INTAS ANIMAL HEALTH

AviPod

An Update for Poultry Professionals

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Organic Acids for Optimising Gut Integrity and Microbial Balance

Healthy Gut, High Performance

Dear Readers,

In modern poultry production, achieving optimal growth and efficient feed utilization remains a primary objective. Gut health plays a pivotal role in achieving these goals, as it directly governs digestion, nutrient absorption and overall bird performance. A well-functioning gastrointestinal tract supports superior feed efficiency and productivity, whereas any compromise can result in reduced growth, increased disease susceptibility and economic losses.

Gastrointestinal system is more than just a digestive organ; it acts as a dynamic interface between bird and its environment. It integrates intestinal structure, microbial populations and immune mechanisms to maintain physiological balance and optimal functionality. A healthy gut depends on the coordinated interaction of epithelial integrity, mucus barriers, beneficial microbiota and immune defences. Together, these components enable efficient nutrient assimilation while protecting against pathogen invasion. Disruption of this delicate balance can lead to dysbiosis and impaired performance.

With increasing restrictions on antibiotic growth promoters (AGPs), maintaining gut health has become more challenging, necessitating the adoption of effective and sustainable alternatives. In this context, nutritional feed supplements such as organic acids have gained considerable importance. By regulating gut pH, suppressing harmful pathogens and promoting beneficial microbial populations, orgainc acid enhance digestive efficiency, strengthen intestinal integrity and ultimately improve overall poultry performance.

We invite you to read the issue and share your valuable experiences and insights by scanning the QR code below or contacting us at aviglo@intaspharma.com.

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Introduction

High growth performance and efficient feed utilization remain the primary objectives of modern poultry production. These outcomes are influenced by multiple factors, including genetics, feed quality, environmental management and disease control. Among these, efficiency of digestion and nutrient absorption plays a central role, making gut health a critical determinant of overall performance. A well-functioning intestinal tract ensures optimal digestion, enhanced nutrient uptake and improved feed conversion efficiency, ultimately supporting superior growth and productivity. Conversely, any compromise in intestinal health impairs nutrient utilization, negatively impacting bird health, growth and economic returns.

Intestinal mucosa serves as a vital interface between bird and external environment, acting as a dynamic barrier that regulates nutrient absorption while protecting against pathogens. Its functionality depends on a highly coordinated balance between epithelial cells, mucus layers, resident microbiota and immune components. Disruption of this balance can weaken barrier integrity, leading to impaired intestinal homeostasis and suboptimal production performance.

Gut health is increasingly recognized as a multi-factorial and holistic concept that extends beyond structural integrity to include physiological functions, microbial ecology and immune competence. It encompasses the interaction of four key pillars: nutrition, intestinal morphology, gut microbiota and immune system. Maintaining harmony among these components is essential to ensure intestinal resilience, welfare and consistent productivity.

With the progressive restriction on antibiotic growth promoters (AGPs), the poultry industry faces new challenges in sustaining performance and controlling disease. This shift, coupled with rising concerns over antimicrobial resistance and increasing consumer demand for antibiotic-free products, has accelerated the adoption of alternative strategies. Among these, nutritional interventions such as organic acids, probiotics, prebiotics, enzymes and phytogenic additives have gained prominence, primarily due to their ability to support gut health and modulate microbial balance effectively.

Gastrointestinal Physiology and pH Dynamics

Understanding the structure and physiology of chicken gastrointestinal (GI) tract is fundamental to managing optimal gut health. Gut represents the largest surface area exposed to external environment, where dietary nutrients, commensal microorganisms and potential pathogens interact directly with host. Efficient gastrointestinal function is therefore essential not only for digestion and nutrient absorption but also for immune protection and overall performance.

Oral Cavity and Crop

Chickens ingest feed using their beak. Their keratinized tongue contains antimicrobial peptides and immune cells that provide an early defence against pathogens. Saliva contributes enzymes (such as amylase) and mucus, aiding both digestion and lubrication. After ingestion, feed passes into the crop where it is moistened and partially fermented. Crop maintains a mildly acidic (~ 4 to 6 pH) environment that helps suppress harmful bacteria while supporting initial microbial and enzymatic activity.

Proventriculus and Gizzard

Chicken stomach consists of proventriculus and gizzard, working together for efficient digestion. Proventriculus initiates chemical digestion by secreting hydrochloric acid (HCl) and enzymes, while also providing antimicrobial protection through its mucus layer and defensive peptides. Gizzard performs mechanical grinding of feed, ensuring proper particle size for digestion. Together, they maintain a highly acidic environment (~ 2 to 5 pH), which enhances protein digestion, activates pepsin and helps eliminate harmful pathogens.

Small Intestine

Small intestine is the primary site for digestion and nutrient absorption, with finger-like villi that greatly enhance absorptive surface area. It maintains the pH around 5 to 7.5. Digestion is supported by pancreatic enzymes and bile, allowing efficient transfer of nutrients into bloodstream. In addition to its digestive role, small intestine is central to immune defence, maintained through four integrated barriers: microbial (beneficial microbiota), chemical (mucus, antimicrobial peptides, IgA), physical (epithelial cells with tight junctions) and immunological (immune cells in the lamina propria).

Caeca

The paired caeca are major sites of microbial fermentation in chickens. Undigested nutrients and dietary fibre are fermented by microbes to produce volatile fatty acids (VFAs), which contribute to gut health and energy metabolism. Caeca maintain a moderately acidic pH (~5 to 6). They also possess strong immune functions, including lymphatic tissues such as caecal tonsils. These structures demonstrate the caeca's critical role in maintaining microbial balance and gut immune homeostasis, while also serving as a niche for both commensal and zoonotic bacteria.

Colon

Colon (Large intestine) is relatively short in chickens compared with mammals and even shorter than the small intestine. It exhibits a near-neutral pH (~6 to 7). Its primary functions include water reabsorption and electrolyte balance, with minimal digestion occurring in the segment.

Gut Microbiota

Chicken gut contains diverse community of microorganisms, together called the gut microbiota. These microorganisms include bacteria, fungi, protozoa and viruses, but bacteria are the most important group because they play a major role in digestion, immunity and gut health.

Gastrointestinal microbiota of chickens can be broadly categorized into luminal and mucosal associated communities. The composition of luminal microbiota is primarily influenced by factors such as nutrient availability, antimicrobial compounds and feed passage rate. In contrast, mucosal microbiota is shaped by host-specific factors including the presence of adhesion sites on intestinal cells, mucus secretion and activity of secretory immunoglobulins. These two microbial groups interact dynamically and influence each other, collectively affecting gut health.

Distribution of Gut Bacteria

Different segments of chicken GI tract harbour distinct microbial populations in terms of type and density. Crop and gizzard are primarily dominated by Lactobacilli and Streptococci, with relatively low bacterial counts. In the duodenum, microbial density is minimal, mainly consisting of Lactobacilli and Bifidobacteria. As digesta progresses to the jejunum, the microbial population increases, with common genera including Lactobacilli, Enterococci and *Clostridiaceae.*

Ileum contains the highest bacterial load within the small intestine, featuring a diverse community such as Streptococci, *Bacteroides*, Clostridia, *Escherichia coli*, Ruminococci, Enterococci and Lactobacilli. Beyond this, caeca host the most abundant, diverse and stable microbial ecosystem, where genera like *Bacillus, Clostridium, Enterococcus* and *Ruminococcus* predominate. Similarly, cloaca also supports a highly diverse microbial population, largely composed of Clostridia, Streptococci, Enterococci and *E. coli*, reflecting its role as a convergence point for intestinal microbes (Fig. 1).

Functions of Gut Microbiota

Protective Functions of Gut Microbiota

Gut microbiota contributes to host defence by forming a protective layer along the intestinal epithelium, thereby limiting the attachment and colonization of pathogenic organisms. These microbes play an essential role in synthesizing key metabolites such as vitamins (including vitamin K and B-complex vitamins), short-chain fatty acids (SCFAs), as well as organic acids such as lactic acid.

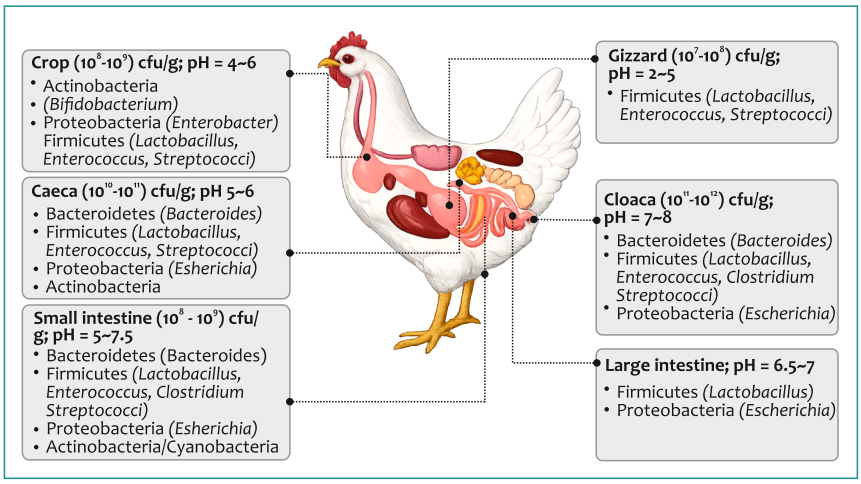


Fig. 1: Bacterial Distribution in Chicken GI Tract
(Oke *et al.*, 2025)

Immune Development and Host Protection

A well-balanced microbial community suppresses of pathogenic organisms through competitive exclusion, enhancement and regulation of immune responses and contribution to nutrient supply. Commensal microbes are also crucial for the development of immune system, including the formation of mucus barrier, maintenance of epithelial integrity and maturation of immune cells such as T lymphocytes, immunoglobulin secreting cells and phagocytes. These components collectively establish a functional barrier that protects against harmful microorganisms.

Nutritional Contributions and Metabolic Roles

In distal regions of GI tract, particularly the caeca and colon, microbial fermentation of undigested dietary components generates a range of energy yielding metabolites and nutrients, including short-chain fatty acids (SCFAs) and vitamins that can be utilized by host. The principal SCFAs produced are acetate, propionate and butyrate. Among these, butyrate is largely utilized locally by intestinal epithelial cells as a primary energy source, resulting in minimal systemic availability.

Beyond their role in energy provision, SCFAs possess antimicrobial activity, contributing to the suppression of pathogenic microorganisms such as *Salmonella*. They also stimulate the proliferation and differentiation of intestinal epithelial cells, thereby enhancing the absorptive surface area and overall efficiency of nutrient uptake. Additionally, SCFA production leads to a reduction in intestinal pH, which helps inhibit the formation of harmful secondary bile acids. Gut microbiota also plays a vital role in nitrogen metabolism. Microbial populations in caeca can convert uric acid into ammonia, which can subsequently be re-assimilated by the host for synthesis of amino acids. Furthermore, microbial cells themselves can serve as a supplementary source of protein and amino acids following their turnover and digestion.

Metabolic Costs and Negative Effects of Gut Microbiota

Despite these beneficial roles, gut microbiota can also impose certain metabolic costs. In upper GI tract, including gizzard and small intestine, microbes compete with host for nutrients such as energy and protein. Additionally, microbial activity may generate toxic by-products, including amino acid degradation products and alter bile acid metabolism, which can negatively impact growth performance and fat digestion. The presence of microbiota also increases mucin production and accelerates epithelial turnover, processes necessary for maintaining gut integrity but requiring additional energy and nutrients. Immune system also becomes more active, producing immunoglobulin A (IgA), which helps regulate microbial populations but further increases metabolic demands.

Dysbiosis and Its Impact

An imbalance in gut microbial community, commonly known as dysbiosis, can adversely affect host health (Fig. 2). Dysbiosis involves changes in the composition or abundance of intestinal microbes, leading to compromised intestinal barrier function, reduced nutrient absorption and increased susceptibility to infection and inflammation.

This condition can be triggered by various non-infectious factors such as environmental stress, dietary imbalances, mycotoxins, poor management practices and host genetics, as well as infectious agents including viruses, bacteria, coccidia and toxin-producing microorganisms like *Clostridium perfringens*.

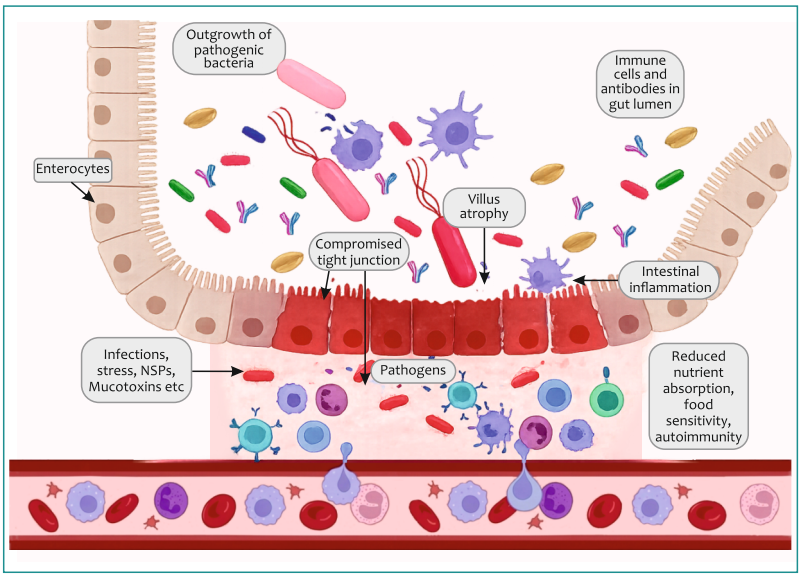


Fig. 2: Dysbiosis and Gut Health Disruption (Fathima *et al.*, 2022)

Gut Integrity and Intestinal Barrier

Gastrointestinal tract is continuously exposed to food antigens, commensal microorganisms and potential pathogens. To maintain health, the intestinal immune system has evolved a multi-layered physical and immunological barrier that preserves gut integrity while allowing immune tolerance and protective responses.

Mucus Layer- The First Line of Defence

Intestinal mucosal layer forms the outermost protective barrier and consists of two distinct regions (Fig. 3). Outer loose mucus layer permits colonization by commensal microorganisms and supports microbial ecology and nutrient metabolism. Inner compact mucus layer is largely free of bacteria and effectively repels microbial penetration toward epithelial cells. This mucus barrier is a central component of innate immunity, preventing direct contact between luminal microbes and the intestinal epithelium.

Epithelial Barrier and Tight Junctions

Beneath the mucus lies a single layer of intestinal epithelial cells (IECs) that separates the microbe-rich lumen from the sterile internal tissues (Fig. 3). Adjacent epithelial cells are connected by tight junctions composed of proteins such as claudins, occludins and zona occludens-1 (ZO-1). These structures seal intercellular spaces near the apical surface, maintain epithelial integrity and regulate selective permeability. Disruption of tight junctions increases intestinal permeability and predisposes to inflammation and disease.

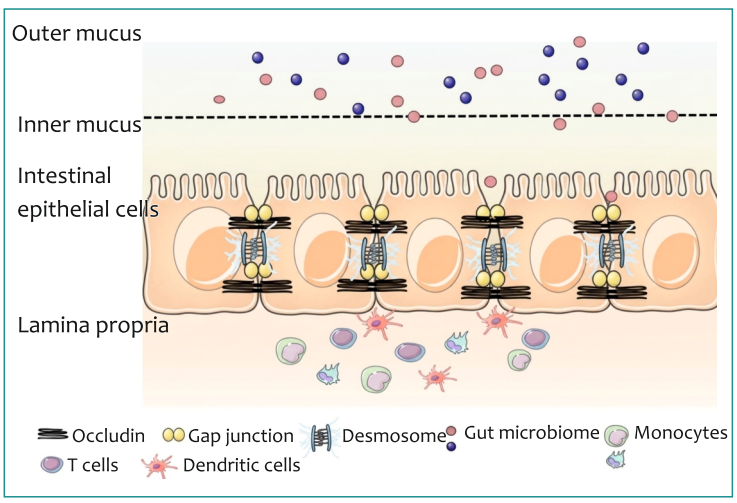


Fig. 3: Intestinal Epithelial Barrier (Chelakkot *et al.*, 2018)

Key Immune Components of Intestinal Barrier Protection

A subset of intestinal epithelial cells secretes antimicrobial peptides (AMPs), including defensins, cathelicidins and C-type lectins, which play a critical role in maintaining gut microbial balance. These AMPs actively kill or inhibit pathogenic bacteria while shaping the composition of gut microbiota. In addition to this, intestinal B cells produce secretory immunoglobulin A (IgA), which binds to luminal microbes, preventing their adhesion and translocation across the epithelial barrier. This process provides effective immune exclusion without triggering excessive inflammation, thereby preserving mucosal homeostasis. Furthermore, intestinal epithelial cells are equipped with pattern-recognition receptors (PRRs), such as Toll-like receptors (TLRs) and NOD-like receptors (NLRs), which are essential for innate immune recognition. Under homeostatic conditions, these PRRs exhibit reduced responsiveness to commensal microbiota, preventing unnecessary immune activation.

However, during infection or injury, PRRs recognize pathogen associated molecular patterns (PAMPs), triggering inflammatory signalling cascades that activate antimicrobial responses and recruit immune cells. Despite occasional breaches in epithelial barrier, this tightly regulated innate immune sensing ensures efficient pathogen clearance while minimizing tissue damaging inflammation.

Immune Cells and Regulation

Gut immune system employs specialized immune cells to maintain immune tolerance and defence, including macrophages, dendritic cells, intraepithelial lymphocytes, T cells and $CD4^+$ T cell subsets (Th1, Th2, Th17 and regulatory T cells (Treg)). These cells communicate *via* cytokines and chemokines to regulate immunity and prevent chronic inflammation.

Dendritic cells play a crucial role in antigen presentation by continuously sampling luminal antigens within the gut environment. These cells process and present antigens to naïve $CD4^+$ T cells in gut associated lymphoid tissues, such as Peyer's patches and caecal tonsils. This interaction drives the differentiation of specialized effector T cell subsets that are finely tuned to the intestinal environment. As a result, the adaptive immune system achieves a balanced response by promoting tolerance toward dietary antigens and commensal microbiota, while simultaneously generating protective immunity against invading pathogens.

Effective gut immunity is achieved through two fundamental strategies:

1. Limiting direct bacterial contact with intestinal epithelium.
2. Rapid detection and removal of pathogens that breach epithelial barriers.

Together, these strategies preserve intestinal health, prevent dysbiosis and mitigate excessive inflammatory responses. Given the importance of microbiota and gut integrity, nutritional strategies play a crucial role in maintaining gut health, particularly under antibiotic-free production systems.

Organic Acids

The increasing restriction on antibiotic growth promoters (AGPs), driven by concerns over antimicrobial resistance and food safety, has intensified the search for effective alternative feed additives in poultry production. Among the available options, organic acids have gained considerable attention due to their safety, absence of harmful residues, low risk of resistance development and beneficial effects on gut health and overall performance. A wide variety of organic acids, characterized by diverse physical and chemical properties, are currently used in poultry nutrition. These compounds are commonly administered either through drinking water or incorporated into feed.

Organic acids are carboxylic acids with the general structure R–COOH, representing a broad group that includes fatty acids as well as certain amino acid derivatives. Within this group, short-chain organic acids (C1–C7) are particularly important due to their well-documented antimicrobial activity. Based on their chemical structure, these acids can be classified into several categories: simple monocarboxylic acids (e.g., formic, acetic, propionic and butyric acids), hydroxy acids (e.g., lactic, malic, tartaric and citric acids) and unsaturated carboxylic acids containing double bonds (e.g., fumaric and sorbic acids).

Mechanisms of Action

Organic acids exert their beneficial effects in poultry through multiple mechanisms of action, primarily involving antimicrobial activity, digestive enhancement and modulation of gut health. Their antimicrobial effect is achieved by penetrating bacterial cell membranes in their undissociated form and subsequently dissociating within the cytoplasm, releasing hydrogen ions (H^+). This process disrupts intracellular pH, interferes with enzymatic activity and impairs DNA replication, ultimately resulting in bacteriostatic or bactericidal effects (Fig. 4). Due to this multi-target mode of action, organic acids reduce the likelihood of microbial resistance development.

In addition to their antimicrobial properties, organic acids contribute to improved digestive efficiency by lowering the pH of GI tract. This acidic environment enhances pepsin activation and facilitates protein digestion. Moreover, organic acids stimulate the secretion of key digestive enzymes, including amylase, protease and lipase, thereby promoting efficient nutrient breakdown and absorption within the digestive system.

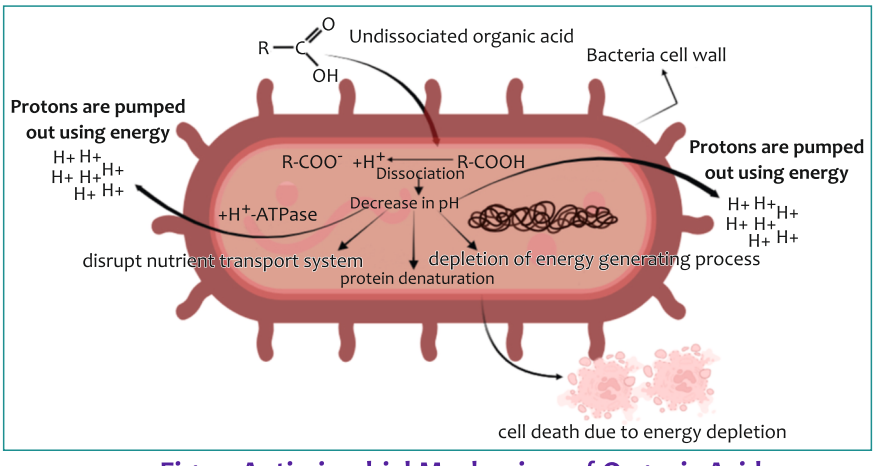


Fig. 4: Antimicrobial Mechanism of Organic Acids
(Chukwudi *et al.*, 2024)

As a result of these combined effects, the supplementation of organic acids has been consistently associated with improved growth performance in poultry. This includes increased body weight gain (BWG), enhanced feed conversion ratio (FCR) and improved nutrient digestibility. These performance improvements are largely attributed to reduced pathogen load, increased proliferation of beneficial microbiota and enhanced nutrient utilization efficiency (Fig. 5).

Furthermore, organic acids play a crucial role in maintaining intestinal health by improving gut morphology and function. Their inclusion in diet has been shown to increase villus height, optimize crypt depth and promote enterocyte turnover, thereby enhancing the absorptive surface area of intestine. Organic acids also strengthen the intestinal barrier by upregulating tight junction protein expression and stimulating mucus production, which together help protect the gut from pathogens and physical damage.

Beyond their effects on digestion and gut structure, certain organic acids particularly butyric acid and its derivatives exhibit significant immunomodulatory properties. They enhance the production of antibodies such as IgG and IgA, stimulate lymphocyte activity and improve the response to vaccination. These effects highlight the important link between nutritional strategies and immune resilience, ultimately contributing to better health and productivity in poultry.

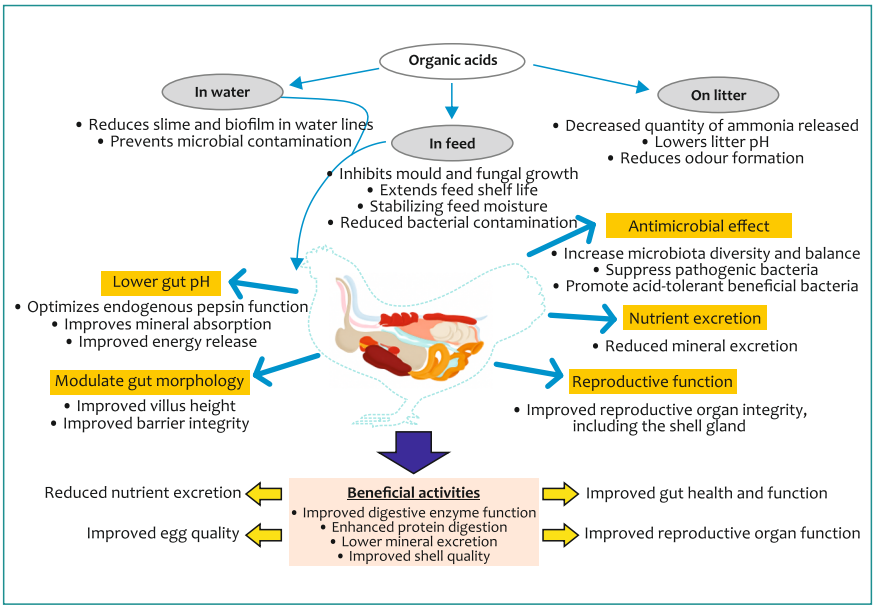


Fig. 5: Application and Beneficial Effect of Organic Acids
(Oketch and Heo, 2026)

Butyric Acid–A Key Functional Organic Acid

Among organic acids, butyrate has attracted significant interest as a promising alternative to antibiotics due to its multiple beneficial effects within GI tract.

Role of Butyric Acid

Butyric Acid, a major short-chain fatty acid, serves as the primary energy source for enterocytes, supporting epithelial metabolism and tissue integrity. Beyond its nutritional role, butyrate exerts strong anti-inflammatory and immunomodulatory actions by activating G-protein-coupled receptors, enhancing the production of anti-inflammatory cytokines and promoting regulatory T cell development. It also strengthens intestinal barrier function by increasing tight junction protein expression, mucin secretion and antimicrobial peptide production, thereby improving resistance against pathogens. Collectively, these multifaceted roles of butyrate contribute to improved gut health, enhanced immunity and better growth performance in poultry.

Limitations and Delivery Challenges of Butyric Acid

Despite these advantages, the practical application of butyric acid in poultry production has been constrained by its strong unpleasant odour and rapid metabolism as free (pure) butyric acid is rapidly absorbed in the upper GI tract, its direct supplementation limits availability to the distal intestine. To overcome this limitation, butyric acid is commonly administered in protected or modified forms that ensure targeted and sustained release along the GI tract.

Delivery Forms of Butyric Acid

Coated Sodium Butyrate: Sodium butyrate encapsulated within lipid or polymer matrices (e.g., beadlet or micro-encapsulated forms) allows controlled release throughout the GI tract, improving delivery to the lower gut.

Butyric Acid Salts: Salts of butyric acid (e.g., sodium or calcium butyrate) are widely used.

Butyric Acid Glycerides: Glyceride (mono-, di- and triglycerides) forms provide a stable and gradual source of butyrate through enzymatic hydrolysis by lipases. These has emerged as a particularly promising candidate due to its improved stability, controlled release and enhanced delivery efficiency within the digestive system.

Glycerides of Butyric Acid

Glycerides of butyric acid, including mono-, di- and triglyceride forms, contain one, two and three molecules of butyric acid esterified to glycerol, respectively.

These derivatives act as effective delivery systems for butyrate within the GI tract and have been associated with enhanced gut development, modulation of gut microbiota, improved control of enteric pathogens, reduced intestinal inflammation and better growth performance.

Butyric acid glycerides undergo enzymatic hydrolysis by pancreatic lipases. Tributyrin, which consists of three butyric acid molecules bound to a glycerol backbone, exhibits greater stability than free butyric acid and is less susceptible to rapid absorption in the upper GI tract. Consequently, glyceride forms of butyric acid are considered advantageous over free butyric acid because they improve stability, eliminate the unpleasant odour and enable a more gradual release of butyrate along lower GI tract.

Table 1: Comparison of Conventional and Glyceride-based Butyrate Sources

Aspect	Free Butyric Acid	Tributyrin
Odor	Extremely strong	Odourless
Feed palatability	Poor	Excellent
Stability	Volatile	Highly stable
Site of release	Mainly upper gut	Mid and lower intestine
Duration of action	Rapid, short	Gradual, sustained

A Synergistic Blend of Butyric Acid Esters with Cinnamaldehyde

Butyrin (butyric acid esters) and cinnamaldehyde play a complementary and highly effective role in improving poultry gut health through both nutritional and functional mechanisms. Butyrin serves as a protected source of butyric acid, allowing its gradual release along different sections of GI tract. Butyric acid is a key energy source for enterocytes (intestinal epithelial cells) and is essential for maintaining the integrity of gut lining. It promotes villi development, enhances tight junction strength and reduces gut permeability, thereby improving nutrient absorption and overall feed efficiency. Additionally, butyrate exhibits strong antimicrobial activity against pathogenic bacteria like *Salmonella* and *Clostridium perfringens*, while supporting beneficial microflora, ultimately contributing to a balanced gut environment.

Cinnamaldehyde, a bioactive compound derived from cinnamon, complements the action of butyrin through its potent antimicrobial, anti-inflammatory and antioxidant properties. It helps modulate the gut microbiota by inhibiting harmful bacteria and improving the dominance of beneficial microbes. Furthermore, cinnamaldehyde stimulates digestive enzyme secretion, enhancing feed digestion and nutrient utilization. Its anti-inflammatory effects also help in reducing intestinal stress and maintaining mucosal health, particularly under challenging conditions such as pathogenic pressure or environmental stress.

Tributas is a next generation synergistic gut modulator containing mono, di and triglycerides of butyric acid combined with cinnamaldehyde. The butyrin serves as an effective source of butyrate, supporting intestinal integrity and providing energy to intestinal epithelial cells, while cinnamaldehyde helps maintain a favourable microbial balance and supports digestive efficiency. Through this complementary mode of action, **Tributas** enhances gut health, supports immune function, enhances growth performance and contributes to improved overall productivity in poultry. **Tributas** can be supplemented @ 250–500 g per tonne of feed.

Conclusion

Optimising gut integrity and microbial balance is essential for efficient poultry production, as digestion, immunity and performance are closely interconnected. Gastrointestinal pH plays a central role in shaping microbial populations, enzyme activity and nutrient utilisation. Organic acids provides an effective strategy to regulate gut pH, suppress pathogenic bacteria and promote beneficial microbiota, thereby improving digestion, intestinal structure and overall bird performance. Among these, butyric acid is particularly important due to its ability to enhance epithelial integrity, modulate immune responses and support gut health. Advanced delivery systems such as butyrins ensure targeted and sustained release, maximising its benefits along the GI tract. Overall, organic acids especially well-designed formulations offer a practical and sustainable approach to maintain gut health, optimise microbial balance and improve productivity in modern poultry systems.

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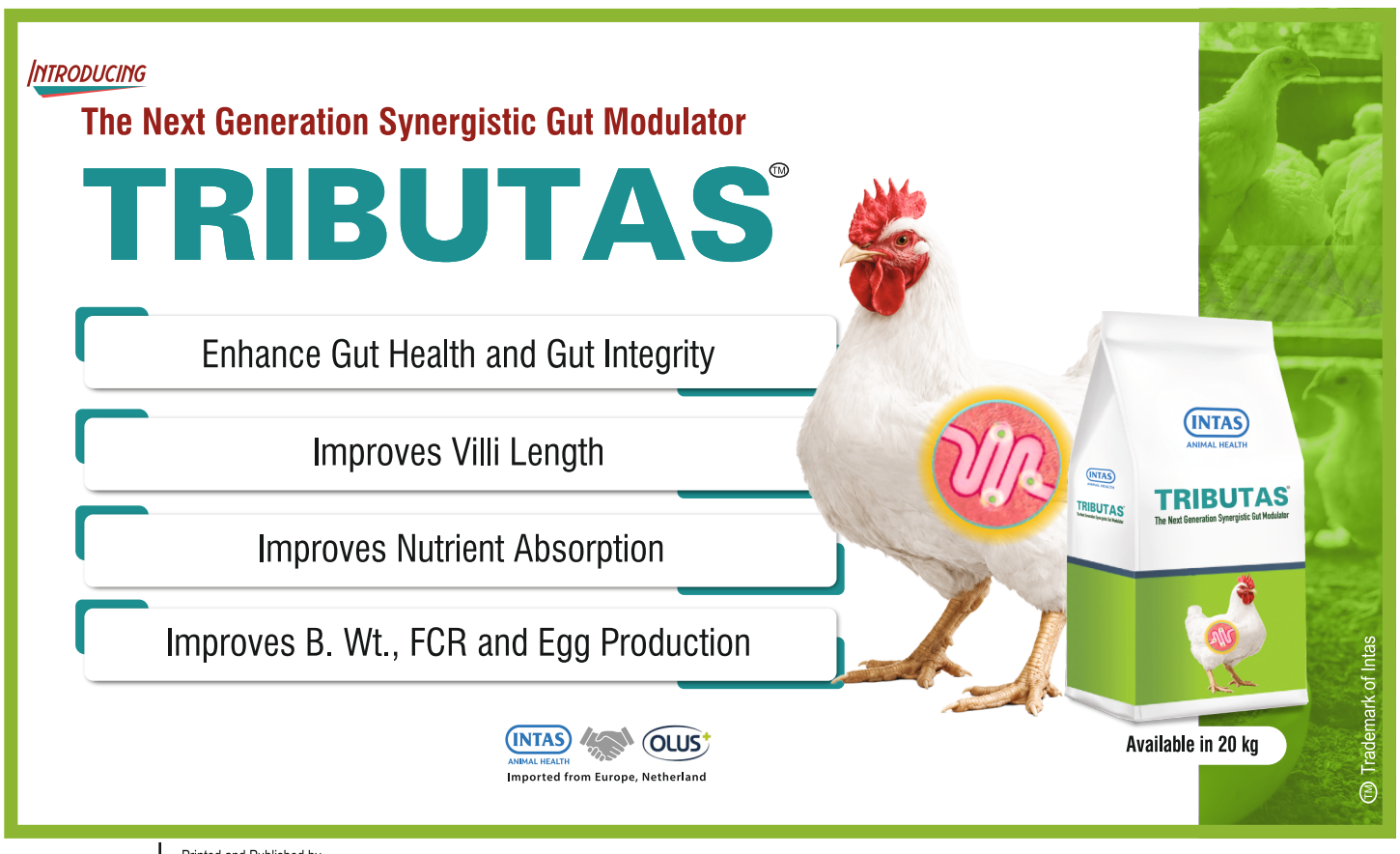
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