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Role of neem (*Azadirachta indica*) feed additive in poultry nutrition, health and production: A review

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Abstract

The incorporation of herbs and medicinal plants into poultry diets has gained considerable attention as a safe and natural approach for enhancing immune function, preventing and managing diseases, and promoting growth. These plant-based feed additives may consequently improve the productive performance and overall health of poultry. In recent years, the use of antibiotics as growth promoters has been restricted or prohibited in many countries because of concerns regarding their adverse effects on consumers and the persistence of antibiotic residues in poultry tissues.

Neem contains numerous biologically active compounds that exhibit a broad spectrum of pharmacological activities. These compounds have been reported to possess antibacterial, antiviral, antimalarial, anti-inflammatory, and antioxidant properties, making neem an important medicinal plant for both human and veterinary applications. The present review focuses on recent research concerning neem, one of the most important medicinal and multipurpose plants traditionally used in India.

Neem (*Azadirachta indica*) is widely regarded as one of the most valuable traditional medicinal plants in India. Almost every part of the neem tree possesses therapeutic properties and therefore has considerable commercial potential. Over the past five decades, substantial progress has been made in understanding the chemical constituents of neem, as well as their biological activities and medicinal applications. Neem is currently recognized as a valuable source of unique natural compounds with potential applications in the development of therapeutic agents for various diseases and in the manufacture of industrial products. This review provides an overview of the biological activities of selected neem compounds, the pharmacological effects of neem extracts, clinical investigations, potential medicinal applications, and their safety profiles.

Keywords: *Azadirachta indica*, hematology, carcass trait, production parameters

Introduction

The widespread promotion of antibiotics as growth enhancers in poultry production has raised concerns regarding their potential impact on animal and human health. Some pharmaceutical companies have encouraged farmers to use antibiotics as growth promoters to achieve higher production and economic returns within a short period. However, consumption of poultry products containing antibiotic residues may expose humans to these substances and potentially contribute to serious health concerns (Kibria *et al.*, 2009) [20]. Globally, the extent to which antibiotics are incorporated into poultry diets as growth promoters varies considerably. Of particular concern is the development and spread of antimicrobial resistance among zoonotic enteropathogens, including *Salmonella*, *Escherichia coli*, and *Enterococci*, in food-producing animals. These resistant microorganisms may be transmitted through the food chain and subsequently pose risks to human health.

As a result, increasing research attention has been directed toward natural alternatives, including essential oils, plant extracts, herbs, and spices, as potential feed additives for livestock and poultry. Craig (1999) [11] suggested that several medicinal herbs may provide protection against pathogenic bacteria while also enhancing immune responses. Among these plants, neem (*Azadirachta indica*) has attracted considerable interest because of its diverse medicinal properties. Its antibacterial and hepatoprotective activities may contribute to improved growth and feed utilization in poultry.

Previous investigations have demonstrated that neem preparations can influence hematological characteristics in poultry. Sadre *et al.* (1984) [33] and Gowda *et al.* (1998) [17] reported that feeding neem preparations to laying hens significantly reduced hemoglobin

concentration, erythrocyte count, and packed cell volume. In addition, neem has been reported to possess immunomodulatory properties capable of stimulating cellular immune responses (Devakumar and Suktt, 1993)^[13]. Therefore, the present review aims to examine the potential effects of neem as a natural feed additive in broiler production, with particular emphasis on its influence on hematological and biochemical responses, growth, feed utilization, and other productive characteristics.

Neem (*Azadirachta indica*)

Neem (*Azadirachta indica*) is a versatile and economically important tree that is particularly widespread in India. It has traditionally been utilized for numerous purposes, including food-related applications, insect control, and ethnomedicinal practices. Different parts of the neem tree have considerable potential for use in animal nutrition. In particular, neem leaves and the oil cake remaining after oil extraction can be incorporated into livestock feed. For centuries, neem leaves, bark, and seed-derived preparations have been used in traditional Indian medicine as well as in ethnoveterinary practices (Biswas *et al.*, 2002; Subapriya *et al.*, 2005)^[7, 38]. The species is indigenous to the dry regions of the Indian subcontinent, Myanmar, and China (Rojas-Sandoval *et al.*,

2014)^[32]. Neem is a medium- to large-sized tree that generally reaches a height of approximately 15-30 m and develops a broad, rounded crown measuring about 10-20 m in diameter. It is predominantly evergreen, although leaf shedding may occur during periods of prolonged dryness (Orwa *et al.*, 2009; Puri, 1999)^[28, 30]. The plant possesses a deep taproot system and is dependent on mycorrhizal associations for optimal growth and nutrient acquisition.

Chemical composition of neem (*Azadirachta indica*)

Chemical Composition of Neem (*Azadirachta indica*) Leaf/Leaf Meal

The chemical composition of neem leaves and neem leaf meal differs considerably among studies. Such variation may be attributed to several factors, including plant variety, geographical origin, soil fertility, stage of leaf maturity, seasonal conditions, and the methods used for harvesting, processing, and drying the leaves. These factors can influence the concentration and availability of nutrients and bioactive compounds present in neem leaves. Consequently, variations in the chemical profile of neem leaf meal should be considered when evaluating its nutritional and biological effects as a poultry feed ingredient.

Parameter	Esonu <i>et al.</i> (2006) ^[15]	Ansari <i>et al.</i> (2012) ^[4]	Obikaonu <i>et al.</i> (2012) ^[25]	Ezzat <i>et al.</i> (2018) ^[16]
Dry matter (%)	92.40	91.00*	—	87.00*
Moisture (%)	7.58	9.00	—	13.00
Crude protein (CP,%)	20.68	20.52	18.10	15.80
Crude fibre (CF,%)	16.60	16.45	15.56	14.60
Ether extract (EE,%)	4.13	4.25	2.50	8.50
Ash (%)	7.10	7.00	5.26	4.50
Nitrogen-free extract (NFE,%)	43.91	42.78	58.22	56.60
Calcium (Ca,%)	—	0.71	—	—
Phosphorus (P,%)	—	0.28	—	—
Magnesium (Mg,%)	—	0.75	—	—
Sodium (Na,%)	—	0.58	—	—
Potassium (K,%)	—	2.00	—	—
Copper (Cu, ppm)	—	34	—	—
Zinc (Zn, ppm)	—	18	—	—
Iron (Fe, ppm)	—	745	—	—
Cobalt (Co, ppm)	—	10	—	—
Manganese (Mn, ppm)	—	60	—	—
Chromium (Cr, ppm)	—	0.8	—	—
Lead (Pb, ppm)	—	27	—	—

*Dry matter is calculated approximately as 100 – moisture where moisture was reported.

Medicinal properties of neem (*Azadirachta indica*)

Neem leaves contain a variety of biologically active compounds with antimicrobial properties, as reported by Makeri *et al.* (2007)^[22] and Valarmathy *et al.* (2017)^[44]. In addition, neem has been associated with anti-inflammatory, antihyperglycemic, antiulcer, antimalarial, antifungal, antiviral, and antioxidant activities (Kale *et al.*, 2003)^[18]. Sodium nimbidate is one of the important bioactive constituents of neem and has been reported to exhibit anti-inflammatory activity. Another important compound, nimbidin, has been associated with antiarthritic effects, reduction of blood glucose levels, and protection against gastric ulcers (Bandyopadhyay *et al.*, 1998; Biswas *et al.*, 2002)^[5, 7]. In ruminant nutrition, condensed tannins and saponins present in plant materials may also contribute to improved rumen ecology and fermentation processes (Suchitra *et al.*, 2008)^[39].

Effect of Neem (*Azadirachta indica*) on Poultry Performance

Several studies have investigated the influence of neem supplementation on growth and productive performance in poultry. Wankar *et al.* (2008)^[45] reported a significant improvement in average body weight when neem leaf powder was incorporated into broiler diets at levels of 1, 2, and 3 g/kg. In contrast, Landy *et al.* (2011)^[21] observed a significant reduction in body weight at 42 days of age when neem leaf powder was included at 7 and 12 g/kg. This negative response may have been associated with the bitter taste of neem, which can reduce feed acceptance at higher inclusion levels.

The findings of Singh *et al.* (2014)^[37] differed from those of Landy *et al.* (2011)^[21], as significant improvements in body weight gain were observed when neem leaf powder was incorporated into layer diets at 1, 2, and 3 g/kg. Similarly, Shihab *et al.* (2017)^[36] reported significant increases in

body weight and feed intake in broilers receiving neem leaf powder at 2 g/kg. Birds supplemented with neem leaf powder generally exhibited improvements in body weight, weekly weight gain, and feed consumption.

Durrani *et al.* (2008) ^[14], however, reported a significant reduction in feed and water intake when neem leaf powder was administered through drinking water. These findings differed from those of Landy *et al.* (2011) ^[21], who found no significant differences in feed intake among treatment groups when neem leaf powder was incorporated into broiler diets at 7 and 12 g/kg. Singh *et al.* (2014) ^[37], on the other hand, observed significant differences in feed intake among treatment groups when neem leaf powder was supplied to layers at 1, 2, and 3 g/kg.

Durrani *et al.* (2008) ^[14] also reported significant improvements in the relative weights of the liver, heart, and gizzard when neem leaf powder was supplied through drinking water at 40 mL/L. Conversely, Kharde and Soujanya (2014) ^[19] found no significant differences in carcass characteristics, including heart, gizzard, and liver weights, when neem leaf powder was incorporated into broiler diets at 1 and 2 g/kg, either alone or in combination with garlic powder at 0.5 and 1 g/kg. Similarly, Shihab *et al.* (2017) ^[36] observed no significant differences in the relative weights of the liver, heart, and gizzard in broilers receiving neem leaf powder at 2 g/kg.

Durrani *et al.* (2008) ^[14] further reported a significant improvement in average body weight when neem leaf powder was administered through drinking water at 50 mL/L. Comparable findings were reported by Onyimonyi *et al.* (2009) ^[27], who observed significant improvements in body weight and body weight gain when neem leaf powder was incorporated into broiler diets at 0.5%.

Effect of Neem (*Azadirachta indica*) on Hematobiochemical Parameters of Poultry

Neem supplementation has also been investigated for its effects on hematological and biochemical parameters in poultry. Alam *et al.* (2015) ^[3] reported no significant differences in hematological indices, including red blood cell (RBC) count, hemoglobin (Hb), packed cell volume (PCV), and erythrocyte sedimentation rate (ESR), when neem leaf powder was added to broiler diets at 1, 2, and 3 g/kg. Nevertheless, neem supplementation was associated with improvements in body weight and feed conversion efficiency, indicating its potential role in enhancing productive performance without adversely affecting major hematological parameters. These observations were consistent with the findings of Bonsu *et al.* (2012) ^[9], who reported that inclusion of neem leaves in broiler diets improved productive characteristics, blood parameters, carcass characteristics, and sensory attributes of meat.

Nodu *et al.* (2016) ^[24] observed no significant differences in most hematological and serum biochemical parameters of broiler chickens administered graded levels of *Azadirachta indica* leaf extract. However, significant differences were observed in total protein and alkaline phosphatase (ALP). Total protein values ranged from 54 to 59 µ/L, whereas ALP values ranged from 249 to 337 µ/L. These findings were comparable with those reported by Trincha *et al.* (2012) ^[42].

Obikaonu *et al.* (2012) ^[25] reported significant reductions in cholesterol, glucose, alanine aminotransferase (ALT), and aspartate aminotransferase (AST) concentrations when neem leaf powder was incorporated into broiler diets at

2.5%, 5%, 7.5%, and 10%. However, no significant differences were detected in total protein, calcium, or sodium concentrations. Similarly, Shihab *et al.* (2017) ^[36] reported significant improvements in total protein, cholesterol, triglycerides, albumin, globulin, and calcium concentrations in broilers supplemented with neem leaf powder at 2 g/kg. The reduction in cholesterol concentration associated with increasing dietary neem leaf meal was consistent with observations reported by Ogbuewu *et al.* (2008) ^[26] in rabbits. Upadhyay (1990) ^[43] likewise reported reduced blood cholesterol concentrations in broilers and rats fed neem leaf meal.

Sharma *et al.* (2002) ^[35] reported that the inclusion of neem seed at concentrations of 25%, 50%, and 75% in broiler diets improved productive performance. Similarly, Sarag *et al.* (2001) ^[34] observed increased body weight and improved feed conversion efficiency when neem oil was incorporated into broiler diets at a concentration of 0.25%. Chakravarty and Prasad (1991) ^[10] also reported substantial increases in body weight following the inclusion of neem leaves in broiler diets.

Obikaonu *et al.* (2011) ^[25] suggested that dietary neem leaves can influence both hematological and serum biochemical characteristics in broilers. Their findings indicated a significant increase in blood glucose and a significant reduction in cholesterol concentration ($p < 0.05$). Increasing the dietary concentration of neem leaf was also associated with a reduction in liver enzyme levels, suggesting a possible hepatoprotective effect.

Tollba *et al.* (2009) ^[41] reported that inclusion of neem leaves in broiler diets improved feed conversion efficiency, feed consumption, body weight, mortality-related outcomes, carcass characteristics, and the development of lymphoid organs, including the bursa of Fabricius and thymus. The treatment was also associated with increases in total protein, albumin, globulin, and triglyceride concentrations, whereas cholesterol and fat-related parameters were comparatively reduced.

Oyagbemi *et al.* (2012) ^[29] investigated the potential of neem at a 10% inclusion level against coccidial infection and demonstrated its possible role in enhancing immunity against both clinical and subclinical infections. Lonkar *et al.* also reported that inclusion of neem seed in broiler diets was associated with a reduction in blood cholesterol levels. Tipu *et al.* (2006) ^[40] described several medicinal properties of neem, including antibacterial, antioxidant, and antiprotozoal activities, supporting its potential application as a natural feed additive.

Deore *et al.* (2005) ^[12] investigated the incorporation of neem oil into broiler diets and reported effects on productive performance at inclusion levels below 5%. Alam *et al.* (2014) ^[2] evaluated the effects of a polyherbal preparation containing neem and other plant extracts (NNTT extract) on hematological parameters in broilers. No significant changes were observed in total leukocyte count (TLC), PCV, Hb, or ESR between the treated and control groups. The authors suggested that the plant-based preparation did not produce either harmful or substantial beneficial effects on these hematological indices. Similar findings were reported by Bishnu *et al.* (2009) ^[6].

Rahaman *et al.*, however, observed significant differences ($p < 0.05$) in ESR and PCV between control and treated groups. Hemoglobin concentration also differed significantly between the groups on day 42. Following

treatment with a combination of neem leaf and ginger extracts, ESR decreased, whereas other hematological parameters increased. These findings were consistent with those of Biu *et al.* (2009)^[8] and Akbari *et al.* (2008)^[1], who reported a significant increase ($p < 0.05$) in hemoglobin concentration in neem-supplemented groups compared with controls. Furthermore, dietary supplementation with neem alone or in combination with turmeric and vitamin E significantly increased PCV values ($p < 0.05$) compared with the control group, which was consistent with the findings of Nayaka *et al.* (2013)^[23].

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