Chinhoyi University of Technology
Journal of Technological Sciences
http://journals.cut.ac.zw/index.php/jts

Poultry endogenous biosurfactants based feed additive, a potential counter to Antimicrobial resistance (AMR) challenge: a review.

[1,2]Chigede Ngavaite, [1]Madzimure James, [1]Chikwambi Zedius, [1]Mpofu Irvin D.T., [3]Muvhuringi Prosper Bright

[1]Chinhoyi University of Technology, School of Agricultural Sciences and Technology

[2]Great Zimbabwe University, Gary Magadzire School of Agriculture, Livestock, Wildlife & Fisheries Department

[3]Zimbabwe Open University, Faculty of Agriculture, Department of Agricultural Management, Mashonaland Central Region, 209 Hayroad, Bindura, Zimbabwe

Abstract

Biosurfactants are amphiphilic microbial secretions containing surface-active biomolecules produced on living surfaces, such as microbial cell surfaces or extracellular surfaces. They possess a variety of characteristics that enable secreting microorganisms to withstand a variety of stressful situations, allowing them to conquer a variety of habitats. Biosurfactants also allow secreting microorganisms to destabilize other bacteria in competition for clinging surfaces, habitats, and substrates, ensuring their survival. Periods of extreme stress are unavoidable in birds, resulting in dysbacteriosis and the production of biofilms by less helpful bacteria. This stressful environment causes a broiler's feed utilization efficiency and immunity to be weakened, increasing the risk of coccidiosis. Farmers utilize a number of antimicrobial treatments to combat decreased immunity and performance, which could lead to drug residue in meat and other poultry products. Residual drugs will exacerbate antimicrobial drug resistance (AMR), which is believed to be around 60% in Zimbabwean cities. The researchers were inspired to look into endogenous biosurfactants after learning about the interesting properties of bacterial metabolites. A desk top study was carried out primarily employing sources to uncover the potential of biosurfactants in the twenty-first century. Many researchers were found to be employing exogenous microorganisms, and the majority of their studies were aimed at cleaning up polluted places. Biosurfactants have a number of features that are relevant to agriculture. Less study has been done on the advantages of endogenous biosurfactants. Biosurfactants are secreted by a variety of microorganisms, primarily bacteria. It is necessary to identify biosurfactant-secreting microbial species and describe their microbial secretions. For the poultry sector, a biosurfactant-based feed supplement can be developed to help combat antimicrobial resistance.

Corresponding Author. Email address: ngavaitec@gmail.com

Key Words: Poultry endogenous biosurfactants, Biosurfacants, Antimicrobial resistance (AMR) challenge, Chicken Gastrointestinal Microbiota

1. Introduction

Biosurfactants are amphiphilic surface-active biomolecules produced on living surfaces by microbes, either on microbial cell surfaces or extracellularly (Sachdev and Cameotra, 2013). The hydrophobic and hydrophilic moieties of the biosurfactants allow them to combine between fluid phases, lowering surface and interfacial tension at the surface and interface respectively (Nayarisseri, Singh, and Singh, 2018; Gayathiri et al., 2022). Surface and interfacial tension reduction, among other properties, allows the biosurfactant secreting microbes to destabilize other microbes in competing for surfaces to cling to, habitats and substrates, so assuring their survival (Barnett and Weir, 2012).

Biosurfactants have a number of interesting properties of interest (Harshada, 2014). These include those concerned with changing of surface active phenomena, such as lowering of surface and interfacial tensions, wetting actions, hydrophilicity and hydrophobicity, emulsification and de-emulsification, detergency, microbial growth enhancement, and antimicrobial action (Gayathiri et al., 2022). This wide range of biosurfactant qualities makes microbes able to tolerate various stressful conditions allowing them to conquer a wide range of environments. Furthermore, biosurfactants have grown in popularity as high value microbial products due to their unique qualities such as increased biodegradability and lower toxicity (Rayeni and Nezhad, 2018). Industries such as oil recovery, environmental bioremediation, food processing, and pharmaceuticals are some of the beneficiaries of the high value microbial products (Sar et al., 2019). Biosurfactants are increasingly being used as an enhanced alternative to chemical surfactants (carboxylates, sulphonates and sulpate acid esters), particularly in food, pharmaceutical and oil industries (Fakruddin, 2012; Sar et al., 2019; Zhang, 2021). Some of their uses include solubilization of water insoluble compounds, heavy metal binding, production of antimicrobial and anti-biofilm compounds (Giri et al., 2019).

The majority of research on biosurfactants uses has been focusing on pollution bioremediation and microbial enhanced oil recovery (Ribeiro, Guerra and Sarubbo, 2020). However, due to their vast range of properties, these microbial compounds have a variety of valuable qualities and applications in a variety of disciplines (Farias et al., 2021). Biosurfactants have potential roles and applications in areas such as agriculture, biomedicine and pharmaceuticals (as antimicrobial agents, immunoregulators, and immunomodulators, as well as their prospective role in signalling and cytotoxic activities (Moldes et al., 2021).

In the agriculture sector, poultry is one common venture which many farmers adopt due to its low resource requirements. Poultry meat is universally accepted, as a result, challenges such as antimicrobial resistance have widespread potential as many people have access to the produce. This has necessitated to focus this review on poultry production. In the poultry industry, endogenous biosurfactants, released by internal microbes normally inhabiting the chicken gut, could be of value during periods of inevitable challenges (such as a new environment for a newly hatched chick) and stress which result in dysbacteriosis (Bailey, 2013). Less beneficial microbes take advantage of the dysbacteriosis created and form biofilms thus adding more stress. Lack of touch with the mother hen also cause delayed development of gut microbiota in newly hatched chicks (Kubasova et al., 2019). As a result, early broiler chicks are particularly susceptible to pathogenic invasion. Under such stressful conditions, broiler feed utilization efficiency and immunity are compromised, increasing the risk of coccidiosis (Bailey, 2013) and poor gut development. Endogenous biosurfactants have the potential to suppress development of pathogenic microbes during these challenging periods in a broiler's life.

Some biofilms will cause the villi to wear down, shortening them and decreasing the effectiveness of nutrient absorption from the intestines. Due to non-beneficial microbes' resistance to antibiotics (Pereira etal., 2007), farmers use a variety of antimicrobial drugs to counteract their effects, potentially resulting in residual drugs in meat and other poultry products (Roto et al., 2015). Antimicrobial drug resistance (AMR), which is estimated to be around 60% in Zimbabwean cities, will be exacerbated by residual medications (Center For Disease Dynamics, Economics and Policy, 2017; Chimbwanda, 2022). Food Agricultural Organisation, (2017) has it that 700 000 people die annually around the world as a result of AMR and it is projected that by 2050, death rate due to antimicrobial resistance will be around 10 million per annum (O'Neill, 2014; Chimbwanda, 2020; Rabaan *et al.*, 2022). In line with worsening AMR challenge, Murray *et al.*, (2022) reported that AMR deaths has overtaken HIV/AIDS and malaria globally. Timely intervention is critical, thus there is urgent need to look for alternatives, such as use of biosurfactants, to reduce use of antibacterial drugs in broiler production. This review, focussing on the 21st century published peer-reviewed work, articulates the potential of endogenous biosurfactants from broilers' gastro-intestinal tract (GIT) to impact the AMR challenge depicted in Figure 1.1. The review unfolds with problem analysis setting the flow for the conceptual framework which is followed by an overview of biosurfactants including their classification and applications. In the following sections, gut health in broilers is reviewed closing the review with key highlights of the challenge of antimicrobial resistance.

1.1 Analysis of antimicrobial resistance problem

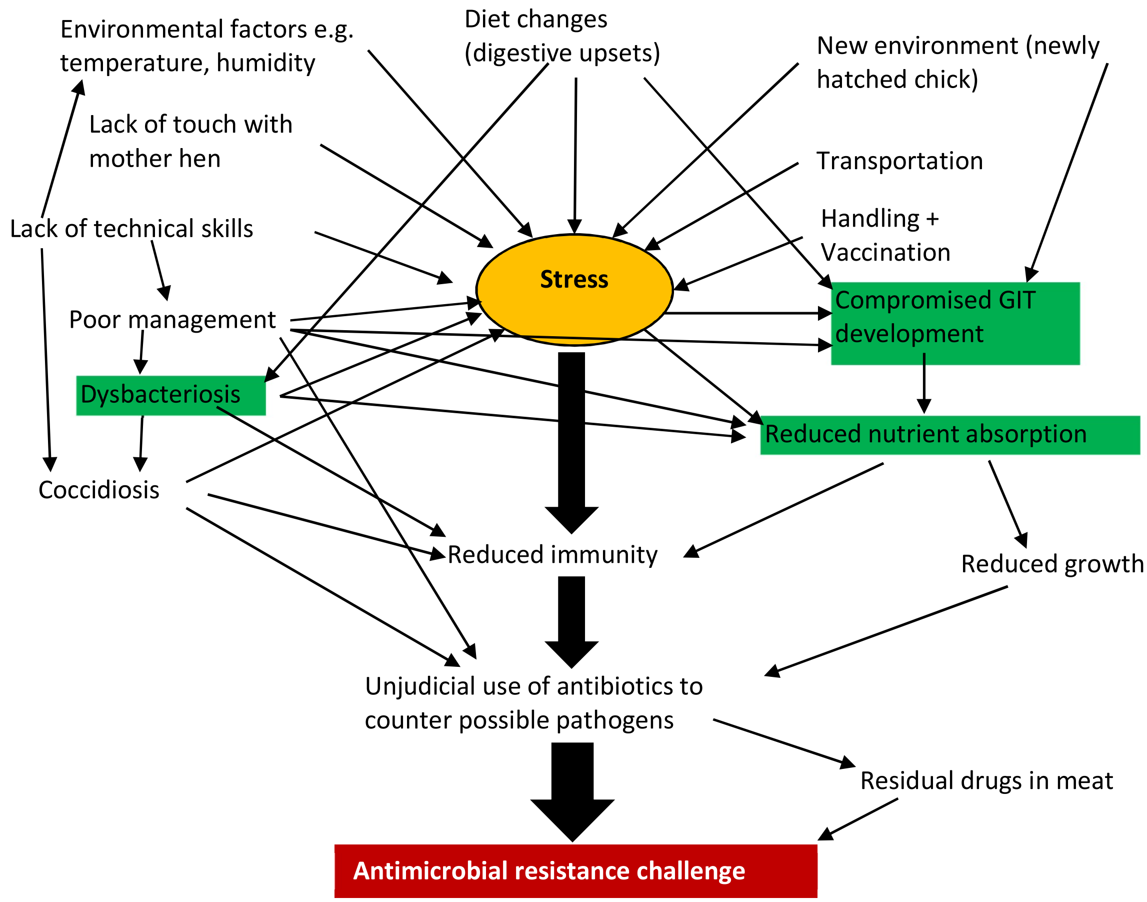

Figure 0.1 Problem analysis

Many factors can contribute to stress in broiler chicks (Figure 1.1), some of which are unavoidable, such as vaccinations and transportation. Stressed birds cannot adequately utilize their diet, resulting in decreased development rate and immunity, increasing vulnerability to diseases and economic loss (Bailey, 2013). Farmers attempt to mitigate the negative consequences by administering antibiotics to their birds, resulting in residual medications in meat and a potential antimicrobial resistance risk.

1.2 Conceptual framework

Biosurfactants' antimicrobial properties will cushion birds during adverse weather preventing possible dysbiosis and improved growth performance reducing AMR in meat, Figure 1.2.

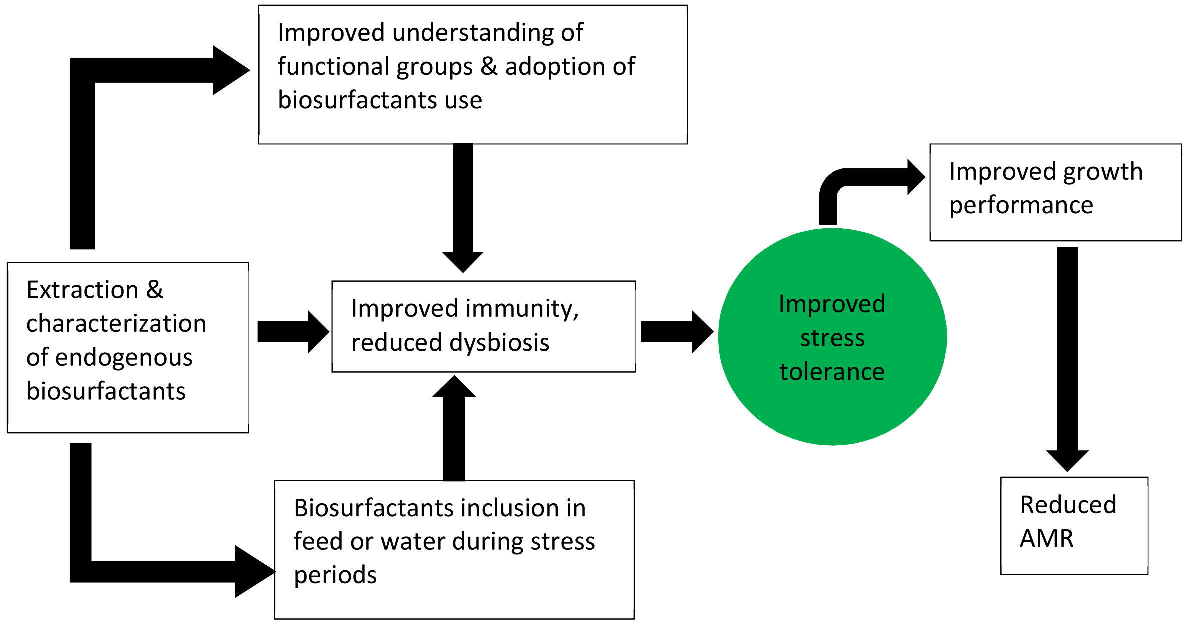

Figure 0.2 Conceptual framework

Endogenous biosurfactant characterization will increase our understanding of their mode of action, prospective usage in broiler production, and adoption of the innovation. The use of endogenous biosurfactants in broiler diets improves the birds' immunity, resulting in higher nutrient utilization and tolerance to various forms of stress. Furthermore, birds will be safeguarded from potentially hazardous bacteria, allowing them to develop healthier gut microorganisms early in life. A healthy gut during early development allows birds to have a larger villi reserve capacity. Diseases such as coccidiosis will be less prevalent as a result of this. As such, broiler producers will profit from enhanced bird performance. The end result is a healthy bird with a robust immune system. As a result, broiler growers can reduce their use of costly antimicrobial medications during the production cycle, subsequently reducing drug resistance hazards for consumers in the process. This will go a long way towards achieving health-related goals such as those established in Zimbabwe's Vision 2030, Africa's Agenda 2063, and SDG (Sustainable Development Goal) 3 (African Union Commission, 2015; Morton et al., 2017; Government of Zimbabwe, 2018).

2 Overview of biosurfactants

Microbes occur in their millions along the digestive system of birds and have to compete for resources. In order to survive within their environment, numerous bacteria secrete molecules (biosurfactants) that selectively suppress growth of other microbes in their vicinity (Barnett and Weir, 2012). Biosurfactants are amphipathic, meaning they possess both a hydrophilic and a hydrophobic end (Mohanty et al., 2021). The hydrophilic end of the biosurfactants constitute either a carbohydrate, an amino acid, a phosphate group, or alike compounds whereas the hydrophobic end in most cases will be made up of fatty acid carbon chain (Nayarisseri et al., 2018). The hydrophilic head of each surfactant is electrically charged, either negative, positive or neutrally charged.

Microbial biosurfactants have a lower toxicity and a higher biodegradability than chemical surfactants (Garg et al., 2018; Mohanty et al., 2021). They are also effective at extreme conditions regarding temperatures, pH and saline concentration. It therefore follows that use of biosurfactants is most welcome in this era of the green revolution, particularly in agriculture were pollution should be minimized at the time when the demand for food is increasing. In broiler production, biosurfactants' effectiveness over a wide array of conditions mean that they can suppress stress thereby enabling the bird to adapt to changes in environmental conditions with minimal drop in performance.

Increase in agricultural productivity to meet an ever growing food demand for human population is a matter of great concern for all nations. Many microorganisms found in the digestive system of birds share a mutualistic relationship with the animals conferring marked beneficial effects on the birds (Sachdev and Cameotra, 2013). In recent years, rhamnolipids derived from *Pseudomonas aeruginosa* have emerged as an important group of biosurfactants with several applications (Barbosa et al., 2022), they have also been produced on a commercial scale (Diaz De Rienzo, Stevenson, Marchant, and Banat, 2016).

2.1 Classification of biosurfactants

Biosurfactants are generally classified by their chemical composition and microbial origin. With chemically produced surfactants, the hydrophilic and hydrophobic regions are neatly separated into a hydrophilic head group (charged or polar) and a hydrophobic tail which consists of linear alkyl groups (Otzen, 2017). The head group charge forms the basis for classification into anionic, cationic, non-ionic and zwitterionic surfactants (Twigg et al., 2020). It is also this separation which allows chemical surfactants to aggregate to roughly spherical micelles in water above the critical micelle concentration where the hydrophilic head-groups forms the surface in contact with water and shield the hydrophobic acyl chains tucked away into the micellar core (Otzen, 2017). Twigg et al., (2020) classified biosurfactants based on their molecular structure into:

i) low-molecular-mass molecules, which efficiently lower surface and interfacial tension, and
ii) high-molecular-mass polymers, which are more effective as emulsion-stabilizing agents.

The major classes of low-mass surfactants include glycolipids in which different sugars are linked to linear or branched alkyl groups (examples include trehalose lipids, sophorolipids and rhamnolipids), lipopeptides in which a cyclic structure is formed from fatty acid linkage of two peptide sequences (examples include surfactin, gramicidins) and phospholipids (Sachdev and Cameotra, 2013). Lipopeptides can act as antibiotics, antiviral and anti-tumour agents, immunomodulators or specific toxins and enzyme inhibitors (Harshada, 2014).

On the other hand, high-mass surfactants include polymeric and particulate surfactants. High molecular mass molecules which are more effective at stabilizing oil in water emulsions, i.e. bind tightly to surfaces (Shapiro, 2018). Examples include amphipathic polysaccharides, proteins, lipoproteins, saponins, lipids or complex mixture of these biopolymers (Harshada, 2014). Saponins often have sugars attached to different positions on the triterpenoid structure (Otzen, 2017).

As a result, biosurfactants are not hard surfactants like their chemical equivalents, which have the ability to bind strongly to oppositely charged proteins and solubilize phospholipid membranes. Otzen, (2017) has it that biosurfactants do not denature proteins nearly as efficiently as anionic surfactants and tend to insert into membranes rather than dissolving them. Biosurfactants are often produced as complex mixtures.

2.2 Applications of biosurfactants

Attention is being directed towards biosurfactants due to their broad range of functional properties and the diverse synthetic capabilities of the microbes (Johnson et al., 2020). Biosurfactants exert their effects to targets in innumerable ways which include: cell wall synthesis inhibition, cell membrane disruption, and metabolic antagonism (Barnett and Weir, 2012).

Some of the potential applications of biosurfactants are in pollution and environmental control and they include microbial enhanced oil recovery, hydrocarbon degradation in soil environment, heavy-metal removal from contaminated soil and hydrocarbon in aquatic environment (Jahan et al., 2020; Farias *et al.*, 2021). There is limited research on biosurfactants' antimicrobial properties and as feed utilization enhancers, improving efficiency of digestion and thus performance of broilers.

2.2.1 Biosurfactants as antiadhesive agents

Biosurfactants such as sophorolipids have been reported to have biofilm disruption abilities (Díaz De Rienzo et al., 2016). Biofilm formation by microorganisms is a phenomenon that occurs naturally and part of the microorganism's strategy to protect itself from external toxic factors (Pereira et al., 2007). Ascites and coccidiosis in broiler production are associated with many genera of bacteria which are strong biofilm formers (Oxford University Press, 2018, p. 17). These biofilms are serious health hazards due to their resistance to antibiotics. Furthermore, presence of biofilms would interfere with nutrient absorption from the GIT. Whereas physical debridement can assist the healing of wounds caused by the bacteria to intestinal lining, biofilm-focused therapeutic approaches can promote more rapid healing in a large proportion of birds (Chung and Khanum, 2017). This will result in improved efficiency of feed utilization. Thus, a biofilm-centric approach to reduce the ability of these pathogens to form biofilms is urgently needed to enable more effective subsequent healing by the body or treatment with antibiotics. In the search for an effective agent that can treat chronic infections, endogenous biosurfactants have potential as antimicrobial, anti-attachment and anti-biofilm disruptors. On the other hand, bacterial biofilms present in the feed industry are potential sources of contamination, which may lead to feed spoilage and disease transmission. Thus controlling the adherence of microorganisms to feed-contact surfaces is an essential step in providing safe and quality products to animals and eventually consumers.

Regardless of biosurfactants potential, there are few studies on biosurfactants and their interaction with bacterial cells (Díaz De Rienzo et al., 2016a; Johnson *et al.*, 2020). A surfactant released by *Streptococcus thermophilus* has been used for fouling control of heat-exchanger plates in pasteurizers, as it retards the colonization of other thermophilic strains of *Streptococcus* responsible for fouling (Muthusamy et al., 2008). In the same vein, biosurfactants released from broilers' GIT can be used to counter potential biofilm formation in cases of an adversity. This will allow birds to recover from potential disease causing microbes in their GIT without a serious drop in production (Díaz De Rienzo et al., 2016). This will reduce use of synthetic drugs and antibiotics in the poultry industry.

Working with oral bacteria, Yamasaki et al., (2020) observed that rhamnolipids had the capacity to suppress growth and biofilm formation by oral bacteria. Earlier on, Dusane et al., (2010) had observed about 80% inhibition of *Bacillus pumilus* cell attachment to polystyrene surfaces after one (1) hour of treatment with low concentrations of rhamnolipids. However, in this study the surface treatment with rhamnolipids did not stop the cells from growing on it. In their study, Díaz De Rienzo et al., (2016a), found out that preformed biofilms of *Psedomonas* *aeruginosa* PAO1, *Escherichia coli* NCTC 10418, *Bacillus subtilis* NCTC 10400 and *Staphylococcus aureus* ATCC 9144 on glass coverslips were disrupted with sophorolipids (5%) in the absence of adjuvants. Therefore, endogenous biosurfactants can confer tremendous advantage to the secreting microbes and the bird is characterized.

2.2.2 Therapeutic applications of biosurfactants

Several biosurfactants have shown antimicrobial action against bacteria, fungi, algae and viruses. The lipopeptide, iturin, from *B. subtilis* has shown potent antifungal activity (Banat et al., 2020). Rhamnolipids inhibited the growth of harmful bloom algae species, *Heterosigma akashivo* and *Protocentrum dentatum* at concentrations ranging from 0.4 to 10.0 mg/l. A rhamnolipid mixture obtained from *P. aeruginosa* AT10 showed inhibitory activity against the bacteria *Escherichia coli*, *Micrococcus luteus*, *Alcaligenes faecalis* (32 mg/ml), and *Staphylococcus epidermidis* (8 mg/ml). The mannosylerythritol lipid (MEL), a glycolipid surfactant from *Candida antartica*, has demonstrated antimicrobial activity particularly against Gram-positive bacteria. There is a dent in literature when it comes to biosurfactants use in the poultry industry employing some of their key properties such as immuno-modulators.

Biosurfactants can be used as antimicrobial peptides, (AMPs), which are essential components of the innate immunity in other animals and higher organisms, contributing to the first line of defense against infections (Chung and Khanum, 2017). Their amino acid sequences, net-positive charge, amphipathicity, and very small size allow AMPs to bind to and disrupt membranes of microbes. Other researchers have shown that AMPs can also inhibit cell wall, nucleic acid, and protein biosynthesis (Chung and Khanum, 2017).

2.3 An overview of gut health in poultry and how it works

The intestinal tract of a bird is a specialized tube that starts at the beak and ends in the cloaca (Bailey, 2019). The primary function of the gut is the conversion and digestion of feed into its basic components for absorption and utilization by the bird. The gut is separated into five distinct regions: the crop, proventriculus, gizzard, small intestine (duodenum, jejunum, and ileum), and large intestine (caeca, colon and rectum). The integrity of the gastrointestinal tract (GIT) and the gut microbial community play key roles in nutrient uptake, development of immunity, and disease resistance (Shang et al., 2018). Changes in the GIT microbial community may impact negatively on feed efficiency, productivity, and health of chickens (Bailey, 2013).

2.3.1 Microbial inhabitants of the broiler gut

The diverse community of mainly bacteria, fungi, protozoa, and viruses in the gut is referred to in many ways: friendly bacteria, gut flora, gut microbiota (Bailey, 2013). Studies focusing on poultry have proposed that the gastrointestinal tract (GIT) of a broiler chicken is colonized by an estimated 640 species of bacteria (Bailey, 2019). The abundance and diversity of the microbiota varies along the GIT and, predictably, the regions which have less tolerable conditions and faster passage of gut contents, like the proventriculus, have lower numbers of bacteria (Rychlik, 2020). The development of the adult gut microbiota begins on hatching where bacteria are picked up from the environment, the feed, and the people handling the chicks post-hatch. The crop is rapidly colonized within 24 hours post-hatch (Kubasova et al., 2019). After one day post-hatch the ileum and caeca are also both dominated by bacteria (Bailey, 2013). After three days the level of bacteria in the small and large intestine increases tenfold. Within two weeks, the typical adult small intestinal microbiota will be well established and after thirty days the caecal flora will have also developed (Bailey, 2019). The time taken for the establishment of the stable adult microbiota can be reduced with optimal brooding conditions and good feed quality.

The crop harbours a large population of lactobacilli responsible for fermentation of the feed energy and subsequent production of lactic acid which lowers the pH of the crop environment (Bailey, 2013). The conditions within the proventriculus are highly acidic creating an environment which is unsuitable for most bacteria. The gizzard also has an acidic environment but has a substantial population of lactobacilli which originates mainly from the crop. The bacterial population of the small intestine is also made up of mainly lactobacilli although enterococci, *E. coli*, eubacteria, clostridia, propionic-bacteria, and fusobacteria can sometimes be found (Kubasova et al., 2019). The bacterial population of the small intestine evolves as the bird ages but will generally be stable by two weeks of age. The caeca provides a more stable environment which allows the colonization of slower growing bacteria (Bailey, 2013). Early on, the caeca are dominated by lactobacilli, coliforms, and enterococci, but by three to four weeks of age the adult caecal flora should be well established and consists of bacteroides, eubacteria, bifidobacteria, lactobacilli, and clostridia. Lactobacilli occur in all sections of the GIT and they have been reported to secrete biosurfactants (Alkan et al., 2019).

2.3.2 The functional importance of chicken gastrointestinal microbiota

The gastrointestinal compartments of chickens are densely populated with complex microbial communities (bacteria, fungi, archaea, protozoa, and virus) that are dominated by bacteria (Wei et al., 2013). Bailey, (2013) asserts that within the GIT there are multiple interactions between the hosts' (bird) cells, the intestinal environment, bacterial cells, and feed components. These interactions emphasize the exceptionally crucial role of gut microbiota in the health and well-being of the bird. However, the GIT microbiome can also be a source of bacterial pathogens such as *Salmonella* and *Campylobacter* which can disseminate to humans or act as a pool for antibiotic resistance and transmission and therefore may pose a serious threat to public health (Kumar et al., 2018).

Shang et al., (2018) avers that a normal gut microbial community has benefits and costs to the host. The primary benefits that are provided by commensal microbiota are competitive exclusion of pathogens or non-indigenous microbes (Dibner and Richards, 2005). Furthermore, the gut microbiota can form a protective barrier by attaching to the epithelial walls of the enterocyte and thus reduce the opportunity for the colonization of the pathogenic bacteria such as Salmonella, Campylobacter, and *Clostridium perfringens* (Rychlik, 2020). This principle is most commonly known as competitive exclusion. There is agreement in literature that responsible bacteria produce vitamins (e.g. vitamin K and vitamin B groups), short chain fatty acids (acetic acid, butyric acid and propionic acid), organic acids (e.g. lactic acid) and antimicrobial compounds (e.g. bacteriocins), lower triglyceride, and induce non-pathogenic immune responses, which provide both nutrition and protection to the animal (Bailey, 2013; Shang et al., 2018). Literature is sketch on endogenous biosurfactants' antimicrobial properties effectiveness against some common pathogens hence the current review basis that the antimicrobial properties of biosurfactants released by gastrointestinal tract microbes can reduce AMR as we will be using naturally produced bacterial metabolites (biosurfactants).

Commensal bacteria maintain the gut immune system in a state of 'alert' through their secretions which can stimulate immune system including the mucus layer, epithelial monolayer, the intestinal immune cells (e.g. cytotoxic and helper T cells, immunoglobulin producing cells and phagocytic cells) (Bailey, 2013; Shang *et al.*, 2018). These tissues build barriers between the host and the microbes and combat undesirable gut microorganisms. This augments well with Bailey, (2019), assertions that animals lacking a gut microbiota are more susceptible to diseases and have poorly developed immune tissues which compromises growth performance of broilers. The wetting property of biosurfactants (Harshada, 2014), is crucial in this respect as it ensures a greater surface area in contact with the host internal lining thereby deterring potential pathogenic microbes from accessing the internal lining of the bird.

In the distal gut (i.e. ceca and colon), the microbiota also produces energy and nutrients such as vitamins, amino acids, and short chain fatty acids (SCFA) from the undigested feed, which eventually become available for the host (Dibner and Richards, 2005). The SCFA are a source of energy to the animals and can further stimulate gut epithelial cell proliferation, thus increasing the gastrointestinal tract absorption surface and growth performance. In addition, gut microbiota also contributes to metabolism of host nitrogenous compounds (Shang et al., 2018). For example, caecal bacteria can convert uric acid to ammonia, which is subsequently absorbed by the bird and further used to produce amino acids such as glutamine. Therefore, biosurfactants have huge potential to improve performance of the bird with respect to feed utilization and immunity of the bird. However, the bird's endogenous biosurfactants have not been researched on to tap this beneficial effect as a result of their properties.

2.3.3 Gut health stability in broilers

Gut health relies on the balance between the host, the intestinal microbiota, the intestinal environment, and dietary compounds (Shehata et al., 2021). An imbalance in this relationship, as caused by poor bird and environment management, compromise gut health. Efficient digestion and absorption of the nutrient components of the feed is attainable when gut health is optimal. Malabsorption of nutrients results in more nutrients being availed to the small intestinal bacteria causing them to overgrow (Bailey, 2013) consequently causing a caecal shift in the required fermentative bacteria as proteins, sugars, and fat pass into the caeca. Changes in the bacterial populations of the small intestine and caeca that occur during an imbalance is commonly referred to as dysbacteriosis (or dysbiosis) and if prolonged can have negative effects on the host (Bailey, 2019). The shift in caecal bacterial activity results in the production of different bacterial metabolites (Bailey, 2013) including amines from amino acids metabolism, which can cause gut irritation making the ongoing gut upset worse. The presence of certain bacteria is increased during dysbacteriosis, the action of these bacteria further affects nutrient absorption. For example, some bacteria can reduce fat absorption by inactivating the bile acids which capture fats out of the diet (Bailey, 2013). Other bacteria can destroy the surface of the villi reducing the surface area available for nutrient absorption. When nutrient absorption is reduced it is common for birds to increase their feed intake in an attempt to meet their nutritional demands. This results in faster gut transit time, and wetter litter which all result in reduced performance. Endogenous biosurfactants have the potential to counter negatives of such deviations from the norm.

2.3.3.1 What is Dysbacteriosis?

Dysbacteriosis is an imbalance in the gut microbiota as a consequence of an intestinal disruption (Bailey, 2013) thus it is not a specific disease, but a secondary syndrome. Teirlynck et al., (2011) defined dysbiosis as a qualitative or quantitative imbalance of normal microbiota in the small intestine, which can lead to a sequential reaction in the GIT, including reduced intestinal barrier function (e.g. thinning of intestinal wall) and poor nutrient digestibility, and therefore, increasing the risk of bacterial translocation and inflammatory responses. If dysbacteriosis is severe enough, it can contribute to wet litter due to a higher digesta flow rate which will consequently promote growth of pathogenic microbes in the litter with potential infection of the birds. Extraction of endogenous biosurfactants and addition of them in feed or drinking water of the birds will help to guard against the microbial imbalance in the GIT of birds during adverse conditions.

Both non-infectious and infectious stressors can lead to dysbacteriosis. The non-infectious factors include environmental stressors, nutritional imbalances, dietary changes, mycotoxins, poor management, enzymatic dysfunction, or host genetics (Teirlynck et al., 2011). Infectious factors include viral or bacterial challenge, coccidiosis, or toxic metabolites produced by harmful microorganisms such as *Clostridium perfringens*. Use of biosurfactants has potential to guard against these non-infectious and infectious stressors against dysbacteriosis.

The presentation of dysbacteriosis varies depending on severity but it is generally characterized by thinning of the gut wall along with gassy and watery gut contents (Bailey, 2013). Dysbacteriosis can be treated with antimicrobial drugs, however, it is imperative that the primary cause be dealt with to minimize resurgence of the problem and possible residual drugs in meat products.

2.4 Antimicrobial Resistance

Antimicrobial resistance (AMR) is a growing threat where the substances ("antimicrobials") used to kill or neutralize pathogens lose their effectiveness because these pathogens would have become immune (FAO, 2017). Antimicrobials span a wide range of treatments to control bacteria, parasites and fungi and play a major role in agriculture and food safety, as well as in human and animal health. On 21st July 2017 in Harare, the Food and Agriculture Organisation of the United Nations (FAO) launched a project for engaging the food and agriculture sectors in Zimbabwe to combat Antimicrobial resistance (AMR) (FAO, 2017). This is an indication that residual drugs in various animal products including poultry meat is a threat to human health therefore, there is need for safe alternatives to minimize the risks posed by residual drugs. In developing countries like Zimbabwe, where exotic poultry production, particularly broiler production, has increased more than 500 % (Brockotter, 2013) coupled with the fact that poultry meat is universally accepted, the challenge of AMR can reach unprecedented levels. This is attributed to the deficiency in skills of raising broilers among small scale producers who may opt for antibiotics use in scenarios un-called for.

Every year 700 000 people die worldwide because of AMR, this number will continue to rise in tandem with food production losses leading to food insecurity without global action (FAO, 2017; Dixon et al., 2021). Antimicrobial resistance is considered one of the greatest threats to human health (Munk et al., 2017; Rabaan et al., 2022). The resistance epidemic has been attributed to the use of antimicrobials in clinical settings and in livestock (Dixon et al., 2021). Research has shown that reducing the use of antimicrobials can decrease the occurrence of resistance (Munk et al., 2017) hence the review evaluating potential of endogenous biosurfactants to minimize use of antibiotics in broiler production. AMR can come as a result of misuse and inappropriate use of antimicrobial agents. In view of this, the Veterinary school of the University of Zimbabwe in GoZ, (2017a) recommended codes of practice when working with antimicrobials which include:

- avoiding the use of antimicrobial agents whenever possible especially for mild and inconsequential infections
- prescribing prophylactic treatment only where a real risk of serious disease exists
- encouraging treatment of clinical cases using drugs that have been selected appropriately based on the laboratory results

- when antimicrobial agents are administered, measures should be taken to ensure full therapeutic doses are given for an adequate period.

Broiler production is easy to start-up considering low cost structures and material equipment required for one to venture into the business. Also broiler meat is universally accepted thus high use of antibiotics pose a serious risk to human health as there is widespread consumption of the meat.

3 Conclusion and Recommendations

Biosurfactants have a number of properties which enable the secreting microbe to conquer the surrounding environment. Biosurfactants can be of low or high molecular weight compounds. They have diversity of applications due to their variable properties. Millions of microbial populations exist in the chicken gut and secrete biosurfactants to conquer their environment and have competitive advantage on available resources. Gut health relies on the balance between the host, the intestinal microbiota, the intestinal environment, and dietary compounds. Biosurfactants can be used to minimize occurrence of dysbiosis thereby reducing use of antimicrobial drugs and consequently antimicrobial drug resistance. Information relating to the exact microbes secreting the antibacterial compounds and the quantities produced is sketch in literature. Researches should aim at identifying the bacteria producing these antimicrobial compounds and characterize the compounds.

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