Chapter 45

Preventive Feed Additives in Poultry Diet

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ABSTRACT

Feed additives are any sort of organic, inorganic, or synthetic compounds or substances added to poultry feed to enhance its nutrition and efficiency. Feed additives play a pivotal role in the poultry industry and are very crucial for the health of birds. Moreover, these additives are also pre-eminent in preventing many diseases and controlling morbidity, as well as mortality. Feed additives impart various benefits to birds' good gut health, carcass gain, increased production, and ultimately favor a better economy. Feed additives can be classified according to their manufacturing process, their impact on the health and performance of birds, and their nutritional value. Different manufacturing agents include antifungals, antioxidants, pellet binders, and flavors, which are also important for increasing the shelf life of feed and its palatability. Moreover, different enzymes, acidifiers, vitamins, amino acids, antibiotics, minerals, etc. can also be added to feed for nutrition and preventive purposes. Different approaches are used worldwide regarding the addition of feed additives in poultry feed to improve the efficiency of the poultry industry, while many are under research.

KEYWORDS
Poultry nutrition, Poultry feed, feed additives, Nutrition, preventive Additives, Health, Prevention, Prebiotics, Feed efficiency, Growth promotors, Oxidative stress reducers

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INTRODUCTION

Feed additives are substances that can be added to the food of an animal, bird, or any human to enhance its nutrition and effectiveness. These can be nutrient or non-nutrient compounds. We can refer to these feed additives as supplements that act as a substrate for these feed items and their nutrients that can affect the gut health of birds. These feed additives can have potential benefits to birds' health. It works by decreasing the feed intake and enhancing the utilization of its nutrients in the body and proper weight gain, thus improving the FCR of the bird. This will ultimately lead to good health of the bird, its improved carcass quality, and dressing percentage. It aids in enhancing the growth rate and production, enhancing health and immunity, and preventing disease, thereby elevating the profit margin (Pandey et al., 2019). As we are aware, there are many challenges in food production today, such as safety, climatic and environmental problems, quality standards, and the effect on gastrointestinal health, and along with it, it costs about 60 to 75% of total production, and there is no margin for any upheaval, that's why we use feed additives that play an important role while combating these challenges. Moreover, feed additives can be used to maneuver feed to increase the FCR so our birds can gain proper weight with less feed intake (Gangadoo et al., 2016).

Following is the role of feed additives used in feed production. It improves digestion, strengthens the function of the immune system and its response, improves the absorption of minerals, gives texture to the feed (Pandey et al., 2019), combats infections and diseases (Pirgozliev et al., 2019), preserves the nutritional value and improves palatability (Pirgozliev et al., 2019). Moreover, it also provides antimicrobial effects and buffer effects, promotes growth, and maintains the wholesomeness of feed.

Need of Feed Additives in Poultry Feed

In recent years, the global poultry industry has looked at remarkable and subsequent growth. The production of poultry has increased by 2 times in the past 30 years. This transition is controlled by expanding the requirement for protein sources. The urging rise, set in motion by an increase in population, incomes, and shift of dietary bias, has fastened poultry as a foundation of the world's food supply. Prime producers all over the world have jumped onto advanced technologies and efficient production systems to meet this demand. The innovations are also helpful in combating the rising threats of different disease outbreaks like new castle disease, avian influenza (Qureshi et al., 2022). Poultry products like feed additives, supplements, antibiotics, etc. are also innovated to ensure the takeover of all the above-described challenges.

Factors Affecting the Feed Intake of Poultry

The following are the important factors affecting the feed intake of birds (Chadd, 2007). It depends upon the birds' requirements. These requirements are influenced by the age, sex, and genotype of the birds. Maintenance of eggs and meat production is influenced by nutrient adequacy of diet, or diet composition. Environmental factors also affect the feed intake (Ferket and Gernat, 2006). Physical and physiological feedback mechanisms (hormonal mechanism, environment, and feed composition), and metabolism (circulating metabolites and liver metabolism) are the other factors affecting the feed intake of our birds (Barzegar et al., 2020). Feed additives in the feed can help in enhancing the efficiency of feed, production maintenance, nutrition improvements, and controlling the metabolism of birds. Different types of feed additives are present in the market, made by different manufacturing companies, to combat all the above challenges.

Classification of Feed Additives

Feed additives can be categorized into 4 major classes. These are classified as feed manufacturing agents, performance-enhancing additives, nutritional additives, and health-improving agents (Okey, 2023).

Feed Manufacturing Feed Additives

Antifungal Feed Additives

Unluckily, ingredients like corn, soybean, etc. are apt to get contaminated by the fungi and their secondary metabolites i.e., mycotoxins, particularly during their storage. Moisture also contributes to the production and proliferation of various fungi. Fungal impurities in feed can also lead to different diseases, bad health impacts as well as economic losses. There are different antifungal feed additives present in the market, and many others are under study. These can be natural or can be prepared synthetically in the laboratory. Here are some different antifungals added as feed additives in our birds 'diet.

Fermented whey in the presence of kefir grains @ 1 liter/kg can be used as an antifungal preservative against *Aspergillus spp., Rhizopus, and Penicillium* (Londero et al., 2014). Metal nanoparticles like ZnO, and Fe_2O_3 are effective antifungal agents (Nabawy et al., 2014). Poultry feed is prone to fumonisins, a mycotoxin produced by fungi of class *Fusarium* spp. *Lactobacillus plantarum MYS6* can be used as a potential antifungal agent against fumonisin-producing *F. proliferatum* MYS9 and can act as an auspicious replacement for chemical preservation of poultry feed (Deepthi et al., 2016). Addition of *Saccharomyces cerevisiae* yeast cell wall in poultry diet can act as an absorbent of mycotoxins (Aflatoxin B1) and cannot have any detrimental effect on birds' health (dos Santos et al., 2021). Cinnamaldehyde and carvacrol both have antifungal and antibacterial properties. Carvacrol and trans cinnamaldehyde can be used in poultry feed as an additive to inhibit the growth of fungi like *Aspergillus flavus*, and *Aspergillus parasiticus* (Yin et al., 2015). Mycotoxin detoxifiers as a feed additive in feed of birds can improve the FCR, and bring antibodies level against different viruses like *New Castle* to normal that can be decreased by aflatoxins in the feed (Afzal and Zahid, 2004). Barberine can also be used as a preservative in food. It helps prevent the growth of different fungi, and molds. Barberine concentration of at least 0.03g/kg in poultry feed can be effective in controlling the growth of different fungi (Geerlofs et al., 2019). *Glycyrrhiza glabra*, a traditional medicinal herb, can also be used as an antifungal, as well as antimicrobial (Gowthaman et al., 2021). Complex of propionic acid, formic acid, and ammonia can be recommended for the treatment of fungal diseases in poultry chicks (dos Santos et al., 2009).

Antioxidant Feed Additives

As we know, stored poultry feed is prone to oxidation. Vitamins, fats, lipids, and proteins present in the feed are degenerated by this oxidation. The degeneration of important compounds in the feed leads to reduced intake of feed, decreased performance, and ultimately reduced production. There are different natural, and artificially synthesized substances present already, and some are being studied to prevent this oxidation of feed materials. Some important antioxidants are discussed below, that can prevent spoilage of the feed ingredients of poultry. Antioxidants are either water-soluble like vitamin C, uric acid, and glutathione, or these can be fat-soluble like vitamin E, and coenzyme Q. Other antioxidants include zinc, vitamin A, selenium, saponins, flavonoids, and tannins.

Different extracts of essential oils like thymol, carvacrol, eugenol, cinnamaldehyde, grapes extracts, and rosemary can be used as antioxidants and can reduce oxidative stress on birds' bodies (Righi et al., 2021). But these can affect the organic functions of the body, depending on the metabolism of the bird. Stored feed for above 30 days (about 4 and a half weeks) is viable for lipid peroxidation. Thymol can prevent this lipid peroxidation of feed, and its rancidity (Luna et al., 2017). Different birds fed with natural photogenic vegetables, and herbs in their feed, showed increased antioxidant quantity in their carcasses, hence protecting it against unfavorable oxidation (Zdanowska-Sasiadek et al., 2019). Vitamin E, a powerful free radicals scavenger, has a favorable impact on the carcass quality of poultry meat.

Pellet Binders

Pellet binders are the binding vehicles that give strength to pellets and provide integrity and stability. These are used to enhance the durability of feed pellets so that they can be available to birds in their best form. These are thought to be reliable agents to prevent any kind of feed impairment during storage or transportation. Pellet binders are added to the feed to enhance the physical quality of poultry feed, the growth of poultry birds, to improve the carcass quality, and dressing percentage of birds, as well as profits and economy. Both kinds of pellet binders, organic and inorganic, are used. Organic pellet binders include lactase monohydrate, sodium lignosulfate, hemicellulose, carboxymethyl cellulose etc. Other inorganic binders include hydrated aluminum silicate (bentonite), and clay. Wheat gluten @ 10g/kg, or a wheat average of 150g (about 5.29 oz)/kg can increase weight in the broiler chicken as well as improve the quality of pellets (Moradi et al., 2018).

Feed Flavors

Feed flavors added in poultry feed to reform its intake is a hot topic in research nowadays. Feed reforming or modification stated by (Balog and Miller, 1989) includes reduced feed intake in the rearing of broiler breeders (reduced fat deposition that is not favorable), and molting stage (forced molting) of layers. It also includes increasing the feed intake in commercial broilers. Feed flavors work by increasing appetite through enhanced nice aroma and color, and in this way feed with low palatability can be fed to birds easily to raise weight (Okey, 2023). The use of different flavors like anise oil, garlic oil, vanilla oil, oregano extracts, molasses, yucca, salts, and different essential oils are under study, but no significant result can be proven in reforming until now.

Performance-enhancing Feed Additives

Enzymes

Enzymes are characterized as non nutritional dietary elements that are added to poultry feed to enhance the accessibility of substrate thus improving proteins, energy intake, and nutrient digestion (Koryagina et al., 2019). These include non-starch polysaccharides (NSP), lectins, phytates, and protease inhibitors (Fig. 1). Phytase has a positive impact on energy utilization in birds, showing increased growth and performance (Selle et al., 2007). Phytases work by breaking phytic acid present in poultry feed and releasing bound inorganic phosphorus for better utilization, absorption, and digestion. NSP plays an important role in improving the GIT health of birds and their performance, but still, its use in feed formulation is scarce (Nguyen et al., 2021). NSPs are referred to as hydrolyzing enzymes that work by enhancing nutrient digestibility, small intestine modification, and decreasing digesta viscosity (Simon, 2000). The use of lectin is controversial due to its anti-nutritional impacts. Protease supplementation in diet can result in enhanced performance of birds, it works by breaking down both stored proteins and anti-nutrient proteins (Erdaw et al., 2016).

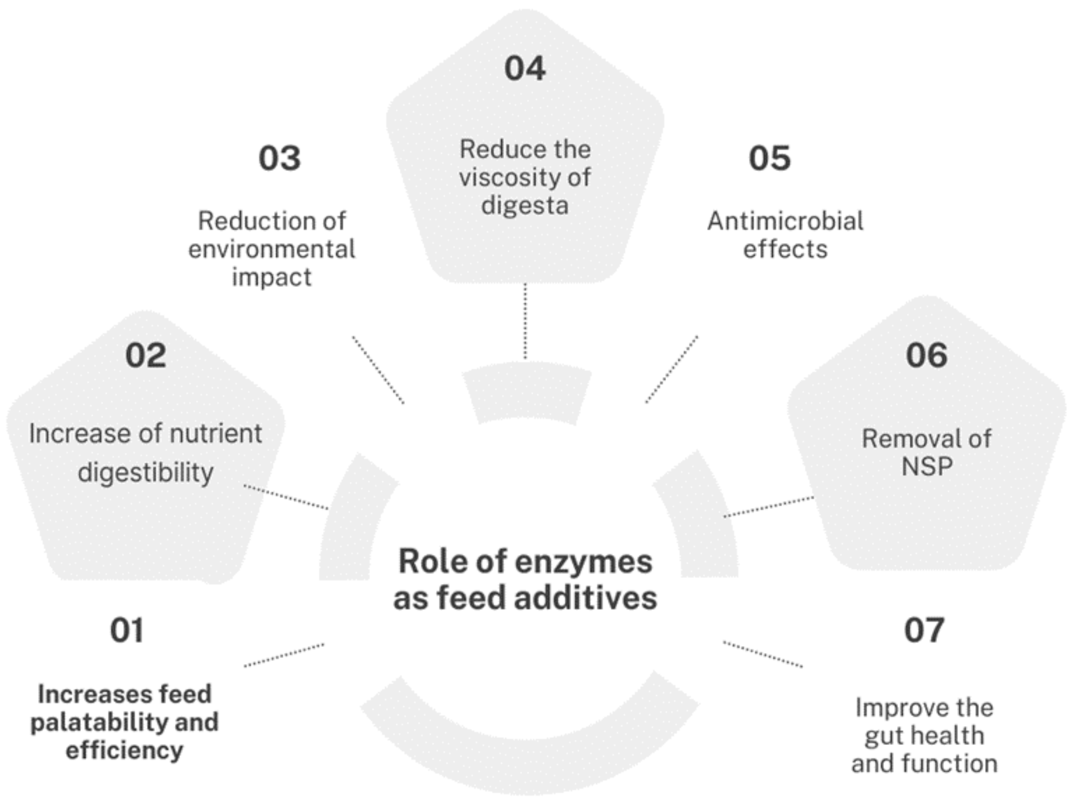


Fig. 1: Role of enzymes as feed additives

Prebiotics and Probiotics

Different prebiotics and probiotics are added to poultry feed with beneficial effects on the performance and production of birds. Prebiotics include lactose acid bacteria (LAB), lactulose, insulin, oligosaccharides of fructose and galactose, xylose, and soya etc. Lactose inhibits the multiplication of *salmonella* and other pathogenic bacteria in the GIT of chicken by altering pH, but excess of lactose can cause watery droppings (diarrhea) (Alloui et al., 2013). Moreover, probiotics commonly used in poultry feed are *Bacillus subtilis, Lactobacillus, Lactococcus lactis*, etc. These microbiota work by altering pH in GIT, making survival of most pathogens impossible (Fig. 2). *Yeast* can also be used as a probiotic. Enhanced growth, performance, and production can be availed by providing a mix of *lactobacillus* and *yeast* (Choudhari et al., 2008).

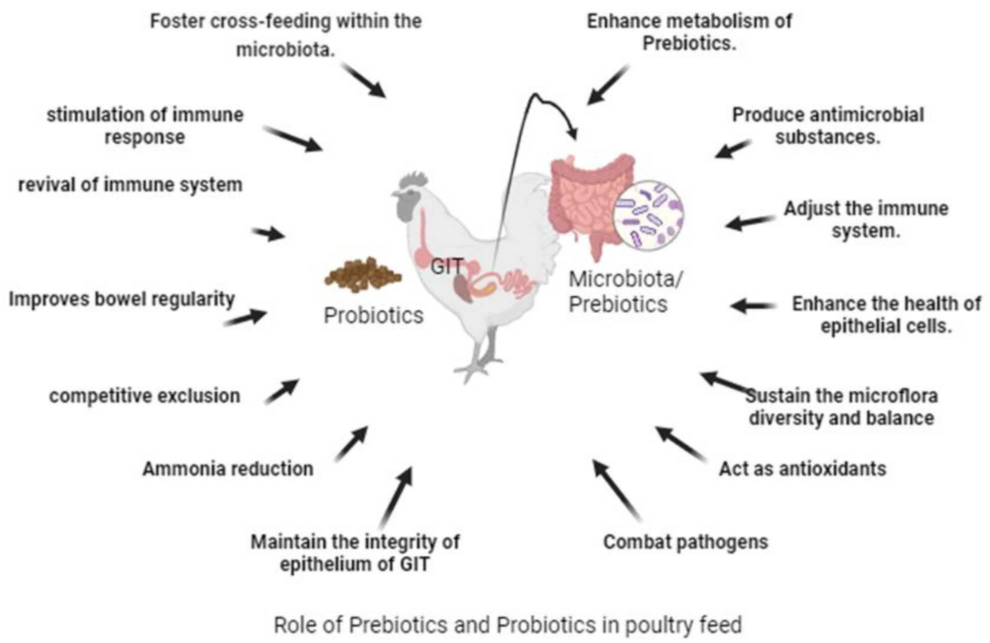


Fig. 2: Role of prebiotics and probiotics in poultry feed

Xanthophylls

These are added to the feed to improve the color of the products obtained from poultry to meet the consumer's demands, e.g., xanthophylls are added to feed to get golden yellow egg yolks (Fig. 3) (Breithaupt, 2008).

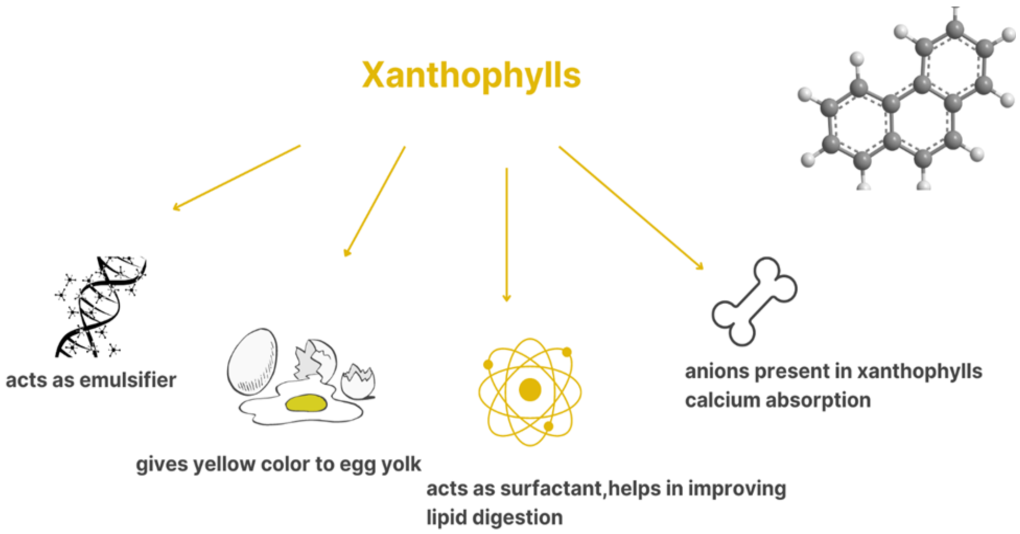
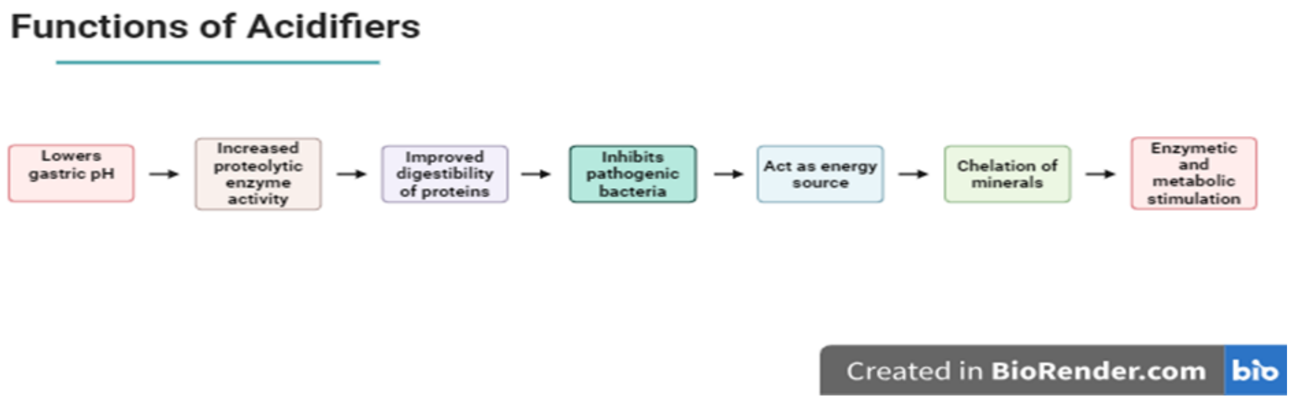


Fig. 3: Role of Xanthophylls in poultry

Antibiotics

In the poultry industry, antibiotics are used for the prevention and treatment of different bacterial diseases that can result in high mortality rates and ultimately lead to loss and poor economics. Antibiotics were used as feed additives in the past but nowadays, their use as a feed additive in poultry feed is banned due to the present scenario of antibacterial resistance or antimicrobial resistance. Various strategies like immuno-stimulation, intestinal integrity protection, and control of harmful bacteria via biosecurity, vaccination, and prevention measures are used to lessen the use of antibiotics. Different alternatives to antibiotics like prebiotics/probiotics, enzymes, photogenic, organic acids, peptides, antibodies, and metals are in use and more are under study and research.

Acidifiers



Acidifiers are mainly used as an alternative to antibiotics. Balanced acidifiers blend (0.1%) of a trio of lactic acid, formic acid, and propionic acid can be used to increase the efficiency of broilers (Hedayati et al., 2013).

ACIDS	EFFECTS
Fumaric acid	Growth, enhancce immunity, aids in digestion, improves health of the intestines of birds, and an antioxidant (Reda et al., 2021).
Propionic acid (Buffered)	Antimicrobial,elevates the GIT health of birds, enhances dressing percentage in female birds, reduces abdominal fat in males to improve performance(Lakshami et al., 2016).
Malic acid	Antimicrobial, improves carcass quality, acidifiers,antioxidant, reduces production of lactate (Qiu et al., 2022).
Sorbic acid	Antimicrobial, improves the efficiency of birds, molds and fugus inhibitors, meat preservatives (Stopforth et al., 2005).
Lactic acid	Improves FCR, enhances the performance of birds, antimicrobial (Polycarpo et al., 2017).
Formic acid	Antibacterial against coliforms and salmonella, enhances the production, improves FCR (El-Faham et al., 2018).
Benzoic acid	Antimicrobial, antifugal, improves the function of gut, regulates enzymatic activity (Mao et al., 2019).
Butyric acid	Maintains the performance, intestinal health, and carcass quality of chicken (Panda et al., 2009).
Tartaric acid	Chelating agent that improves FCR, preservative pH control agent (Al-Tmimy, 2022)..

Phytogenic Compounds

The addition of phytogenic feed additives helps in improving the microbiota of birds' gut, increasing digestibility, and performance, ultimately leading to increased yield and profits. These additives also improve the oxidation status, and immune status of birds. These are mostly used as substitutes for antibiotics (Fig. 4). These additives work by improving nutrient digestion and absorption in small intestines (Amad et al., 2011). These additives involve different herbs like oregano, thyme, carvacrol, and different essential oils. Some of these are also described below (see essential oils as feed additives).

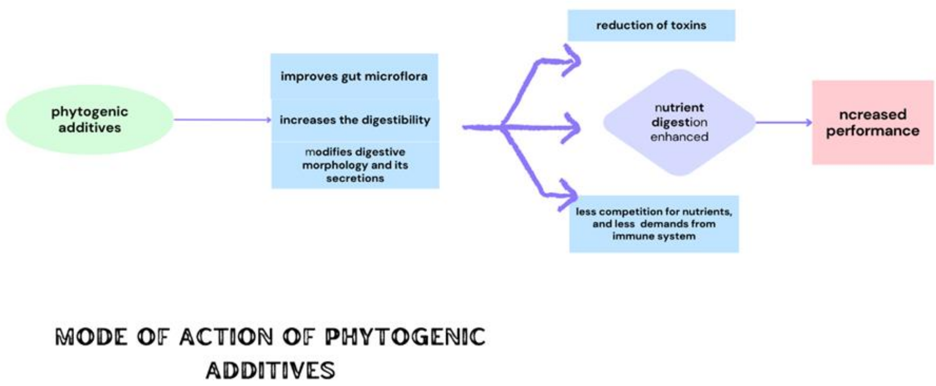


Fig. 4: Mode of action of phytogenic additives

Nutritional Feed Additives

Vitamins

Vitamins are organic compounds present in natural feed as well as can be present in synthetic feed. These can be water-soluble as well as fat-soluble. Water soluble vitamins contain vitamin C, and vitamin B complex including thiamine, riboflavin, pantothenic acid, niacin, pyridoxine, biotin, cobalamin, and folate. B complex is essential for the normal growth of the body and its development. Fat-soluble vitamins contain vitamins A, D, E, and K. These vitamins also provide aid in the health maintenance of chicken and good egg quality. Deficiency of these vitamins can cause different diseases and syndromes in poultry.

Table 1: Different roles of vitamins

Vitamins	Role
Vitamin C	Improves the performance of birds, reduces heat stress, modulates the immune system by responding to infections and inflammations, helps in growth and development (Van Hieu et al., 2022).
Thiamine (B1)	Regulates basic metabolism, essential in nerve functioning, thiamine co enzymes synthesized artificially are used in treatment of coccidiosis, and fungal infections (Tylicki et al., 2018).
Riboflavin (B2)	Modulates the microbiome of intestines, improves intestinal functions, an an energy source, stimulates the proliferation of cells of epithelium, antimicrobial, act as immunity boosters, beats different kinds of pathogens (Biagi et al., 2020).
Niacin (B3)	Maintains optimum performance, and reduces the risks of infections and diseases, mediates the transport, necessary for skin, ayes, and inhibits cancer cells growth, antioxidant (Hrubsa et al., 2022).
Pantothenic acid (B5)	Antioxidants are involved in producing several neurotransmitters, and hormones for growth and development (TURAL and TUZCU, 2023).
Pyridoxine (B6)	Weight gain, improves FCR, improves carcass quality (Tagar ,2005).
Biotin (B7)	Improves metabolism (Zhao et al., 2024).
Folate (B9) and Cobalamine (B12)	Improves growth performance of chickens, enhances the carcass and meat quality, boosts the metabolism (Giguere et al., 2005).
Vitamin C (Ascorbic acid)	Improves the health of chicken, helps in growth and development, acts as an antioxidant and an anti-inflammatory, enhances the eggshells, quality, reduces the risk of broken eggs in layers, improves immunity of the birds, helps in regulating the stress (Van Hieu et al., 2022).
Vitamin A	Essential for vision, growth, and development, maintains optimal performance, acts as an antioxidant, enhances the rate of laying and egg production, increases the egg mass and weight, helps in improving hatchability (Khan et al., 2023).
Vitamin D	Improves the performance of birds, immunity, and bone health. It also maximizes the digestion of minerals thus enhancing the growth (Swiatkiewicz et al., 2017).
Vitamin E	Improves the growth and performance of broilers, enhances the composition of carcass and meat quality, reduces heat related stress and mortality (Calik et al., 2022).
Vitamin K	Helps in promoting bone health, aids in modulating metabolism of calcium and phosphorus (Guo et al., 2020).

Amino Acids

Amino acids are characterized as breakdown products of proteins and are essential for the existence of living beings. These are also classified as essential as well as non-essential. Essential amino acids include histidine, leucine, isoleucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine. Other non-essential or conditional amino acids include alanine, arginine, alanine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, proline, serine, and tyrosine. All these amino acids are necessary for a proper portion of the poultry diet. In poultry feed, these amino acids have a positive impact on egg mass and yolk weight and should be provided in the laying phase of layers (Alagawany et al., 2021). Tryptophan, valine, isoleucine, and arginine added in feed can dispense functional outcomes. These amino acids can help reduce thermal stress, oxidation, intestinal challenges, and feathering, thereby improving efficiency and high yield (Lee et al., 2023).

Feed Additives for Health Improvement

Coccidiostats

Coccidiosis is a parasitic disease caused by the *Eimeria species* and has always had dangerous impacts on the lives of chickens, causing excessive mortality, and severe economic losses. To wage the war against coccidiosis, several anti-coccidia drugs known as coccidiostats, several vaccinations along with some alternatives, and control approaches are used worldwide. Several synthetic coccidiostats include halofuginone, clopidol, amprolium, and sulfoquinoxaline, while some authorized ionophores including monensin, salinomycin, naracin are also used (Martins et al., 2022). Although live vaccinations have good results against coccidiosis, biosecurity breaches in introducing live parasites at farms have limited its application, and various other alternative approaches have been used (Peek and Landman, 2011). Essential oils can also be used in diet to prevent coccidiosis (see essential oils as feed additives).

Feed Additives and Nanoparticles

It has been suggested by scientific studies in various fields that nanoparticle feeding helps in improving digestion, immunity, and efficiency in the performance of livestock as well as poultry. Nanoparticles refer to minute entities ranging in size from 1 to 100 nanometers, and their sizes can vary according to the bulk (Hasan, 2015). These can be organic, inorganic, or carbon-based, and can be in more than one dimension (Khan et al., 2022). We can prepare them in physical, chemical, or mechanical ways (Ealia and Saravanakumar, 2017). We can use these minute particles for therapeutic, preventive, and diagnostic approaches (Youssef et al., 2019). We can use these nanoparticles to provide supplements, nutrients, vitamins, minerals, antibiotics, and vaccinations in our poultry birds. We can use some nanoparticles to reduce bacterial growth and contamination in feed, to stimulate the proliferation of useful bacteria in their guts, and others to enhance the efficiency of production (Gangadoo et al., 2016). We can also identify the adulterations in feed using these nanoparticles (Abd El-Ghany et al., 2021). These nanoparticles can also help us in the diagnosis of different poultry diseases, and for biosecurity purposes. The most important and useful application of these nanoparticles is their antimicrobial effect as antivirals, antibacterials, and antifungals (Abd El-Ghany et al., 2021).

Classification of Nanoparticles

Nanoparticles can be classified as organic, inorganic, and carbon-based (Khan et al., 2022). Organic nanoparticles include polymers, ferritin, micelles, dendrimers, and liposomes (Ijaz et al.,2020). Inorganic nanoparticles can be metal-based (Al, Cd, Cu, Au, Fe, Pb, Ag, Zn) (Patra and Lalhriatpuii, 2020), or metal oxides (FeO, ZnO, Al2O3, TiO2). Carbon-based nanoparticles include Fullerenes, Graphene, Graphene oxide, carbon nanotubes, carbon nanofibers, activated carbon, and charcoal. These can also be immune-invigorating edifices, virus-like particles, or self-gathering proteins (Youssef et al.,2019). These are also present in the form of emulsions and dispersions (Singh, 2016).

Application of Nanoparticles in Poultry

Copper nanoparticles are widely used in the poultry industry. As they are not found in bulk in the body of birds, copper nanoparticles can be given to birds, hence providing an alternative for antibacterials and growth promotors (Sharif et al., 2021). To improve growth rate, body weight, and FCR, silver NPs are widely used in poultry feed at the dose rate of 900 ppm (Anwar et al., 2019). Thyme essential oil-loaded chitosan NPs regulate the intestinal microbiota and can be used instead of antibiotics as growth promotors (Hosseini and Meimandipour, 2018). Curcumin nanoparticles are also used in the poultry industry to increase productivity, as curcumin is a good antioxidant, can modulate immunity, and can improve the dietary intake of birds (Geevarghese et al., 2023). Nanotechnology has a wide scope in improving poultry feed production and combating all production challenges related to different poultry diseases like Salmonellosis and campylobacteriosis etc. (King et al., 2018). Methionine-coated zinc NPs can be used to enhance digestion, performance, and bone density (Alkhtib et al., 2020). Selenium NPs can enhance reproductive performance as well as immunity of broiler, Zn NPs can be used to improve FCR, Montmorillonite – composite NPs can reduce aflatoxin toxicity, and Bio complex of glutamine and nano-diamond NPs in chicken can help in weight gain and growth (El Sabry et al., 2018). Nanocapsules of aloe vera, nettle root, and dill extract can enhance growth, and as antibiotics replacements (Meimandipour et al., 2017). Metallic nanoparticles can be used to ingress the quality of feed, and the presence of any pathogen, allergen, or toxin in feed (Couto and Almeida, 2022). ZnO is an excellent antibacterial against *Salmonella gallinarum, Pseudomonas aeruginosa, and Bacillus anthracis* in the poultry industry (Raguvaran et al., 2015). Alginate-based nanoparticles coated with cellulose derivatives can be used against bacteria that have multi-drug resistance, or antimicrobial resistance (Roque-Borda et al., 2021). Activated carbon NPs are widely used as toxins absorbents in poultry feed (Colovic et al., 2019). Polymeric nanocapsules are widely used for antioxidant delivery to the target site in safe mode (Horky et al., 2018).

Essential Oils as Feed Additives

Essential oils are oily extracts of different parts of plants like their flowers, fruits, buds, roots, branches, bark, and seeds obtained by methods of distillation, extraction, or crystallization. There are thousands of essential oils present worldwide, extracted from different plants, but only about 300 are of commercial importance (Anuranj et al., 2022). Essential oils which are the secondary metabolites of plants can be used in the feed industry for poultry and livestock as a replacement for the antibiotic growth promotors. These EOs are not just used as antibiotic growth promotors, but these oils also have antiviral, antifungal, insecticidal, antipyretic, antioxidant, cytotoxic, and antiparasitic effects as well (Stevanovic et al., 2018). EOs promote the growth of birds by amplifying the secretions in their guts, and by intensifying the absorption of essential nutrients, eliminating the harmful and nosy microorganisms in their digestive tracts, and by reducing stress factors (Zeng et al., 2015). These oils also can stimulate immunity and blood circulation (Brenes et al., 2010). EOs are used in a blend with other transit oils in poultry feed to boost the production performance of birds (Krishan and Narang, 2014). These oil blends can reduce the risk of diseases like coccidiosis (*Eimeria*), and necrotic enteritis (*Clostridium perferingens*) (Amerah and Ouwehand, 2016). Moreover, Mesophilic bacteria, Enterobacter, and Enterococcus can also be controlled through EOs dietary therapy in poultry (Stamilla et al., 2020). These can also be used against gram-negative bacteria like *E. coli, Mycoplasma gallisepticum, M. synovia, Pseudomonas aeruginosa, Salmonella enteritidis*, fungi like *Aspergillus fumigates,* and toxins like Aflatoxin B1 (Adaszynska-Skwirzynska and Szczerbińska, 2017). The Hypercholesteremic effect is also seen in broilers (2% lowered serum cholesterol concentration) (Lee et al., 2004), which is a good merit of EOs to prevent joint diseases in chickens. The use of EOs in poultry diets makes the meat lean which has reduced the hyperlipidemia risk in end users (Marappan Gopi et al., 2013). Essential oils can also act as coccidiostats (VLAICU et al., 2022).

Different Essential Oils as Feed Additives

Thyme oil *(Thymus vulgaris)* @ 100mg/kg along with carvacrol @ 200mg/kg helps in digestion by increasing the small intestines' villi length, thyme oil extract supplementation @ 100ppm enhances the immunity, and peppermint oil @ 200mg/kg increases the protein digestion (Mandey and Sompie, 2021). Essential oil blends @ 0.25 or 0.5g/kg can increase the weight gain of quails in poultry by lowering feed intake and enhancing FCR (El-Shenway and Ali, 2016). Essential oil supplementation in the diet has a positive impact on the gut microbiota of broiler chickens, and ultimately increases their growth rate (Tiihonen et al.,2010). Basil EOs, thyme oil, rosemary oil, and sage EO contain many phenolic compounds, acids, and other derivatives that can act as antioxidants (VLAICU et al.,2022). Eugenol (0.5-1%) clover extracts essential oil works in a similar way as other essential oils by reducing feed intake and improving FCR (Tahir et al., 2019). Thyme oil and anise can have additive or maybe synergistic effects on weight gain, improved FCR, and low serum cholesterol levels (Al Mashhadani et al., 2011). Recommended the dose rate of 0.3g/kg of cinnamon oil in the diet can accelerate the growth performance of chickens (Choudhury et al., 2018).

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