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# Classification of Feed Additives Used in Poultry and Livestock Production: A Review

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**Abstract:**
Feed cost accounts for between 65 and 75% of the total cost of production in any commercial poultry and livestock enterprise. Several approaches have been recommended towards solving the high feed cost problem including the use of unconventional local feed raw materials, manipulation of feed forms and feeding methods and use of feed additives. Nutritionists and experts in animal production have advocated for inclusion of feed additives as a means of optimizing the uptake of nutrients from alternative feed raw materials to improve production. Feed additives are substances added to feed to improve efficiency of feed utilization and acceptance, or for enhanced metabolism and animal health. Feed additives tend to fall into certain categories which describe their action in the feed or in the animal which serve as a guide to farmers in their applications. This paper presents a review of the classifications of feed additives with some as alternatives to antibiotics in promotion of health and performance in poultry and livestock. These feed additives have been classified into feed manufacturing, performance enhancing, nutritional feed additives and feed additives that improve animal health.

*Keywords: Feed additives, classification, antibiotics, poultry performance, poultry and livestock*

## INTRODUCTION

The reason for poor poultry performance has always been attributed to change in environmental conditions, presence of diseases incidental to the production environment and poor feed quality (Baumgard and Rhoads, 2012; Ukwu, 2013). Feed quality is however usually outside the direct control of most small-scale poultry farmers in Nigeria (Okoli and Udedibie, 2017). This is because most small-scale intensive poultry farmers depend on commercial poultry feeds for the feeding of birds. Several studies have particularly shown the poor physical (Omede, 2010), nutritional (Uchegbu *et al.*, 2009) and other biophysical and toxicological characteristics (Okoli *et al.*, 2009; Omede *et al.*, 2012) of commercial poultry feeds produced in Nigeria. The feeding of such commercial feeds may not result in optimal performances in birds (Ukwu *et al.*, 2018) even when chick quality is assured. Therefore, enhancing the benefits of feeding is imperative to the improvement of poultry production in the country.

Of all the poultry inputs required for optimal commercial poultry production, feed accounts for between 65 and 75% of all cost items (Esiobu *et al.*, 2014). Thus, any improvement in the performance of poultry such as broiler and layer chickens due to their diet is capable of increasing profitability. Birds require optimal feed intake in order to remain healthy and productive (Ferket and Gernat, 2006). Poultry feeds are compounded from several feedstuffs such as cereal grains, soybean meal, meals from animal by-products, fats, vitamin and mineral premixes (Blake and Hess, 2014). These nutrients are derived from a mixture of conventional feedstuffs however, the high cost of conventional feed raw materials has necessitated the search for and utilization of

unconventional feed raw material in poultry feed formulation. This has made research on feeds and feeding a vital issue with the aim of cutting down the cost of feeding animals without compromising performance (Adeola and Olukosi, 2009).

Several approaches have been recommended towards solving the high feed cost problem including the use of unconventional local feed raw materials (Okoli and Udedibie, 2017), manipulation of feed forms and feeding methods (Abdullahi *et al*., 2013) and use of feed additives (Ugwu and Okoli, 2017) have been applied to reduce cost of feeding chickens in Nigeria. Nutritionists and experts in animal production have also advocated for inclusion of feed additives (Terrence, 2005) as a means of optimizing the uptake of nutrients from alternative feed raw materials to improve production. Feed additives are substances added to feed to improve efficiency of feed utilization and acceptance, or for enhanced metabolism and animal health. Peter *et al* (2003) stated that feed additives are added for a variety of reasons which include addition of colour and flavour to diet and to alter the efficiency and speed of growth of animals. The inclusion of feed additives into compounded feed is now a common practice in animal feed industry.

Feed additives must be approved by the appropriate authority before they can be used in livestock or poultry feeds (EFSA, 2009). The principal aim of this regulation is to ensure that all additives approved for use are safe not only for the animals which are the intended target, but also those involved in its handling and the ultimate human consumers of such animal products. As a result, such additives will have to undergo series of tests to demonstrate that they are safe to handle and use. Feed additives tend to fall into certain categories which describe their action in the feed or in the animal (EU Feed Additives and Pre-Mixtures Association, 2003). They include feed manufacturing additives, performance enhancing additives, feed additives that improve animal health and nutritional feed additives.

## FEED MANUFACTURING ADDITIVES

This classification refers to a group of additives which influences the technological aspects of the feed. It does not directly influence the nutritional value of the feed but may do that indirectly by improving its handling or hygienic characteristics. Examples of this class of additives are antifungal agents, pellet binders, antioxidants and feed flavors among others.

### Antifungal Agents

These are chemicals or salts such as propionic acid salt (Sodium or calcium salts) used to prevent mold growth in stored feed ingredients and mixed feeds. These mold inhibitors are recommended when the grain moisture content and relative humidity are relatively high or when the grain is damaged, broken or insect-infested (Ugwu and Okoli, 2017).

### Antioxidants

Antioxidants are compounds that prevent oxidative rancidity of polyunsaturated fats. It is important that rancidity of feeds be prevented because it may cause the destruction of vitamin A, D and E and several of the B-complex vitamins (Ezeokeke *et al*., 2008). The effects can be prevented by inclusion of effective anti-oxidant such as ethoxyguin (6-ethoxy -1, 2 –dihydro-2, 4 trimethylquinoline), BHT (butylated hydroxytoluene), or BHA (butylated hydroxyanisole) and vitamin E in the ration (Jacobs, 2016). Many of the most valuable products in the feed industry are readily subject to auto-oxidation. Feed ingredients which are high in unsaturated fatty acids are

prone to auto-oxidation and subsequent rancidity of fat sources such as fish by-products and essential vitamins (Ezeokeke *et al*., 2008).

It is therefore important that rancidity of feeds be prevented because it may cause the destruction of vitamin A, D and E and several of the B-complex vitamins. The breakdown products of rancidity may also react with epsilon amino group of lysine thereby decreasing the protein and energy values of the ration. The effects can be prevented by inclusion in the ration with an effective anti-oxidant such as ethoxyguin (6-eloxy -1, 2-dihydro-2, 4 trimethylquinoline) BHT (butylated hydroxytoluene), or BHA (butylated hydroxyanisole) (Jacobs, 2016). These products can be used singly or in combination with each other. Most anti-oxidants function by providing the unsaturated chemical bond of a fatty acid with an opportunity to combine with a hydrogen molecule. Vitamin E can serve as an anti-oxidant both in the feed and in the cell of an animal ingesting the feed (Ezeokeke *et al*., 2008). Such antioxidants as ethoxyquin, BHT, or BHA are unable to prevent peroxidation within the cell. Consequently, they cannot reduce the dietary requirements for vitamin E. Oxidation reactions are accelerated by high temperature, light (ultraviolet and blue), ionizing radiation, peroxides, lipoxidase enzymes, organic ion catalyst (hemoglobin) and trace mineral (copper). Oxidation reactions are inhibited by refrigeration, exclusion of light, exclusion of oxygen, destruction of enzymes, metal deactivators and antioxidants (Surai, 2002).

**Pellet Binders**

These are used to produce firmer and stronger pellets with decreased tendency to crumble. Example is bentonite or hydrated aluminium silicate, a clay mineral with surface active properties whose effectiveness increase with steam used in their pelleting process. Hemicellulose and lignin extracts which are by-products of wood processing are also used as pellet binders (Ugwu and Okoli, 2017).

**Feed Flavour**

This refers to additives which improve the palatability (i.e., voluntary intake) of a diet by stimulating appetite, usually through their effect on the flavor or colour of the diet. They are sweetners used with feed of low palatability or when there is the need to increase feed intake, especially during the period of stress or sickness. Example is vanilla extracts which encourage piglets to eat voraciously.

## PERFORMANCE ENHANCING FEED ADDITIVES

As the name implies, these additives improve the performance of animals when included in feeds. Growth as a performance index includes measures such as weight, weight gain, feed conversion and feed efficiency aimed at evaluating the development of chicken (Esonu, 2006). Feed additives in this category include enzymes, probiotics, xanthophylls, prebiotics, synbiotics, acidifiers, phytogenics and adsorbents or binders.

**Enzymes**

These are biological catalysts which bring about biological reactions without themselves undergoing any change. They comprise mainly amino acids and are involved in all metabolic and catabolic pathways of digestion. Poultry naturally produces enzymes that aid in the digestion of feed, these enzymes are not capable of breaking down completely the fibre component resulting in lower performance when fibrous materials are high in the feed (Iyayi, 2009), hence the need for an exogenous enzyme.

**Probiotics**
Probiotics are described as organisms and compounds that influence the balance of the intestinal microbial population to increase growth and efficiency of livestock. FAO/WHO (2001) stated that probiotics are live microorganisms which when consumed in adequate amount, confers a health benefit on the host. Probiotics promote the establishment and development of a desirable intestinal microbial population in the animal. Its ability to promote performance and health of poultry has been associated with direct uptake of dissolved organic material mediated by these microorganisms (Ezema and Ugwu, 2014).

**Xanthophylls**
These were originally called phylloxanthins. They are yellow pigments derived from the carotenoid group of compounds and are so named due to their contribution to the yellow band in early chromatography of leaf pigment. Xanthophyll contains either a hydroxyl group or pairs of hydrogen atom that are substituted by oxygen atoms (Esonu, 2006). They are found in leaves of most plants where they act to modulate light energy and also in bodies of animals, where they are derived from feed and dietary animal products that contain them. For example, the yellow colour of chicken egg yolks, fat and skin comes from ingested xanthophylls called lutein which is often added to feed for this purpose (Malheiros *et al.*, 2016). This yellow pigment found in eggs and skin of chicken tends to modify the consumer's acceptance.

**Antibiotics**
For growth promotion, antibiotics are fed at lower level than for prevention or treatment of disease in both ruminants and non-ruminants. Examples are erythromycin, neomycin, oxytetracycline, and tylosin. Due to the pressure antibiotics exerted in intestinal microflora to select for antimicrobial resistance which has huge animal and public health consequences, alternatives are being researched to replace them in animal production (M'Sadiq, *et al.,* 2015).

**Prebiotics**
Prebiotics are generally defined as indigestible non-starch feedstuffs that beneficially affect the host by selectively stimulating the growth or activity of one or a limited number of beneficial bacteria residents in gastrointestinal tract (Gibson and Roberfroid, 2008). They are not digested by the enzymes in monogastric animals making them available for fermentation by intestinal microflora to stimulate the growth of lactic acid bacteria that suppress the growth of undesirable pathogenic species (Roberfroid, 2005). Examples are inulin and oligofructose that have strong prebiotic properties.

**Acidifiers**
These are organic acids that are added to poultry feed in order to reduce feed buffering capacity and to maintain the optimum pH of feed and intestinal contents, thus inhibiting the growth of pathogenic bacteria in the intestine (Ugwu and Okoli, 2017). Examples of this class of additives are formic, propionic, acetic, fumaric and malonic acids.

**Phytogenics**
These are plant-derived compounds incorporated in farm animal's diet to improve their growth (Jacela *et al.,* 2010). Their mode of action is still not fully understood but many studies have attributed their growth stimulatory effects to their antimicrobial, antioxidative, improved gut function and increased dietary palatability resulting from enhanced flavor (Windisch *et al.,* 2008). Examples are essential oil, herbs, spices and terpenes (rosemary, oregano and thyme).

**Adsorbents or Binders**

Adsorbents such as zeolites (especially clinoptilolite), clay minerals and activated charcoal belong to this class of additives. Zeolite and clay minerals have been used as feed additives to ameliorate mycotoxicosis and to improve performance in animals (Ugwu and Okoli, 2017). Clay minerals have been used widely in poultry diets to improve chicken performance as a result of their binding property, especially when diets contain mycotoxins. Zeolites or clinoptilolite are crystalline, hydrated aluminosilicates of alkali earth cations, with infinite three-dimensional structures with unique adsorptive properties. They have been used as feed additive in order to ameliorate mycotoxicosis and improve animal performance. Recently clinoptilolite has been approved as feed additive in European Union at the highest inclusion rate of 2% of dry matter.

In laying hen, the administration of clinoptilolite improves feed conversion rate (Olver, 1997), increases the number of eggs laid (Yannakopoulos *et al*., 1995) and improves eggs quality characteristics (Tserveni-Gousi *et al.*, 1993). In broilers, it accelerates their growth rate by increasing feed consumption and feed conversion efficiency and improves carcass quality by lowering fat percentage (Christaki *et al.*, 2001; Mirabdolbaghi *et al.*, 2002). In ostriches, it has been reported that clinoptilolite affects the total bacterial counts of the eggshells. Dedousi *et al*. (2008) observed that when used as a nest material in ostriches, it reduced the total bacterial count of egg shells compared to river sand. This finding was attributed to the fact that clinoptilolite adsorbed and immobilized the bacteria from the nest environment, resulting in a net reduction of their number. As a result, the number of free microorganism able to infect the eggs laid in nest with clinoptilolite, were less than those in nests with other materials.

The use of activated charcoal as feed additive in improving health and performance in poultry had shown to be very beneficial. Edrington *et al*. (1997) fed broiler chickens with a diet supplemented with 0.5% super activated charcoal (SAC) for 21 days and observed a 4.6% increase in body weight in comparison with control birds, however there were no effect on the feed conversion ratio. Although no serious infection was encountered during the experiment, mortality of control birds stood at 12.7% as against the experimental groups that was 0.98%. The authors attributed this effect to the presence of available microelements and the detoxification effect of charcoal. Kutlu *et al*. (1999) applied feed supplemented with 2.5% charcoal and noted that the body weight of the broilers increased by 5.9% and 7.8% at 3 and 6 weeks respectively, which were statistically higher than the control group. Majewska *et al*. (2002) observed that the addition of charcoal at 3kg per ton of feed improved the performance of meat turkeys, reduced mortality and increased the crude protein content in the breast muscle. Samanya and Yamauchi (2001) noted that when activated charcoal was added to diets of broilers, the body weight gain and feed conversion efficiency increased.

## NUTRITIONAL FEED ADDITIVES

This class of feed additives supply specific nutrient(s) required by the animal for optimal performance. Much of the nutrients required by farm animals are derived from the major feed ingredients such as maize, wheat and soybean meal, but if these were the only ingredients then, the animal will not grow well due to deficiency in some essential nutrients. In the case of animals in the wild, such deficiencies are either tolerated or ameliorated by selection of a wide variety of dietary ingredients, many of which are seasonal in availability.

In modern day farming, the nutrient requirements of farm animals are well understood and all requirements can be met through direct dietary supplementation of limiting nutrients, such as vitamins, amino acids and trace minerals.

**Vitamins**

Vitamins are essential nutritional supplement required for optimum health and physiological functions such as growth, maintenance and reproduction (Alagawany *et al.,* 2021). They exert catalytic functions that facilitate nutrient synthesis, thus controlling metabolism and affecting the performance and health of poultry. They are classified into fat soluble (A, D, E, and K) and water-soluble vitamins (B1, B2, B6, B12, folic acid, pantothenic acid, biotin, niacin and vitamin C). Deficiency of any of the vitamins manifest as cessation of growth, incoordination, weakness, ataxia, xerophthalmia and blindness occur in chicken due to deficiency of vitamin A (Alagawany *et al.,* 2021). Exudative diathesis and encephalomalacia are seen due to deficiency of vitamin E while polyneuritis, perosis and impairment of feed utilization occur due to deficiency of vitamin B complex. Vitamins such as vitamin B12 folic acid, panthothenic acid and biotin acid are essential for normal development of hemopoietic organs and for erythropoiesis and their deficiencies leading to anemia (Alagawany *et al.,* 2021).

Diets supplemented with vitamins play an important role in disease treatment and prevention, because it enables an animal to make use of protein and energy for health improvement, FCR, growth and reproduction (McDowell and Ward, 2008). Ferdous *et al.* (2018) reported that the addition of vitamin in water improved on the hematological and serum biochemical profiles without any detrimental effect on broiler chickens. It may also improve the development of intestinal mucosa and protect enterocytes from oxidative stress (Hassanpour *et al.*, 2016).

**Minerals**

Minerals are important components of feed which are required as activator of hormone, enzymes, skeletal and structural maintenance of bone, egg formation and for maintenance of acid-base balance and osmotic homeostasis (Ravindran, 2010). They are needed in animals for optimum health and proper physiological functions. Hence, poultry require macro element as well as micro or trace minerals in the diet. Macro minerals such as calcium (Ca) and phosphorus (P) are the most abundance element in the body (Esonu, 2006). This group also includes chloride (Cl), magnesium (Mg), potassium, (K), sodium, (Na) and sulphur (S) with their requirements in diets usually higher than 100mg/kg feed (Ravindran, 2010). Trace minerals such as manganese (Mn), selenium (Se), copper (Cu), iron (Fe) and zinc (Zn) are necessary for chicken development as a result of their requirement in many metabolic pathways as co-factors of enzymes. They are required in poultry in trace amount usually about 0.01% (Ravindran, 2010). Trace minerals are required in the physiological function necessary to sustain life, including growth, reproduction, immune system functions, energy metabolism and bone formation (Dibner *et al*., 2007).

Calcium (Ca) is a major mineral in poultry nutrition as an important component of bones, shells, blood-clot formation and muscle contraction (Talpur *et al*., 2012). Lack of calcium ions in bones led to the deterioration of the skeletal structure and reduction in bone strength (Kwiatkowska *et al*., 2017). Zinc and manganese are co-factor involved in carbonate and mucopolysachride synthesis which are necessary to bone and egg shell formation (Swiatkiewicz *et al*., 2010) coupled with their contribution in carbohydrates, lipids and amino acid metabolism (Suttle, 2010). The supplement of 12mg/kg of manganese (Mn) in poultry feed from either organic or inorganic sources was sufficient to provide optimum performance in broiler (Mwangi *et al.,* 2019). Saleh *et*

*al.* (2018) reported that dietary zinc (Zn) supplementation improved growth performance, humoral immune response, antioxidant properties, nutrient digestion and reduced lipid peroxidation in broiler meat.

Copper is involved in both humoral and cell-mediated immunity (Alagawany *et al.,* 2021). It has been used in poultry production as supplement due to its microbiological activities and the ability to increase body weight (Makarski *et al.,* 2014). The supplementation of copper sulphate (CuS04) for up to 200mg/kg feed in broilers had beneficial effects in growth. Copper is also involved in iron transport, metabolism and in the formation of red blood cells. Samanta *et al.* (2011) confirmed that copper supplementation was an effective way of improving on the hematological profiles of broiler chickens.

Selenium is an important trace mineral for the maintenance of health and growth of humans and animals (Kielizek and Blazejak, 2016). When supplemented in diet, it improved the rate of hatchablilty, fertility and the overall productive performance of chicken including meat quality (Rizk *et al*., 2017; Ravindran and Elliot, 2017). It increases bursa and thymus weight and also led to increased immunity (Hussian *et al*., 2004). Iodine is a trace mineral with several biological roles including proper functioning of thyroid gland (Alagawany *et al.,* 2021).It is a component of the hormones (triiodothyronine and thyronine) that play essential role in regulating the metabolism, cellular oxidation and intermediary cell activity of the thyroid gland (Lewis, 2004). Its supplementation can as achieve through dietary iodine sources such as sodium iodide (NaI) and potassium iodide (KI) in animal diets. In poultry, iodine supplementation is mainly achieved through mineral premix in the form of iodized salt, $Ca(IO_3)_2$ which has been reported as an essential micro nutrient in laying hens with strong impact on growth performance of birds (Opalinski *et al*., 2012).

**Amino Acids**

Amino acids are functional and structural unit of protein that plays vital physiological roles in the body of animals (Bortoluzzi *et al*., 2018; Debnath *et al*., 2019). They are classified into two groups: non-essential (synthesized in the body) and essential amino acids (cannot be synthesized rapidly enough to meet the metabolic requirement). Examples of ten essential amino acids are lysine, methionine, tryptophan, threonine, arginine, isoleucine, leucine, histidine, phenylalanine and valine out of which lysine; methionine and threonine are referred to as limiting amino acids in poultry (Okata, 2016; Rehman *et al*., 2019). Glycine and serine are the non-essential limiting amino acids in poultry diet (Siegert and Rodehutscord, 2019) while cysteine and tyrosine are regarded as semi-essential amino acids because they can be synthesized from methionine and phenylalanine respectively (Ravindran, 2010).

After absorption, amino acids are assembled and metabolized to form proteins that are used to build different body tissues (Alagawany *et al.,* 2021). Beski *et al.* (2015) reported that dietary synthetic amino acid supplementation to poultry diets improved feed conversion efficiency and reduced nitrogen excretion.

## FEED ADDITIVES THAT IMPROVE ANIMAL HEALTH

Included in this category of feed additives are also antibiotics, probiotics, prebiotics, synbiotics, acidifiers and coccidiostats.

### Coccidiostats

These are products used to control intestinal health of poultry through direct effects on the parasitic coccidial organism concerned (Williams, 2005). Anticoccidial agents are used to prevent coccidiosis. Examples of several coccidiostats available are Amprolium 250®, Intracox® and Amprolium 200® all of which are imported and marketed in Nigeria by respective veterinary pharmaceutical companies who stand as sole distributors for the parent producing companies overseas.

### Antibiotics e.g. Chlotetracycline and Oxytetracycline

In this case, antimicrobial agents (antibiotics) are included in feed at a level aimed at eliminating infection or disease. This is unlike the low dose inclusion of antibiotics usually associated with growth promotion in livestock as stated earlier.

## CONCLUSION

Feed cost accounts for between 65 and 75% of the total cost of production in any commercial poultry and livestock enterprise. Nutritionists and experts in animal production have advocated for inclusion of feed additives as a means of optimizing the uptake of nutrients from alternative feed raw materials to improve production. Feed additives tend to fall into certain categories which describe their action in the feed or in the animal which serve as a guide to farmers in their applications. They have been classified into feed manufacturing, performance enhancing, nutritional feed additives and feed additives that improve animal health. More so, exogenous enzymes, acidifiers, prebiotics, probiotics, synbiotics, antioxidants, adsorbents and phytogenics have also been identified as varying alternatives to antibiotics in view of the ban placed on the sub-therapeutic inclusion of antibiotics in animal diet for growth promotion purposes due to antimicrobial resistance.

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