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Review Article

Eucalyptus leaves: "Bioactive Substances: Essential Oils;" Effects on Broiler Health and Production for Healthy Chicken.

Muhammad Rizwan*, Hamza Irshad, Tariq Jamil, Muhammad Shehroz Sarfraz, Dibaj Azhar Bhatti, Muhammad Ahmad, Muhammad Umair, Zaid Mustafa, Rana Akkasha Akram, Muhammad Haris Raza Farhan and Muhammad Taha Babar Awan

Faculty of Veterinary Sciences, University of Agriculture Faisalabad, Pakistan

***Corresponding Author:** Muhammad Rizwan, Faculty of Veterinary Sciences, University of Agriculture Faisalabad, Pakistan.

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Abstract

Eucalyptus native to Australia is one of the largest trees belonging to the family Myrtaceae with the property of multiple uses and benefits. Every part such as leaves and bark possesses its own property. Oils extracted from eucalyptus leaves have various phytochemicals like 1,8-cineole, p-cymene, limonene, etc, and can be extracted through various methods such as hydrodistillation, solvent extraction, etc. Each phytochemical possesses its health benefits like antibacterial, antimicrobial, antifungal, antiviral, anti-inflammatory, antioxidant, etc. These compounds can be used for human health purposes and for animals as well. In the poultry industry, eucalyptus has great importance for use in a sense of improved broiler growth with proper development of the immune system. It can be used. It is used in the poultry industry to replace the use of antibiotics that affect human health. Eucalyptus also possesses properties to improve respiratory health, digestive health and gut health. During heat stress, it is used to prevent the mortality of birds.

Keywords: *Eucalyptus*: Composition; Bioactive Compounds; Pharmacological Uses; Role in Broiler Health and Production

Introduction

Eucalyptus leaves have been widely studied for their bioactive substances, specifically essential oils (EO) [1]. These oils have been shown to have a range of medicinal properties, like antimicrobial, anti-inflammatory, and antioxidant effects, etc. There are various extraction methods through which we can achieve EO from eucalyptus leaves, such as steam distillation, cold pressing, and solvent extraction [1]. The choice of extraction method can affect the yield and composition of the EO, and thus the potential medicinal properties. In the field of animal husbandry, eucalyptus essential oils (EEO) have their effects on broiler performance and immunity. Broiler chickens are a vital part of the poultry industry, providing a significant source of protein for human consumption [6]. However, the intensive nature of broiler production can lead to a range of health and welfare issues, including poor growth performance, high mortality rates, and an increased risk of disease. Therefore, it is important to identify ways to improve the health and performance of broilers to ensure a sustainable and profitable poultry industry. Broiler growth performance, feed efficiency, and overall health can be improved by EEO through the broiler's diet [3]. Additionally, EEO have been found to have a positive impact on the immune system of broilers, potentially reducing the incidence of disease. EEO can have an effect on the gut microbiota of broilers, which is associated with beneficial effects on broiler health. The gut microbiota plays an important role in the health and well-being of animals, and changes to this community of microorganisms can have a range of effects on host physiology, metabolism, and immunity. The EO extracted from Eucalyptus leaves have also been found to have an antimicrobial effect, which can be attributed to the presence of compounds such as eucalyptol, cineole, and p-cymene. These compounds act against a variety of pathogens, including bacteria, viruses, and fungi. The antimicrobial effect of

EEO is of particular interest in the context of animal health, as it can potentially reduce the need for antibiotics [1]. The overuse of antibiotics causes the development of antibiotic-resistant bacteria, which poses a significant threat to both animal and human health [2]. Therefore, finding natural alternatives to antibiotics is of great importance. While EEO can have positive effects on broiler performance and immunity, the use of antibiotics is still widely used in the poultry industry.

The objective of this review is to provide an overview of the current state of knowledge on the bioactive substances in eucalyptus leaves, specifically EO, and their extraction methods. Additionally, the review will examine the effects of EEO on broiler production. The article will also discuss the potential use of EEO as a natural alternative to antibiotics in the management of broiler health. The studies reviewed suggest that EEO can improve growth performance, feed efficiency, and overall health of broilers as well as have a positive impact on the immune system of broilers, potentially.

Eucalyptus

World's most important genera, "Eucalyptus" belong to the Myrtraceae family which also includes other well-known plants such as Myrtle, Clove, and Guava [6]. This family comprises 140 genera and 900 species and subspecies grown in tropical and subtropical parts of the world. In 1788, a French botanist Charles Louis described the first Eucalyptus tree and named it "Eucalyptus" [8]. The name "Eucalyptus" is derived from the Greek words "eu" meaning "well" and "kalyptos" meaning "covered," referring to the cap that covers the flower buds [9]. Eucalyptus is native to Australia. Few of them are native to New Guinea, Indonesia, and the Philippines. In the early 1800s, Eucalyptus trees were introduced to other parts of the world, particularly to California, South Africa, and South America as a means of controlling soil erosion, as windbreaks, and as a source of wood and other products [8]. It is mainly cultivated for its timber, pulp, and EO because of the medicinal properties and therapeutic uses they possess (Table 1). It is a fast-growing tree with a property of use in paper production [9]. But the important research subject is to be considered the use of eucalyptus leaves for biomass resources. In Turkey, Eucalyptus is a monotypic genus such as Eucalyptus camaldulensis, grown commercially for timber [7].

Part of plant	Use
Bark	The Bark of the Eucalyptus plant can be used as insect dust in form of fine powder [39].
Leaves	Tea prepared from leaves is used as a preventive measure to control diabetes mellitus and to cure colds, sore throats and flu [39].
Essential oil	Used as a flavoring agent, to prevent food from spoiling, and as a cure for influenza, and other respiratory infections [40].

Table 1: Uses of parts *Eucalyptus*.

Chemical composition

Eucalyptus is a rich source of chemical compounds such as alkaloids, flavonoids, propanoids, tannins etc. identified in various species (Table 2). 1,8-cineole, citronellal, globulol, pipertone, aromadendrene, allo-aromadendrene are present in leaves and shoots. Dextrin and sucrose are in flowers [26]. Asparagine, borneol, caproic acid, citral, cysteine, eudesmol, fenchone, glutamic acid,

Compound (%)	*Eucalyptus maideni*	*Eucalyptus astrengens*	*Eucalyptus cinerea*	*Eucalyptus bicostata*	*Eucalyptus camaldulensis*
Alpha-pinene	1.27	6.96	4.08	2.16	12.7
1,8-cineole	83.59	60.01	79.18	81.29	34.5
Alpha-terpineol	-	-	2.20	-	14.1
p-cymene	-	2.31	-	-	42.1
Gamma-terpinene	-	-	-	-	-
Globulol	3.61	3.74	-	1.81	-
Limonene	-	-	-	-	5.5
Pinacarvone	1.28	4.70	-	3.93	-
Guaiene	-	1.33	-	-	-
Borneol L	-	-	-	-	5.5
Spathulenol	-	1.15	-	-	3.2

Table 2: Chemical composition of leaf essential oils.

glycine, p-menthane, myrecene, mytenol, threonine and verbinone are present in fruits [27]. Except for *E. Citriodora* which contains citronellal as the major bioactive compound, Eucalyptol represents the major phytochemical in most of the *Eucalyptus* spp. Extraction methods affect the composition of oils [28]. The effect of geographical location on the composition of oils has been discussed in detail.

Bioactive compounds: "Essential oils"

Bioactive compounds are present in different parts of the plant like leaves, bark [33]. These compounds possess different therapeutic properties like anticancer, antibacterial, antifungal etc (Table 3). Compounds can be used in powder form or liquid form. If we want to use these compounds in powder form then there will be simple use of eucalyptus leaves [27]. If liquid form use is required then compounds are to be extracted from parts of the plant through various methods [30,31]. There are almost ten methods to extract bioactive compounds from different parts of the *Eucalyptus* plant like steam distillation, solvent extraction, cold pressing, supercritical fluid extraction, microwave-assisted extraction, ultrasound-assisted extraction, enzymatic extraction, fermentation extraction, subcritical water extraction, polysaccharide isolation [33]. These methods are widely used for the extraction of bioactive compounds from different plants and not only eucalyptus. The choice of method will depend on the desired compound and the quality and quantity required. Steam distillation involves exposing the plant material to steam, which causes the essential oil to vaporize. The vapours are then condensed and collected as a liquid [29]. Solvent extraction involves using a solvent, such as ethanol or hexane, to dissolve the desired compounds from the plant material. The solution is then separated and the solvent is removed, leaving behind the desired compounds [30]. Cold pressing does not involve any heat or chemical treatment, it uses mechanical pressure to extract the essential oil. Supercritical fluid extraction (SFE) involves using a supercritical fluid, such as carbon dioxide, as a solvent to extract the desired compounds from the plant material because it possesses properties of both gas and liquid [31]. Microwave assisted extraction (MAE) uses microwaves to generate heat and increase the solubility of the bioactive compounds in the extraction solvent. Ultrasound assisted extraction (UAE) uses ultrasonic waves to generate high-frequency sound energy which causes mechanical agitation of the plant material and solvent, leading to an increase in the solubility and extraction efficiency of the bioactive compounds [32]. In enzymatic extraction method enzymes are used to break down plant materials and release the desired bioactive compounds such as cellulases, pectinases, and xylanases. In fermentation extraction method microorganisms are used to convert the plant material into flavonoids, phenolic compounds, and terpenoids. Bioactive substances can be extracted from the eucalyptus plant through subcritical water extraction by using water at temperatures and pressures below its critical point (374°C and 221 bar, respectively). This method is known to effectively extract a wide range of bioactive compounds, such as flavonoids, terpenoids, and phenolic compounds while minimizing damage to thermally labile compounds [33]. Polysaccharide isolation extraction method involves the use of various techniques, such as centrifugation, precipitation, and filtration to separate and purify polysaccharides from the plant material.

Bioactive compound	Health benefits
1, 8-cineole	Therapeutic properties against airway diseases like asthma [41].
Alpha-pinene	Hypoglycaemic and anti-inflammatory properties [42].
Eudesmol	Tumor growth suppressor [43].
Limonene	Antibacterial, antiviral, antifungal, antioxidant, anti-inflammatory [44].
p-cymene	Antonociceptive, anxiolytic [45].
Terpinen-4-ol	Anticancer, anti-parasitic [46].
Terpineol	Anticonvulsant, antiulcer, antihypertensive [47].
Alpha-phellanderene	Anticancer, antimicrobial [48].

Table 3: Major bioactive compounds and their related health benefits.

Pharmacological uses of *Eucalyptus* leaves

Different species of Eucalyptus possess medicinal properties (Table 4) as an antiseptic and against upper respiratory tract infections such as colds, influenza, and sinus congestion [18]. *E. Citriodora, E. Globulus, E. Camaldulensis, E. Teretcorni* possess antimicrobial, analgesic and anti-inflammatory properties [18]. The EO of Eucalyptus show antimicrobial, antifungal, anticandidal, antibacterial, antioxidant, expectorant and cough stimulant activity [10]. EO is also used externally for skin infections and cuts due to its disinfectant effect [11]. Besides all above mentioned properties, essential oils also possess herbicidal [12], insecticidal [13], anthelmintic [14], anti-tumor [15] and anti-leeching properties as well as for skin infections [16] and mastitis [17].

Antibacterial

Bacterial diseases play a serious role in the poultry industry especially in broilers. Salmonellosis, colibacillosis, mycoplasmosis, or infections by ornithobacterium or clostridia are commonly occurred [49]. In recent years, most of the outbreaks are present regarding salmonella, campylobacter genus and *E. Coli*. It is a problem to run broiler production at large scale due to complex

Species	Benefits
Eucalyptus globulus	Antiviral, antimicrobial, antioxidant, antifungal, anti-insecticidal, preservative and flavouring agents.
Eucalyptus radiate	Antibacterial.
Eucalyptus citridora	Antimicrobial, Anti-inflammatory, antifungal and analgesic.
Eucalyptus staigeriana	Antioxidant.
Eucalyptus camaldulensis	Antimicrobial, antifungal, antioxidant.
Eucalyptus blakelyi	Antiseptic, anti-inflammatory.
Eucalyptus botrioydes	Antifungal, antiseptic.
Eucalyptus bridgesiana	Antimicrobial, antifungal, antioxidant.
Eucalyptus caley	Anti-inflammatory.
Eucalyptus cephalocarpa	Antibacterial, antioxidant, antifungal.
Eucalyptus cinerea	Antiviral, antibacterial, antifungal.
Eucalyptus cosmophylla	Antifungal, anti-inflammatory.
Eucalyptus crebra	Antioxidant, antiviral, antimicrobial, antifungal, anti-inflammatory, preservative, flavouring agents.
Eucalyptus dealbata	Antifungal, antimicrobial.
Eucalyptus eximia	Antifungal, antimicrobial.
Eucalyptus grandis	Antioxidant, antimicrobial, anti-inflammatory.
Eucalyptus intermedia	Antibacterial, antiviral.
Eucalyptus maculata	Antibacterial, antiseptic.
Eucalyptus maidenii	Antibacterial, antiviral, analgesic, flavouring agent.
Eucalyptus melliodora	Flavouring agent.
Eucalyptus microtheca	Antibacterial, antiseptic, antifungal.
Eucalyptus nitens	Antioxidant, analgesic.
Eucalyptus nortonii	Antiviral, anti-inflammatory.
Eucalyptus punctata	Preservative, flavoring agent.
Eucalyptus robusta	Antioxidant, antibacterial, antifungal.
Eucalyptus saligna	Antiviral, preservative.
Eucalyptus tereticornis	Antimicrobial, antioxidant.
Eucalyptus viminalis	Analgesic.

Table 4: Various species of *Eucalyptus* and their benefits.

microbial infections like Clostridium -E. Coli- *Staphylococcus aureus- Eimeria sp* [50]. Most of the essential oils exhibit antimicrobial properties and mostly exhibit stronger than others. Still, the true mechanism of action of these essential oils has not been identified but it is clearly said that it depends on their chemical composition and a cascade of reactions involving the entire bacterial cell [51]. So, it is accepted that lipophilic character involves in mechanism in a way the components cross the membrane barrier of the cell and permeate mitochondria to inhibit. Among others, they act to stop membrane bound electron flow and energy metabolism that will lead to collapsing of the proton pump and ATP pool [52]. The use of essential oils in high concentrations may also lead to the denaturation of cytoplasmic protein and cell lysis [53]. EO show activity against both gram positive and gram negative bacteria but stronger action against gram positive bacteria like bacillus cereus, bacillus subtilis, clostridium colinum, clostridium septicum, listeria monocytogenes, staphylococcus aureus, and streptococcus gallolyticus [54]. EO act against gram negative bacteria including *Campylobacter jejuni, E. Coli, Mycoplasma gallisepticum, Mycoplasma synoviae, Pseudomonas aeruginosa, Salmonella entiridis, Klebsiella sp, etc* [55]. Some oils act against antibiotic resistance developing bacteria having bactericidal properties against methicillin resistant *Staphylococcus aureus* (MRSA) and vancomycin resistant enterococci (VRE) [56]. *E. Globulus* possess antibacterial property

against gram positive and gram negative bacteria as well. There are alpha-terpineol and para-isopropyl phenol compounds in *E. Globulus* responsible for antibacterial activity. There is antibacterial property also against some oral pathogenic microorganisms due to eight phloroglucinol-sesquiterpene along with three novel compounds as macro carpals (H, I and J) in oils extracts of *E. Globulus* leaves. Dried methanolic extract of *E. Globulus* leaves has antibacterial activity against *E. Coli, Candida albicans, Staphylococcus aureus* and *Pseudomonas aeruginosa* [19]. Most of the bacteria were susceptible to *E. Globulus* oil extract, now susceptible to *E. Teriticornis* oil extract. 1.25 micro liter per mililiter showed the highest activity against *H. Influenzae, H. Parainfluenzae* and *S. Multophilia*. MIC value of eucalyptus oil ranges from 0.56 to 4.50 mg/ml [20].

Antiviral

Antiviral activity against mumps virus. *E. globulus* essential oil extract has shown antiviral activity against herpes simplex virus 1 and 2 [21]. Freshly prepared camphor oil (*E. globulus*) with glycerol dilutions gives a complete cure to human facial demodicosis at concentrations of 50, 70 and 100%. The mechanism of action of EO against viruses has not yet been identified [62]. However, studies have shown the antiviral activity of a few EO such as thyme oil against adenoviruses, oregano oil and carvacrol against enteroviruses and rotaviruses [63].

Antifungal

E. globulus leaf oil extract has shown antifungal activity against *Malassezia furfur* [19]. Labill, oil extract of *E. globulus* exhibits antifungal activity against *Aspergillus flavus* and *Aspergillus parasiticus*. MIC of oil extract ranges from 1.13 to 9 mg/ml [20]. Monoterpenes, components of essential oils, are effective against yeast and filamentous fungi and some components are against molds of fungi like Aspergillus including A [57]. Fumigatus is the most common cause of aspergillosis in poultry production. Studies have shown the property of oregano essential oil against aflatoxin B1 [58].

Anti-inflammatory

Eucalyptus oil extracts also possess anti-inflammatory properties [22]. Eucalyptol, an oil extract of *E. Globulus* acts against bronchial asthma, respiratory tract infections, and other steroid sensitive disorders by inhibiting cytokines [19]. Basically, eucalyptol inhibits the production of TNF-alpha, IL-1 beta, leukotriene B4 and thromboxane B2 in human blood monocytes. Moreover, eucalyptol is also used as an anti-inflammatory agent in patients affected with upper and lower respiratory tract diseases [23].

Antiseptic

Eucalyptus is famous for being used for respiratory tract infections as an antiseptic agent due to eucalyptus oil which exhibits strong disinfectant properties [24].

Analgesic

E. citriodora, E. Teriticornis and *E. Globulus* have shown analgesic properties as intraperitoneal administration of essential oils [18].

Antimalarial

In Brazil, *E. Globulus* used as an antimalarial plant [19]. It acts as inhibiting the growth of *Plasmodium falciparum* by intragastric administration [21].

Anthelmintic

Various phytochemicals of eucalyptus leaves exhibit anthelmintic property as use of the eucalyptus-chloroform solution for hookworm treatment [24]. *E. Globulus* oil extract has shown activity against Indian adult earthworms [20]. The most common parasitic disease of poultry is coccidiosis caused by Eimeria [59] which is destructive to litter [60]. The cause of coccidiosis is determined by the use of coccidiostat. Eugenol, isopulegol, carvacrol, carvone and thymol, these essential oils can be used against coccidiosis in poultry as a preventive measure [61].

Antioxidant

E. Globulus EO possesses the highest antioxidant activity such as gamma terpinene [25]. Compounds like globulusin A and eucaglobulin scavenge DPPH free radicals in a concentration dependent manner. In poultry production, the use of eucalyptus essential oils can reduce lipid peroxidation in the meat of chicken [64]. High contents of polyunsaturated fatty acids are responsible for the production of peroxides, lipids, oxysterols or malondialdehyde due to oxidation in the thigh muscles of chicken. So, the use of EO is encouraged in poultry feed to control oxidation in meat [65]. Antioxidant components present in EO are absorbed in the intestine to perform their functions properly at the body level [66].

Role in Broiler Health

Respiratory health

Essential oils are active compounds of plant extracts known for their positive effects on health. The use of eucalyptus essential oils has been proven successful during respiratory challenges [67] in

poultry as their use as a preventive, helps to remove symptoms and improves breathing [67]. These compounds possess different positive effects like antimicrobial, antifungal activity, or a positive effect on respiration. Sometimes, it seems like only one or two chemicals in essential oil are responsible for a specific function. So, there are extracted depending upon their desired activity or efficacy. There are two major components of an essential oil known as very effective such as menthol and 1,8-cineole [67]. The concentration of these two components varies in essential oils depending upon the origin of the plant extract [68]. As poultry industry is trying its best to replace antibiotics with such natural compounds that will provide safe and effective results. Using these oils as an alternative or supportive treatment in poultry is beneficial [69,70]. As they have a positive effect on the airways by thinning mucus and removing it from the airways because they possess both antispasmodic and expectorant properties [69,70]. The 1,8-cinele essential oil has proved its property to reduce panting along with anti-inflammatory and immune stimulating effects [71]. So, it is highly used in poultry during hot environments to reduce panting in birds and the incidence of respiratory infections also. Menthol is famously known for its cooling effects [72]. As it activates cold receptors present on the mucous membrane. So, it is beneficial to use it not only during respiratory infections but also during heat stress [72]. Besides the good effects of both 1,8-cineole and menthol, other essential oils also possess antimicrobial and antifungal properties. Use of these essential oils as a preventive measure in poultry help to reduce respiratory infection during heat stress where most of the chances of respiratory infections. In poultry, respiratory infections lead to reduced feed intake, poor growth and poor FCR in broilers [69,70]. So, use of these essential oils in affected flocks proves a supportive treatment and restores respiratory functions.

Digestive health

In the poultry industry, eucalyptus has been used to improve poultry production. Eucalyptus essential oils possess useful effects on the digestive system [68]. Terpenoid compounds in essential oils help to maintain balanced microbiota and also increase nutrient absorption by boosting the digestive enzymes resulting in improved digestion [73]. It is important to maintain good FCR. Some essential oils provide taste to the feed which ultimately results in increased secretion of saliva and gastric juices [73]. But, few are so irritating that they damage the mucous lining of the digestive system. So, it is necessary to select the essential oils appropriately.

Gut health

Essential oils, probiotics and antimicrobial peptides are used as alternatives to antibiotics in broiler production. Eucalyptus essential oils with their bioactive compounds that possess antibacterial, antifungal and antioxidant properties are good alternatives such as menthol, terpenoids and 1,8-cineole [74]. The interaction of essential oils or other natural products with intestinal bacteria leads to changes in gut morphology, nutrient absorption and immunity [73] of the host because gut bacteria determine gut health and animal growth [74]. Eucalyptus essential oil is used in broiler production around the world. Studies have shown the anti-inflammatory effect of essential oils on the intestine by maintaining remaining aspects such as intestinal probiotic bacteria, intestinal epithelium and growth performance [75] of broilers as compared to the use of antibiotics as growth promoters in broilers that affect the intestine at the level of intestine thickness, villus height [75], crypt depths [75]. Therefore, essential oils are used as alternatives to antibiotics for broiler production.

Heat stress

There are metabolic changes in broilers to maintain their body temperature under the situation of heat stress that may lead to losses on performance and immunodepression [35]. After brooding, birds produce their own body temperature. During high temperatures, birds refuse to eat [43] which affects broiler performance. During low temperatures, birds need more energy to produce body heat so they like to eat more which affects weight gain [35], but with a poor feed conversion ratio. Environmental conditions must be kept properly according to animal requirements. They may affect animal metabolism which further leads to poor animal production and metabolic diseases such as ascites [36]. So, to keep the energy cost minimum for physiological adjustments and to obtain better broiler production it is necessary to pay attention to the interaction between animals and the environment. So, it is necessary to use some alternatives to decrease heat stress in broilers for better production. In the poultry industry, Eucalyptus is used to improve thermal comfort in broilers which possesses an additional effect of improving the immune system [36]. EO menthol and 1,8-cineole generate the feeling of freshness in the thermoregulatory sensors of the endocrine system of birds also stimulate the immune system, and inhibit inflammatory responses and antimicrobial effects [34]. During high temperatures, birds start panting to maintain their body temperature. But, it may lead to respiratory microbial colonization and diseases. Besides the action of reducing heat stress in broilers, eucalyptus oil also has antimicrobial and immunostimulatory effects on bird's respiratory tract [37]. 1,8-cineole causes stimulation of the immune system by stimulating anti-inflammatory effects and phagocytosis in the organism [38].

Role in broiler production

There is a need of using some natural products in the poultry industry to replace antibiotics for better growth [33] and performance of broilers because this is a drawback of consuming such meat with antibiotic residues. Eucalyptus has been used in the poultry industry for years. Processing of the plant is done via different methods. Different compounds are extracted from different parts of the plant like leaves and bark. Eucalyptus can be used in different forms such as powder or oil. Eucalyptus is used in the poultry industry through various methods such as drinking water, spray and feed additives [44,45].

Ingredient (%)	Starter (Day 1 to 14)	Grower (Day 15 to 25)	Finisher (Day 26 to 40)
Corn	50.91	54.27	57.66
Soybean meal	41.52	37.57	33.52
Vegetable oil	3.40	4.31	5.22
Limestone	1.42	1.32	1.24
DCP	1.38	1.22	1.09
Vitamin mix	0.25	0.25	0.25
Mineral mix	0.25	0.25	0.25
Salt (NaCl)	0.31	0.31	0.29
Lysine	0.19	0.18	0.18
Methionine	0.37	0.32	0.31
ME (kcal/kg)	3000	3100	3200
CP (%)	23	21.5	20
Lysine (%)	1.40	1.29	1.19
Methionine + cysteine (%)	1.08	0.99	0.94
Threonine (%)	0.99	0.93	0.86
Calcium (%)	0.96	0.88	0.81
Phosphorus (%)	0.48	0.44	0.405

Table 5: Broiler diet.

Different studies have shown the positive effects of eucalyptus on broiler health and production. Through feed, eucalyptus powder is added to poultry feed [46] at a specific concentration relative to the feed (see table 5). Through drinking water or spray methods, extracted EO are used. Different studies have shown different concentrations of eucalyptus use. At lower concentrations, there will be fewer results and late production of broiler [60]. At higher concentrations, it may lead to toxic effects for broilers. So, these are used at specific concentrations for early and better growth of broilers for healthy chicken. Studies have shown that eucalyptus powder can be used at 0.25% [34] and 0.5% of the feed. At both concentrations, there will be a minor difference in the growth of the broiler [33]. But, at 0.5% of feed eucalyptus powder, there will be improved immunity and lower FCR of the flock. Eucalyptus is not only used for growth purpose but also possess properties to improve the immunity of the broiler [19,33]. Studies have shown that in broilers, eucalyptus can be used either throughout the production period or during the finisher phase. To get the benefit of improved immunity, it should be used throughout the production period such as the starter, grower and finisher phases [45,47]. A trial of 500 broiler birds was done including one control group and two experimental groups. Among the experimental groups, one was set for 0.25%EP and the other was set for 0.5%EP of the feed. Other parameters like temperature, humidity, oxygen and carbon dioxide levels were maintained at proper level. Vaccination schedule was about ND+IB (live) at day 1, ND+H9(killed) at day 5, ND (live) at day 10, IBD (live at day 13 and ND (live) at day 25. Weight was measured at different periods of age (Table 6). After 14 days, weight gain was 15g of 0.25%EP group and 20g of 0.5%EP group. After 25 days, weight gain was 35g of 0.25%EP group and 59g of 0.5%EP group. After 40 days, weight gain was 42g of 0.25%EP group and 64g of 0.5%EP group.

Age (weight gain in gram)	BD	BD + 0.25%EP	BD + 0.5%EP
1 to 14 days	310	325	330
15 to 25 days	914	949	973
26 to 40 days	2090	2132	2154

Table 6: Effect of Eucalyptus powder on performance traits at different periods through feed.

BD: Basal diet

EP: Eucalyptus powder

Through drinking water, eucalyptus oils are used. Studies have shown the use of eucalyptus oil at a concentration of 1L in 4000L of drinking water [66]. At this concentration, eucalyptus shows improved weight gain with improved FCR in broilers. Again a trial of 500 broiler birds was done to check the broiler performance after intake of eucalyptus oil via drinking water. One control group and the other experimental group. Body weight was measured at different periods of age (Table 7). After 14 days, weight gain was 32g. After 25 days, weight gain was 60g. After 40 days, weight gain was 87g.

From both trials of feed and drinking water, it was concluded that there is no bad impact of eucalyptus on broiler health and production.

Age	Body weight (g)	Weight gain (g)
1 to 14 days	302	334
15 to 25 days	900	960
26 to 40 days	2045	2132

Table 7: Effect of eucalyptus on broiler performance via drinking water.

Through the spray method, eucalyptus oil is used at a concentration of 1L in 200L of water for spray [68]. This method is used when the flock is affected by some type of infection that will disturb the respiratory tract of the bird. As eucalyptus possesses antimicrobial and immunostimulatory effects, it cleans the airways and stimulates the immunity of mucosal lining to prevent the occurrence of disease. It also exhibits other properties like antiviral, antifungal, anti-inflammatory, antioxidant, and anthelmintic properties [9-11]. Eucalyptus is used worldwide in the poultry industry not only to improve the growth of chickens but also because it is safe to use. There is no evidence reported yet that the use of eucalyptus in poultry birds will affect human health on the consumption of such meat.

Conclusion

"*Eucalyptus"* a medicinal plant native to Australia, possesses various pharmacological properties such as antimicrobial, antioxidant, etc. There are different species of this plant such as *Eucalyptus camaldulensis, Eucalyptus globulus,* etc. And each specie exhibits its biological property. Deeply, each specie has its chemical composition such as 1, 8-cineole, and menthol. These compounds are extracted by various methods and can be stored in different forms like oil, and powder, depending upon the purpose of usage. To get better growth, it is used via feed and drinking water. It also exhibits properties like it can be used for respiratory health, digestive health, and gut health, during heat stress. Body systems disturb when there is an occurrence of disease then eucalyptus oils can be used as a spray method as it alleviates the symptoms of the respiratory system. There is a need to use natural products like eucalyptus for meat production than the use of antibiotics that may cause health problems for humans. So, eucalyptus is used worldwide in the poultry industry as it is safe to use.

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