern natural substances (and probiotics) which have a long history of safe use in animals and are generally recognized as safe. However, it remains mandatory that the origin and composition of commercial products are traceable and that all individual ingredients are of a microbiological and chemical quality which meets the requirements of national feed legislation.

Clay minerals and phyllosilicates may be contaminated with environmental pollutants such as dioxins due to their adsorptive properties and can accumulate dioxins at higher levels than soil organic matter. Sources of clay mineral clays need therefore to be checked for an undesirable contamination with toxic heavy medals and dioxins.

Special attention needs to be given to all products (probiotics, postbiotics, synbiotics, bacteriophages) containing live microorganisms or are directly derived from microbial cultures to identify any biological hazards including undesirable spoilage microorganisms, and potential residues of the fermentation process, in which often antimicrobials are used.

Phytogenic feed additives, when produced on a larger scale, may contain a significant amount of (undesirable) botanical impurities, e.g. toxic seeds and acquire resilient bacterial spores (Clostridium spp.) during their vegetative stage. Moreover, many aromatic plants are known to accumulate easily heavy metals and persistent environmental pollutants, including dioxins and dioxin-like PCBs (Polychlorinated Biphenyls) as well as pesticides.
8. Conclusions

Multiple opportunities and examples for advanced feeding practices and functional feed additives were identified that allow for the safe and effective replacement of AGPs and the overall reduction of the need to use antimicrobials in livestock systems.

The nature of these feeding strategies is diverse, allowing a tailored approach for individual animal species and age- and production groups. Moreover, feeding practices and sustainable livestock system rely heavily on the availability of feed and feed ingredients in each geographic region. The many alternatives identified in this report include the use of locally produced feed ingredients and feed additives as well as products originating from a circular economy. They consider also the incorporation of a total nutritional approach will support the withdrawal of antimicrobials as growth promoters, and contribute to an overall reduction of the use of antimicrobials in livestock farming.

Feed additives may be selected to support feed taste and flavour, feed processing and the stability of valuable feed ingredients to safeguard an optimal nutritional value (minerals and vitamins) of mixed animal diets and total mixed rations. Feed additives and functional feed ingredients may also be used to improve feed palatability to support feed digestibility and mitigate the effects of undesirable anti-nutritional factors and contaminations with biological and chemical hazards.

Feed additives and various functional feed ingredients improve gut health and the innate immune system by direct interaction with the gut microbiota, the main target of the previously used AGPs. Various feed additives described above are also able to stimulate additional physiological functions of the intestines, such as the secretion of endogenous digestive enzyme and bile fluid and hence feed digestion. Moreover, a support of gut barrier integrity and intestinal immunological defense mechanism are common targets and biomarkers of efficiency as these parameters are related to the overall resilience of animals to infections and environmental stressors, thereby reducing the need to use antimicrobials for the maintenance of animal health and welfare.

Feed additives used in the replacement of AGPs are generally blends composed of different classes of feed additives to achieve optimal health benefits also under varying physiological and environmental stress conditions. Current limitations for the use of such blends can be availability, standardization of composition and quality, regulatory hurdles in the evaluation of complex mixtures of natural ingredients, and cost-efficiency.

Many feed ingredients and additives improving gut health have a history of safe use in human and animal health care, and are generally considered as safe. Nevertheless, a major prerequisite for the ultimate use of feed additives in the replacement of AGPs is the setting of standards for transparent pre-marketing authorization, including the assessment of efficacy and safety for the target animal and downstream within the food chain, including the safety and quality of animal-derived products such as milk, meat and eggs. Such transparent standards encourage feed producers and farmers to replace AGPs and to join others in their commitment to prevent the further spread of antimicrobial resistance, one of most significant threat to public health.
9. Recommendation

Stakeholders involved in livestock production are invited to join initiatives in their efforts to reduce the global dimension of antimicrobial resistance. One of the precautionary measures which requires widescale adoption is the responsible and prudent use of antimicrobials in animal production. While certain antimicrobials remain essential in the treatment of diseased animals animal health and welfare purposes, veterinary oversight in the use of antimicrobials should endorse only use of antimicrobials that is prudent and responsible.

The use of antimicrobials as growth promoters or for the correction of shortcoming in farm management and hygiene needs to be discouraged and replaced by animal nutrition and overall management improvements, complemented with the use of non-antimicrobial feed additives. Examples of such strategies are briefly summarized in this report.

United Nations agencies and intergovernmental organizations such as FAO and WOAH, and the feed sector stakeholder organizations are invited to facilitate knowledge dissemination about advanced feeding practices and feed additives that can be used to replace the use of AGPs and to reduce the overall use of antimicrobials. Doing so will reduce the risk of AMR and simultaneously improve feed efficiency, animal health and welfare and and ultimately feed and food safety and security.

The establishment, by national competent authorities, of a legal framework for testing the efficacy claims of alternative feeding strategies and additives and defining minimum requirements for their quality, safety and efficiency will encourage and support the uptaking of these sustainable production strategies.
10. References


