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Prosopis Africana Extracts as Potential Natural Alternatives to Synthetic Antibiotics and A Key for Sustainable Broiler Production: A Review

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The chicken sector is more vulnerable to antimicrobial resistance, the buildup of toxic or dangerous residues in meat and eggs, and environmental contamination as a result of the widespread and careless use of antibiotics in most nations. Natural solutions, such as medicinal plants, are required to address these issues. These plants have been shown to contain a variety of phytochemicals, including phenols, flavonoids, terpenoids, tannins, alkaloids, and saponins. These chemicals endow plants with a multitude of medicinal qualities. One of the many alternatives to antibiotics is Prosopis africana extract, which includes stem bark, leaves, roots, and their essential oils. Antioxidant, antibacterial, antifungal, anti-helminthic, antiviral, hepatoprotective, immune-stimulatory, and antimicrobial properties are among the many pharmacological activity of P. africana preparations. They are also an abundant supplier of vital minerals and amino acids that support enzyme function and provide defense against the effects of oxidative stress. Using extracts from Prosopis africana is the way forward for effective chicken production, environmental sustainability and food hygiene.

1. Introduction

Public concern over potential antibiotic resistance risks related to human health has driven interest in poultry nutrition and adoption of antibiotic free feeding systems (Ulrich and Arne, 2022). This has led to the development of feed additives such as Prosopis africana extracts that can be used as in-feed antibiotic alternatives in livestock feeding strategies (Lius, 2022; Jan, 2021). The extracts have a wide range of potential benefits all targeting the enhancement of performance of livestock.

The medium-sized, annual savannah tree Prosopis africana is a member of the fabaceae family. The majority of Asia and Africa (both East and West Africa) are home to the plant (Kolapo et al., 2009). There are roughly forty-five species of it, and it can reach heights of 4 to 20 meters. It has a thick tap root that expands quickly and deeply into the earth (Orwa et al. 2009). The plant's leaves range in size from 12 mm to 30 mm and are bipinnate, with 9–16 oblong leaf pairs (Aremu et al., 2007). When dried, the seeds of Prosopis africana can open freely inside a yellow-intermeshed pod (Weber et al. 2008).According to Kolapo et al. (2009), the plants' seeds, leaves, roots, and stem bark have lots in phytochemicals and are typically used to treat bronchitis, fever, gonorrhea, toothache, stomachache, dysentery, and body aches.

The variances in plant extract effectiveness can be attributed to a variety of factors, including climate, location, harvest stage, and storage conditions, as well as variations in the chemical content of the extracts made from Prosopis africana (Jan, 2020).Numerous phytochemicals found in P. africana extracts have been shown to have a variety of pharmacological effects, including anti-inflammatory, anti-helminthic, antioxidant, antimicrobial, immune-stimulatory, anti-fungal, and hepatoprotective qualities (Kalemba and Kunicka, 2003).

Essential minerals like potassium, phosphorus, calcium, manganese, magnesium, zinc, and copper are present in Prosopis africana (Ajiboye et al., 2013). According to Yanwuyi et al. (2010), these minerals are critical for the activation of essential enzymes and for protecting against a state of oxidative stress. Additionally, P. africana contains the amino acids methionine, lysine, threonine, leucine, alanine, phenyl alanine, cysteine, and proline, as well as vitamins A, B2, B5, B6, B9, and B12. These nutrients are essential for reducing cellular damage, scavenging free radicals, promoting collagen formation, and further enhancing antioxidant activities (Alagbe, 2022).

Considering the wealth of potential found in Prosopis africana and the growing awareness of the need to offer natural antibiotic substitutes instead of manufactured ones. This review summarizes earlier research and emphasizes the need of advancing food safety and sustainable livestock practices.

The phytochemical makeup of extracts from Prosopis africana

phenols

Due to their antioxidant and free-radical scavenging qualities, phenolic compounds help keep animals healthy (Dai and Mumper, 2010). Phenols work by depriving bacteria of their substrate, which causes fragmentation of the bacterial cytoplasm (Cowan 1999). In their investigations, Cushnie and Lamb (2005) and Davies et al. (1998) found that the inhibition of enzymes by oxidized substrate was the cause of phenols' potency against bacteria.

Alkaloids

According to Nath et al. (2018) and Singh (2008), alkaloids are naturally occurring organic molecules that have a nitrogen heteroatom in their framework. According to Ayushi et al. (2021) and Wink (2016), alkaloids may have a variety of medicinal effects on birds, including antibacterial, analgesic, and antioxidant qualities. It has been found that alkaloids prevent the synthesis of proteins and RNA (Nath et al., 2018).

Flavonoids

According to Cowan (1999), the carbonyl group of flavonoids has hydroxyl groups at positions 3 and 7. Moreover, it has been proposed that they possess antioxidant and antibacterial qualities. Additionally, they may attach to bacterial cell proteins, inhibiting and deactivating enzymes (Cushnie and Lamb 2005).

Tannins

Every portion of a plant, including the stem, bark, roots, leaves, fruits, and flowers, contains tannins (Lim et al. 2006). The capacity of tannins to form complexes with proteins and polysaccharides via covalent and hydrogen bonding is one of their primary characteristics (Szallasi, 2005). Enzyme inactivation results from tannins' capacity to bind to surface proteins and form complexes that do so.

Enzyme inactivation results from tannins' capacity to bind to surface proteins and form groups that do so. According to Lim et al. (2006), it also causes membrane rupture and substrate restriction as a result of complex formation.

Saponins

A class of phytochemicals known as saponins is one of the main defense mechanisms plants have against microbial, fungal, and insect invasion. Whilst the quantity and concentration of saponins in plants differ from species to species, they are present in the majority of plant species (González-Lamothe et al. 2009). According to Morrissey and Osbourn (1999), saponins function by building compounds with sterols or polysaccharides inside the microbial cell membrane, which destroys the integrity of the cytoplasmic membrane.

Pharmacological properties of Prosopis africana

Antimicrobial properties

A study carried out by Badri et al. (2016) showed essential oils from Prosopis africana have the capacity to inhibit the activities of some bacteria's, such as: Shigella flexneri, Salmonella typhi, Proteus mirabilis, Pseudomonas aeruginosa, Klebsiella pneumonia, Enterococcus faecalis, Listeria monocytogenes and Bacillus cereus due to the presence of phytochemicals like phenols, tannins and flavonoids which have been suggested to perform multiple biological activities against pathogenic organisms. Another studies have showed that methanolic and ethanolic extracts from the leaves, stem bark and roots of Prosopis are effective against Salmonella typhi, Proteus mirabilis, Enterococcus faecalis and Listeria monocytogenes (Tajbakhsh et al., 2015).

The properties of antioxidants

Extracts that are aqueous, methanolic, and ethanolic have a number of medicinal uses and have the ability to scavenge free radicals that can lead to infections in an animal's body (Darogba et al., 2009). Additionally, according to Saad et al. (2017), prosopis oil demonstrated efficacy against Erwinia spp., C. albicans, P. vulgaris, E. coli, and Shigella spp. Additionally, research has demonstrated that adding 400 mg/kg of prosopis oil to broiler diets can have a major impact on the activity of enzymes such as glutathione peroxidase, catalase, reduced glutathione, superoxide dismutase, and malondialdehyde (Alagbe, 2023).

Hypolipidemic characteristics

According to earlier research by Rahman et al. (2011), Prosopis extracts administered to rats at doses of up to 600 mg/kg significantly affected their levels of triglycerides, total cholesterol, low density lipoprotein, very low density lipoprotein, and atherogenic index (meat safety index), indicating a potential preventive effect against cardiovascular diseases. Additionally, according to Alagbe et al. (2022), adding 800 mg/kg of Prosopis africana essential oil to the diet can lower the amount of saturated fat and raise the amount of polyunsaturated fat in broiler meat (Alagbe, 2022).

In summary

Medicinal plants are infinitely capable of producing phytochemicals, which are chemical substances with a vast range of possible benefits, all aimed at improving bird performance. Prosopis africana extracts contain several substances, which have been demonstrated to be safe, efficacious, and environmentally benign. Additionally, studies have revealed that P. africana extract includes considerable amounts of phenols, tannins, alkaloids, terpenoids, and flavonoids, which provide them antibacterial, antioxidant, antifungal, antiviral, and other beneficial properties. Additionally, adding nutrition to broiler feed may improve the birds' performance. These will increase the output of chickens and lower the rising number of antibiotic-resistant illnesses.

Table 1: Some bioactive compounds in Prosopis africana oil and their properties (Adapted from (Alagbe, 2023)

Active compounds	Medicinal properties	References
Prosogerin A (6 Methoxy-7-hydroxyl dioxyflavone)	Antibacterial, antioxidant and immune-stimulaory	Guimarães (2010)
Prosogerin B (2,4 dihydroxyl -5 methyl dioxychacon)	Antimicrobial, hepato-protective and antioxidant	Jim´enez-Arellanes et al. (2003)

2,4-bis (1-phenylethyl) phenol	Antioxidants, antifungal	Kokoska et al. (2002)
β-phenethylamine	Antifungal and immune-stimulatory	Lin et al. (2000)
2,4,6-tris(1-phenylethyl) phenol	Antibacterial, antiviral	Loizou et al. (2010)
α-pinene	Antioxidant and digestive stimulants	Alagbe et al. (2022)
α-terpinene	Antioxidant, antibacterial,	Alagbe et al. (2023)
β-pinene	Antioxidant, antimicrobial	Egunyomi and Oladunjoye (2012)
β-myrcene	Antioxidant, digestive stimulants	Edeoga et al. (2005); Alagbe (2022)
α-phellandrene	Antioxidant, Antifungal and antimicrobial	Idowu et al. (2006)
α-terpinolene	Antioxidant, antibacterial	Guimarães (2010)
γ-terpinene	Antioxidant, immune-stimulatory	Jim´enez-Arellanes et al. (2003)
1-terpineol	digestive stimulants	Lalitha et al. (2011)
4-terpineol	digestive stimulants	Lin et al. (2000)
Humulene	Antibacterial, anti-helminthic	Loizou et al. (2010)
Caryophyllene	digestive stimulants	Alagbe et al. (2022)
Copaene	Antimicrobial	Wild (1994)
Cis-linaloxide	Antifungal	Xu and Chang (2007)
α-Selinene	Antioxidant, anti-inflammatory	Shai et al. (2008)
γ-Elemene	digestive stimulants	Shaheen et al. (2005)
α-Gurjunene	Immuno-stimulatory, antioxidant	Özçelik et al. (2011)
β-Elemene	Antimicrobial, antioxidant, digestive stimulants	Singh et al. (2023); Omokore and Alagbe (2019)
β-Cyclocitral	Anti-inflammatory, digestive stimulants	Kolapo et al. (2009)
3-hexenyl-2-methylbutanoate	Anti-bacterial	Inngjerdingen et al. (2004)
Exo-methyl-camphenilol	Antimicrobial	Ezike et al. (2010)
Caryophyllene oxide	Antibacterial, antioxidant	Enright et al. (2002)
Benzene -1-methoxy-2-methyl	Antifungal	Fabricant and Farnsworth (2001)
Napthalene, 1,2 hydro-1,1, 6 –trimethyl	Antimicrobial	Inngjerdingen et al. (2004)
Cycloheptasiloxane, tetradecamethyl	Anti-inflammatory	Chua (2013); Daniel et al. (2023)
Nerolidyl acetate	Anti-inflammatory	Azmir et al. (2013)

1-Cyclohexene-1- butanal, alpha, 2, 6, 6- tetramethyl	Anti-inflammatory	Atanasov et al., 2015; Alagbe (2024)

Effects of Prosopis africana extracts on the general performance of birds

Type of extracts used	Concentration used	Effect on broilers
Prosopis africana essential oil	400 mg/kg	Increased body weight gain
		Increased pancreatic enzyme production
		Improved nutrient utilization
		Increased feed intake
		Reduced mortality rate
		Increased in carcass weight
Prosopis africana essential oil	800 mg/kg	Increased production of polyunsaturated fatty acid in meat sample
		Improved sensory attributes of meat
		Increased in pack cell volume, red blood cell, haemoglobin, white blood cell, total protein, amongst others
		Scavenging free radicals
		Increasing antibody titres in birds after vaccination
		Decrease in population of pathogenic microorganisms
Prosopis africana stem bark extracts (aqueous)	8ml/litre of water	Increased final body weight gain, feed intake and *Lactobacillus sp* count in the gut of broilers

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