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REVIEW ARTICLE

POTENTIAL USE OF *ACACIA* LEAF MEAL AS PROTEIN FEED SOURCE FOR POULTRY DIETS: A REVIEW

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ABSTRACT

Poultry accounts for more than 30 % of all animal protein consumption worldwide. It is estimated that by 2030, poultry will account for 41 % of all animal protein consumed by people due to low income and population growth. Protein feed sources are considered the most valuable but expensive ingredients in poultry production. High feed cost is the major problem faced by livestock and poultry farmers, especially those in rural communities. The need to search for alternative feed sources has triggered much interest in the use of *Acacia* meals including *A. karroo, A. tortilis, A. nilotica, and A. angustissima* leaf meals in poultry diets since they are readily available, grow in abundance, and cover large areas in most parts of Africa. *Acacia* meals have high nutritional values due to their large amounts of crude protein, hence, can effectively serve as an alternative protein feed source for the poultry diet. However, their utilisation is restricted by the presence of tannins within the leaves. Previous research on the inclusion of *Acacia* meals in poultry species focused mainly on broiler chicken diets. Therefore, the present review encompases the potential use of *Acacia* meal as a cheap and alternative protein source in poultry diets.

Keywords: *Acacia* meal, Tannins, Protein feed source, Poultry

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INTRODUCTION

Poultry production worldwide contributes more than 30% of protein for human consumption through meat, eggs, and their products (Hafiz *et al.,* 2015; Motsepe *et al*., 2016). Rosegrant *et al.* (2001) reported that there is high demand for poultry meat. This is attributed to the high nutritional value and affordability of poultry meat when compared to other animal protein supplies (Hafiz *et al.,* 2015). As a result, the poultry industry continues to grow year in and year out making it a significant contributor to global food security, income, and employment opportunities particularly for rural-based communities (Mbajiorgu *et al.,* 2007). Seasonal changes including climate change and drought conditions affect the quantity and quality of feed raw materials which result in shortages and high poultry feed costs (Mthethwa, 2018). The hike in feed costs is mainly on protein and energy feed ingredients which adversely affect poultry industries, especially commercial and smallholder poultry farmers. Poultry meat is the most preferred meat by consumers because it is considered healthier, tastier, and cheaper than meat from other livestock (Brenes and Raura, 2010; DAFF, 2011; Hafiz *et al.,* 2015). However, chicken meat is constrained by its high amount of unsaturated fatty acid contents, which exposes meat to lipid oxidation, leading to microbial spoilage (Wapi *et al.,* 2013). This process causes undesirable meat with poor quality, low shelf life which also affect the price and consumer preference. (Tshabalala *et al.,* 2003; Cunha *et al.,* 2018; Mthethwa, 2018). Synthetic antioxidants have primarily been used to retard lipid oxidation in chickens but their continued use is, however, considered harmful to humans as they produce carcinogenic effects (Gheisari *et al.,* 2017; Lorenzo *et al.,* 2018). Because of this, consumers tend to shift their preference to meat produced naturally without the use of growth hormones and chemicals (Tshabalala *et al.,* 2003; Shah *et al.,* 2014; Lorenzo *et al.,* 2018; Nikmaram *et al.,* 2018; Cunha *et al.,* 2018). These problems have triggered more research interest in finding possible alternative feed sources in the poultry industry. Thus, it is important to find alternative, low-cost, and effective feedstuffs to reduce costs while maintaining high productivity. It has been reported that most fodder trees and shrubs have high crude protein on a dry matter basis and can be used as an alternative protein source in poultry feeds to elevate bird productivity since they are affordable and readily available (Jamala *et al.,* 2013; Tufarelli *et al.,* 2018). In addition, other authors observed that dietary tannins inclusion from *Acacia* meals in diets reduced fat deposition in broiler chickens (Ng'ambi *et al.,* 2009; Hafeni, 2013). The most common *Acacia* species includes *Acacia karroo, Acacia tortilis, Acacia nilotica, Acacia angustissima, Acacia saligna and Acacia scaffneri*. Although they have high crude protein content, their utilisation, anti-nutritional factors (amount and types of tannins), viability, and palatability need to be taken into consideration as they affect animal performance (Mokoboki *et al.,* 2005; Anon, 2009; Hassan and Abd El-Dayem, 2019). There is limited information about the use of various *Acacia* meals as alternative protein sources in poultry feeds to improve productivity and reduce feed costs. The aim was to report on the potential use of *Acacia* meals as protein feed sources in poultry production.

Description of various *Acacia* species: *Acacia* species are leguminous trees and shrubs which remain green almost throughout the year. They are known to adapt and survive in dry, poor, and harsh environmental conditions and they are highly distributed in most parts of the world (Mokoboki *et al.,* 2005; Mashamaite *et al.,* 2009; Mapiye *et al.,* 2011; Mathobela, 2018). The common *Acacia* species includes; *Acacia karroo, Acacia tortilis, Acacia nilotica, Acacia angustissima, Acacia saligna and Acacia schaffneri. Acacia karroo*, also called *Vachellia karroo*, is the most widespread *Acacia* species in Southern Africa, where it is commonly known as sweet thorn (Mapiye *et al.,* 2011). It adapts well to different environmental conditions (Mathobela, 2018). *Acacia karroo* is abundant in South Africa and grows well during the dry season, mainly in dry parts of the country (Mokoboki *et al.,* 2005). *Acacia tortilis* also called *Vachellia tortilis* is the most common valuable thorned *Acacia* species which falls under *Leguminaceae* family. It is characterised by a twisted browny pod structure and umbrella-shaped canopy; thus, it is called an umbrella thorn (Orwa *et al.,* 2009). It has a deep root system that enables it to tolerate heavy browsing and severe droughts, it thus adapts well to harsh conditions of arid and sub-arid areas of Africa (Mathobela 2018). *Acacia nilotica* has a deep taproot system with extensive lateral roots that helps it to thrive in dry areas. It is observed as a weed in some areas including some parts of South Africa. *Acacia angustissima* is a thornless tree or shrub characterised by a short trunk and belongs to *Mimosaceae* family. It can grow well in harsh environments such as prolonged drought and occasional freezing conditions. It has also been reported to recover well from frequent cuttings (Ncube *et al.,* 2012). Many scientific studies are based on the use of *Acacia* meals in ruminant diets. However, information on the use of *Acacia* leaf meals in the poultry diet is limited. These *Acacia t*ree species are abundant and readily available in most parts of Africa.

Nutritional value and chemical composition of *Acacia species:* The nutrient component, digestibility, metabolism, concentrations of essential nutrients, intake of nutrients, and the secondary compounds determines the feeding and economic value of forage species consumed by animals (Adesogan *et al.,* 2006; Gebeyew *et al.,* 2015). The nutritive value of tanniniferous forages such as *Acacia* species is determined by the amount of tannin content found within their leaves (Mlambo *et al.,* 2009). This specifically includes; the chemical structure, molecular weight, and concentration of tannins found in tanniniferous forages (Mueller-Harvey, 2006: Mlambo *et al.,* 2009). It is, therefore, important to consider the anti-nutritional factors such as tannin levels in *Acacia* leaves when feeding animals as they affect their utilization by the animals (Mokoboki *et al.,* 2005; Brown *et al.,* 2016). Other factors influencing the variation in the nutritional value of *Acacia* leaves of the same species from different trees include; population, soil, climate, stage of growth, browse pressure, and assay methods (Mapiye *et al.,* 2011). It has been reported that most tree species-rich in natural-occurring polyphenolic compounds such as tannins contain high crude protein contents (Mlambo *et al.,* 2015) compared to other forages such as grasses and cereal grains (Chepape *et al.,* 2011). Some authors observed high crude protein, minerals, and fatty acids in *Acacia* leaves which makes them a suitable protein supplement for animals (Ngwa *et al.,* 2002; Mapiye *et al.,* 2011). The amount of crude protein in *Acacia* leaves can be utilised effectively by ruminant animals during the dry season (Marume *et al.,* 2012) and has been reported to be high enough to meet protein requirements for broiler chickens (Mthethwa, 2018). *Acacia* leaves have also been reported to contain low detergent fibre which indicates a high feeding value (Mokoboki *et al.,* 2005; Mapiye *et al.,* 2011). Tables 1 and 2 below show the chemical composition and mineral content respectively of the leaves of selected various *Acacia* species.

Tannin composition of *Acacia* meals: *Acacia* species contain high phenolic compounds in various parts of the tree including the leaves. These compounds perform several functions including high-level antioxidant activities and plant protection against browsers (Sultana *et al.,* 2007). Some of these compounds such as tannins are considered antinutritional. Tannins are astringent phenolic compounds found in plants or herbs (Maudu, 2010). Other researchers define tannins as a heterogeneous group of secondary metabolites that are soluble in water and polar solution (Tufarelli *et al.*, 2017; Singh, 2017). Large and complex tannins can easily be degraded into smaller tannins by water or dilute acids in 30 minutes at a gradual increase in temperature (Mashamaite *et al.,* 2009). Tannins have a high molecular weight that is above 500Da and are characterized by their ability to bind to form soluble or insoluble tannin-protein complexes. Unlike other phenolic metabolites, they can precipitate proteins from an aqueous solution (Al-Hijazeen *et al.,* 2016; Huang *et al.,* 2018). They can also form complexes with other nutrient compounds such as polysaccharides, alkaloids, nucleic acids, and minerals (Singh, 2017). In plants, tannins act as chemical defensive mechanisms to protect them against pathogens, herbivores, insects, and harsh environmental conditions (Mazid *et al.,* 2011). Furthermore, they have been reported to perform biological activities such as antioxidant, anti-microbial, anti-parasitic, anti-virus, metal-chelating, and protein precipitation in plants (Huang *et al.,* 2018). Factors including; plant species, cultivars, tissues, leafage, stage of development, and environmental conditions such as exposure to herbivores, nutrient stress, light intensity, and temperature determine the type and quantity of tannins found in various plant trees of the same species (Frutos *et al.,* 2004; Huang *et al.,* 2017). Approximately 80% of woody plants such as *Acacia* species contain tannin compounds (Huang *et al.,* 2018). Furthermore, tannins are present in various feeds such as fodder, legumes, browse leaves, and fruits (Mlambo *et al.,* 2004). They are highly concentrated in the most vulnerable parts including new leaves and flowers (Frutos *et al.,* 2004). In addition, they are also found in many poultry feedstuffs, including sorghum, peas, and cottonseed (Nyamambi *et al.,* 2007). According to Moyo *et al.* (2012) tannins found in leguminous trees are regarded as one natural antioxidant substance.

Table 1: Chemical composition of various selected *Acacia species* (g/kgDM).

Species	Dry Matter	Ash	Crude Protein	Crude fibre	Neutral detergent fibre	Acid detergent fibre
A.karroo	922.0	51	154.0	259.0	450.0	300.0
A.tortilis	947.7	65.0	150.2	218	621.7	544.9
A.nilotica	951.6	56.5	151.7	6.53%	572.0	472.2
A.agustissima	979.2	23.40%	249.0	130.0	287.0	153.8
A.saligna	925.0	9.81%	165.8	178.2	336.0	209.0
A.schaffneri	925.0	-	229.0	161.0	329.0	287.0
A.robusta	950.0	82.7	160.0	-	455.0	279.0
A.xanthophloea	943.0	87.6	216.0	-	471.0	304.0
A.hockii	89.70%	-	14.65%	5.71%	-	-
A.senegal	878.0	77	238.0	-	245.0	141.0
A.reficiencs	879.0	91	158.0	-	186.0	111.0
A.nigrescens	938.0	78.3	178.0	-	630.0	477.0
Acacia colei	92.4%	3.3%	24.8mg/g	7.06%	-	-
A.galpinii	944.5	-	149.6	-	509.0	454.7
A.sieberiana	926.0	-	169.0	-	427.0	323.0
A.hebeclada	971.8	-	164.9	-	570.1	428.8
A.rhemniana	957.4	-	102.7	-	487.9	441.6
A.leucophloea	95.45%	4.55%	25.81%	6.70%	-	-

Sources: (Ngwa *et al.,* 2002; Mokoboki *et al*., 2005; Al-soqeer, 2008; Mapiye *et al.*, 2011; Nsahlai *et al.,* 2011; Fuentes *et al*., 2012; Mbongeni, 2013; Ng'ambu *et al.,* 2013; Zia-Ul-Haq *et al*., 2013; Brown *et al.,* 2016; Ncube *et al.,* 2017b; Mthethwa, 2018; Gudiso *et al.,* 2019; Abd El-Galil *et al.*, 2018; Gebremeskel *et al.,* 2019; Aruwayo *et al*., 2020; Otemuyiwa *et al.,* 2020).

Table 2: Mineral content of various selected *Acacia species*.

Species	Calcium (g)	Potassium (g)	Phosphorus (g)	Magnesium (g)	Total condensed tannin (mg)
A.karroo	27.40	1.40	1.50	3.60	82.50g
A. tortilis	9.6	17.30	23.0	3.0	51.5
A.nilotica	14.9	16.00	15.0	4.9	67.7
A.agustissima	7.6	8.30	1.8	1.8	1.06%
A.saligna	1.52%	-	0.15%	2.5%	2.69%
A.rubusta	21.4	13.00	13.0	3.4	64.4
A.xanthophloea	12.0	18.00	22.0	3.1	59.5
A.nigrescens	11.5	10.60	15.0	3.5	40.5

Sources: (Mapiye *et al.*, 2011; Fuentes *et al.*, 2012; Mbongeni, 2013; Ncube *et al.,* 2017b; Mthethwa, 2018; Abd El-Galil *et al.,* 2018).

Tannins are among the important anti-nutritional factors of various browse trees, including *Acacia* species (Mlambo *et al.,* 2009). Nutritional effects of tannins depend on tannin concentration, molecular weight, and structure, as well as animal factors (Mlambo *et al.,* 2015). According to Sugiharto *et al.* (2019), low tannins inclusion in poultry diets has a positive impact on their health and performance. This is supported by studies that reported that low levels of dietary tannins from *Acacia* meals improved the growth performance of ruminants

(Ng'ambu *et al.*, 2013) and monogastric animals, more especially broiler chickens (Huang *et al.,* 2018). Other studies observed that low tannins inclusion had no adverse effect on poultry productivity (Cui *et al.,* 2018; Manyelo *et al.,* 2019). However, the utilisation of tannin-rich leaf meals can further be improved by various techniques such as soaking feed with alkaline or water solutions (Nawab *et al.,* 2020), sun drying, cooking, fermentation (Sugiharto *et al.,* 2019), detannification process with wood ash then store at room temperature (Brown *et al.,* 2016; Nawab *et al.,* 2020), dilution, extraction using organic solvents, biodegradation by white-rot fungi, the use of Magadi soda containing alkalies (sodium carbonate, sodium bicarbonate, and sodium sesquicarbonate) (Ben Salem *et al.,* 2005) and the use of binding agents such as polyethylene glycol and polyvinyl pyrrolidone to extract tannin compounds from plants and effectively assist in reducing anti-nutritional factors (Nsahlai *et al.*, 2011).

There are two groups of tannins in plants, this includes condensed tannins and hydrolysable tannins (Maudu, 2010). They are differentiated according to their chemical structure and characteristic properties (Singh, 2017), and they can both precipitate proteins (Mashamaite *et al.,* 2009). It has been reported that complex phenolics such as condensed and hydrolysable tannins show greater antioxidant activities compared to simple phenolics (Huang *et al.,* 2018).

Condensed tannins: Condensed tannins (CT), also called proanthocyanidins are non-hydrolysable tannins with a condensed chemical structure (Huang *et al.,* 2018). CT is divided into polymerized products including flava-3-ols and flava-3,4-diols or a mixture of both (Al-Hijazeen *et al.,* 2016). Their structure consists of unbranched polymers having 2 to 5 or more flavonoid units joined by carbon to carbon linkages (van Wyk and Gericke, 2000), which can be broken by hydrolysis (Kambashi *et al.,* 2014). CT has no carbohydrate core, however, they are derived from the condensation of flavonoid precursors without the action of specific enzymes (Ng'ambi *et al.,* 2009). They are water-soluble polymeric phenolics with high level of phenolic hydroxyl group which allows them to bind to proteins (Ng'ambi *et al.,* 2009) and other molecules such as metal ions and polysaccharides, thus preventing the microbial attack on proteins (Tshabalala *et al.,* 2013).

According to Ng'ambi *et al.* (2009), CT compounds are found in abundance in higher plant species and are more active in precipitating proteins than hydrolysable tannins. They are also found in pastures and can be used for various purposes (Idso and Idso, 2002). CT mainly acts as a defensive mechanism in plants against herbivores (Tshabalala *et al.,* 2013). They have a molecular weight ranging from 1000 to 20,000 Da (Huang *et al.,* 2018). They are the most common complex phenolics found in a variety of browse sources, including leguminous forage, trees, and shrubs, particularly in the leaves and pods (Ashok and Upadhayaya, 2012).

CT has been identified as an anti-nutritional factor influencing productivity in monogastric animals (Mokoboki *et al.,* 2005). The negative effect of high CT forages in the diets on feed intake, nutrient digestibility, palatability, protein metabolism, and animal performance are due to their ability to bind to proteins (Huang *et al.,* 2018). Hence, CTs in *Acacia* leaves reduce leaf utilization by animals (Mapiye *et al.,* 2011; Nsahlai *et al.,* 2011; Brown *et al.,* 2016). It has been reported that *Acacia* leaves contain about 4.52% DM level of CT and they tend to be beneficial at low levels when gradually included in animal diets (Ng'ambi *et al.,* 2009).

Hydrolysable tannins: Hydrolysable tannins (HT) are ester compounds of sugar made up of glucose and phenolic acid. They consist of phenolic acids such as hexahydroxydiphenic acid and gallic acid or condensation products of ellagic acid which are partially or esterified to the hydroxyl groups of glucose (Okuda and Ito, 2011; Mlambo *et al.,* 2015). Hydrolysable tannins are distinguished by a central carbohydrate core with several phenolic carboxylic acids connected by ester linkages (Ng'ambi *et al.,* 2009). Hydrolysable tannins are more highly reactive to extracting solvents than CT and can be hydrolyzed by mild acids or mild bases to yield carbohydrates and phenolic acids (Mashamaite *et al.,* 2009). However, Maudu. (2010) reported that HT can produce carbohydrates and phenolic acids through hydrolysation by weak acids or bases. They can also be hydrolysed by hot water or enzymes such as tannase (Mashamaite *et al.,* 2009). Unlike CT, HT can be broken down in the gastrointestinal tract with ease before being absorbed by the animal (Huang *et al.,* 2018). They have lower molecular weights (500 to 3,000 Da) and products produced from hydrolysis of HT may be the cause of toxicity in animals (Mlambo *et al.,* 2015). Where HT are not toxic, they still influence animal nutrition by inhibiting the action of various enzymes (Yoshida *et al.,* 2000). A variety of plants and trees can synthesize HT and most of those used as animal feeds contain low HT (Mashamaite *et al.,* 2009).

Effect of tannins on poultry production: Tannin compounds are strongly astringent and influence palatability, intake, feed efficiency, growth rate, and digestibility in animals (Hassan *et al.,* 2003; Kim and Miller, 2005). The responses in performance to different tannin supplementation vary depending on the type, source, and amount of tannins, the basal diet, and the animal receiving the supplementation (Patra and Saxena, 2011). Getachew *et al.* (2000) reported that high lignification in browse plants such as *Acacia* species tend to reduce digestion along the gastrointestinal tract, thus resulting in reduced animal performance. However, Reed *et al*. (2000) and Nawab *et al.* (2019) reported that high tannin content in most browse plants is one of the main factors leading to reduced animal performance. They drastically reduce feed intake by binding to dietary proteins (Mashamaite *et al.,* 2009), cell walls, and soluble cell adhesion molecules while increasing the bitter taste of the feed material consumed by the animal (Mthethwa, 2018). The adverse effect of high dietary tannins on animal performance has been well documented (Yacout, 2016; Brown *et al* 2016). It has, however, been reported that tannins found in tanniniferous plants such as *Acacia* species can have either positive or negative effects on animal performance (Mashamaite *et al.,* 2009). Furthermore, dietary tannins from different plant species at high, moderate, or low levels have varying effects on both ruminant and monogastric animals (Reed *et al*., 2000; Nawab *et al.,* 2019).

According to Ng'ambi *et al.* (2009), tannins in monogastric animals such as pigs and poultry, form very complex compounds with proteins, digestive enzymes, and starch in the digestive system. The formation of tannin-protein complexes reduces protein breakdown and increases amino acid loss through excretion. According to NRC. (1994), the inclusion of high tannin in chicken diets causes nutritional problems. Moreover, the reduced feed intake due to the inclusion of plants containing tannin in the diets causes growth depression in chicks (Mashamaite *et al.,* 2009). Other studies concluded that high dietary condensed tannin inclusion has a negative effect on the performance of broilers (Hidayat *et al.,* 2021). In addition, the inclusion of feedstuff with condensed tannins in chicken diets before the age of three weeks has also been reported to negatively affect starch digestibility and apparent digestibility of amino acids depending on tannin levels consumed (Ng'ambi *et al.,* 2009). Mansoori and Acamovic. (2000), also observed that dietary tannins increased the excretion of proteins, bile acids, and hyper secretion of enzymes and endogenous mineral losses in birds. Bento *et al.* (2005) also reported that oral administration of tannin or tannin containing material causes an increase in endogenous mineral losses in chickens.

However, monogastric animals including pigs and poultry can tolerate tannin containing feedstuff differently due to a varying number of taste buds in their mouth (Ng'ambi *et al.,* 2009). In addition, various methods to reduce tannins from *Acacia* meals hence, improving their utilisation have been well documented (Ben Salem *et al.,* 2005; Nsahlai *et al.,* 2011; Mapiye *et al.,* 2011; Brown *et al* 2016; Sugiharto *et al.,*2019; Nawab *et al.,* 2020). The conclusions imposed on tannin as the main factor reducing feed intake are unfair since the reduction in feed intake can be caused by failure to consume feeds rather than the feed itself (Ng'ambi *et al*., 2009). Thus, studies found that the dietary intake of tanniniferous browse did not affect animal growth and performance (Mashamaite *et al*., 2009; Mthethwa, 2018). In addition, tannins are capable of clearing poisonous substances in animal bodies (Gxasheka *et al.,* 2015). The supplementation of tannin rich *Acacia* leaf meal in goat diets improved growth performance (Ng'ambu *et al.*, 2013). Broiler chicks can tolerate low percentage levels of dietary tannins. This is supported by Ng'ambi *et al.* (2009), who observed that the inclusion of low condensed tannin levels from *Acacia* meals can be effective in broiler diets without any harmful effects on performance, and diet intake, digestibility, and live weight of the chickens. Similarly, Manyelo *et al. (*2019) concluded that low tannins inclusion in the broiler diet has no adverse effect on the productivity of broiler chickens. In addition, Huang *et al.* (2018) reported that low to moderate tannin concentration improved health, nutrition, and performance in non-ruminants.

Economic efficiency of using *Acacia* meals: Feeds constitutes a greater proportion of poultry production costs, hence, the price of each ingredient required has a greater effect on the economic efficiency (Mthethwa, 2018). The low cost of feeding with readily available and easily accessible feeds could improve both the economic and ecological viability of livestock enterprises by reducing total feed costs (Mapiye *et al.,* 2011; Mthethwa, 2018). Access to cheap and readily available alternatives has been reported to be economically beneficial to livestock farmers due to the reduced cost of production. Thus, it is important to find economically valuable alternative feed sources produced locally to replace conventional feed ingredients, while maintaining low feed costs (Hafeni, 2013). The economic efficiency of utilizing *Acacia* meals in poultry diets has been reported in studies mainly focusing on broiler chicken production. Abd El-Galil *et al.* (2018) observed that the inclusion of 8% *Acacia saligna* leaf meal in Mamourah growing hens diet resulted in higher net returns, percentage of economical efficiency, and relative economical efficiency of feed, and least feed cost of kg gain compared to other inclusion levels. Hassan and Abd El-Dayem. (2019) also found that 6% *Acacia* leaves meal in broiler diets improved economic efficiency % of feed and relative economic efficiency of feed compared to the control diet. According to Madzimure *et al.* (2018), the inclusion of 50 g/kg *Acacia anguistissima* in broiler chickens' diet resulted in the highest net returns, consequenctly, yielding better economic benefits than other inclusion levels. However, Olerede *et al.* (2000) observed that a 10% *Acacia nilotica* seed kernel meal level to replace groundnut cake in chicken diets could be economically beneficial as it resulted in the lowest feed cost/kg and highest total revenue and economic efficiency.

Table 3: Effect of tannins from *Acacia* meals on feed intake, digestibility, and performance in broiler chickens.

Species	Inclusion level	Conclusions	References
A.angustissima leaves	5%	Did not affect the weight gain, carcass yield, and meat quality characteristics of broiler chickens.	Ncube *et al.* (2018).
A.karroo leaves	9 and 12 g/kg	Did not affect diet intake, digestibility, and live weight, but reduced fat pad weights of broiler chickens.	Ng'ambi *et al.* (2009).
A.karroo leaves	20g/kg	Reduce fat deposition in broiler chickens.	Hafeni. (2013).
A.tortilis leaves	90 g/kg	Improved storage time and antioxidant activity in broiler chickens	Mthethwa. (2018).
A.tortilis seeds	20%	Had no adverse effect on carcass characteristics of broiler chickens, thus can be used as broiler feed without any effect on the carcass.	Ikiamba. (2020).
A.saligna leaves	8%	Could be used effectively in chicken diets without adversely affecting their performance.	(Abd El-Galil *et al.,* 2018).
A.schaffneri seeds	-	Did not affect FCR and could be used in poultry diets to partially replace commercial feed ingredients as protein and energy sources	(Fuentes *et al.,*2012).
A.angustissima leaves	60.77, 90.14 and 70.98 g/kg	Improved feed intake, weight gain, and FCR. Thus, it could be included in broiler diets a,s a cheap alternative protein source	(Gudiso *et al.,* 2019).
A.nilotica seeds	10%	Had no adverse effect on broiler organ weights. Thus could be included in broiler diets as a replacement for groundnut cake	(Olerede *et al.,* 2000).

***Acacia* meals as a protein feed source in poultry diets:** Feeding of forages can be beneficial to poultry farmers as they can reduce the dependence on the traditional protein and energy feed ingredients. Hence, various forage species, including *Acacia* meals can be used as alternative protein sources for livestock species (Tufarelli *et al.,* 2018). Sugiharto *et al.* (2019) reported that the inclusion of leaf meals in broiler diets helps to lessen the use of protein-rich feedstuffs by partially replacing them, consequently, reducing feed costs. Some *Acacia* meals often used in poultry diets include *Acacia angustissima, Acacia tortilis*, *Acacia karroo*, *Acacia saligna,* and *Acacia schaffneri*. The inclusion of *Acacia angustissima* in broiler diets to improve growth and carcass characteristics has been well documented. This species shows a greater potential to be used as a protein feed source to partially replace common protein sources in broiler diets (Ncube *et al.,* 2012; Ncube *et al.,* 2017a; Madzimure *et al.,* 2018; Gudiso *et al.,* 2019). Ncube *et al.* (2015) also observed that *Acacia angustissima* meal can be used efficiently as a crude protein source in broiler diets when it is harvested at the mid maturity stage to maximize crude protein and condensed tannin levels. Other studies reported the use of *Acacia tortilis* meal in broiler diets. It was concluded that the meal can help reduce the portion of other protein ingredients in broiler diets by partially replacing them without any detrimental effect on performance and carcass yield (Miya, 2019; Ikiamba *et al.,* 2020). Ng'ambi *et al.* (2009) observed that *Acacia karroo* leaf meals have the potential to be used as additives in poultry diets at lower levels. According to Fuentes *et al.* (2012), *Acacia schaffneri* seed meal can effectively be used in the backyard production system to partially replace expensive protein and energy feed sources in poultry diets. Abd El-Galil *et al.* (2018) also found that *Acacia saligna* leaf meal can be utilised in chicken diets without any negative effects on their performance and further recommended its use. However, there is limited information on the use of *Acacia* meals as a protein source in the diets of other poultry species such as indigenous chickens, ducks, turkeys, ostriches, and guinea fowls.

Conclusion: *Acacia* meals have been in use for more than a decade in broiler diets. Although they contain high tannin levels, they have been proven to be highly effective when partially incorporated into chicken diets. The use of *Acacia* meals in poultry rations will help farmers reduce the costs of purchasing commercially used expensive feedstuffs such as fish and soya bean meals. It can therefore be concluded that *Acacia* meals can show greater potential to be utilised safely as a protein source for broiler poultry as various meals were proven to be effective in many research papers. However, there is a need for further research on the use of *Acacia* meals in diets of other poultry species such as indigenous chickens, ducks, turkeys, and ostriches.

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