Using Paulownia leaves as feed additive in poultry diets: a review

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Abstract

The rapid changes in the course of the countries of the world have greatly increased the prices of fodder materials. It has become imperative to search for feed alternatives that provide the requirements of poultry in terms of energy, protein, vitamins, and mineral elements. Paulownia or princess tree (scientific name: *P. tomentosa*) is a genus of plants belonging to the Paulownia family of the Lamiaceae order, It is a tree that has 6 to 17 varieties and is one of the fastest growing and most commercially widespread trees for the production of hardwoods, its fragrant flowers characterize it. The Paulownia is a fast-growing tree, the Paulownia tree can live from 85 to 100 years, and the Paulownia tree becomes abundantly shaded within 16 to 18 months, and reaches a height of 9 meters in three years. Large trees bloom flowers such as lavender and jasmine, and flowers are add to the daily authority of some people. Some civilizations use the leaves to feed animals, and their original home in China, as it contain good levels of energy, protein, potassium, manganese, calcium, phosphorus, and zinc. Paulownia can be very useful in laying hens diets, as these breeds need low amounts of protein. Therefore, the current review aims to shed light on some studies that dealt with the importance of bologna as a feed additive for poultry.

Keywords: paulownia, poultry, nutrition, feed alternatives.

Introduction

According to Cassidy et al. (2013), 36 percent of all calories produced globally each year are fed to animals, with the US, Brazil, and China generating the majority of the world's animal feed. To help the animal feed industry, it is essential to find substitute non-food plant resources. Inadequate feed supplies, both in terms of quality and quantity, are a significant global constraint on livestock output. There are several benefits to using fodder trees as a source of fodder on smallholder farms. Feeder trees continue to produce during dry spells because they are resistant to abrupt weather shifts. Additionally, it has been suggested that trees, shrubs, and herbs are important as a source of fodder due to their nutritional capacity (compared to grasses, fodder trees, shrubs, and herbs have relatively higher concentrations of crude protein, minerals, and neutral detergent fiber) for animals that browse and graze for longer periods throughout the year in areas of poor quality pastures (Lefroy et al., 1992). Fast-growing, well-suited for coppicing trees like the paulownia provide copious amounts of leafy biomass for use as fodder, mulch, and erosion control, among other things. Paulownia species make good intercropping partners since they don't compete with food crops for nutrients (Jiang et al., 1994). Moreover, trees are an important source of shade for animals and lumber for construction and fencing in many regions of the world (Topps et al., 1992). Short-rotation tree bioenergy crop Paulownia elongata (family Paulowniaceae) is economically significant (Joshee., 2012: Basu et al., 2015). Snow, (2015) has provided a historical description of the introduction of the genus Paulownia to the United States and its current situation in the state of Georgia, however, there are no quantitative data on tree growth and leaf analysis for Georgia settings. Paulownia wood is renowned for its flexibility, moisture resistance, and flame-retardant qualities as well as its unique texture, grain, and color (Li and Oda 2007: Zhu et al., 1986) As a tree with rapid growth, the fruits, wood, bark, roots, seeds, leaves, and flowers of Paulownia have been claimed to have several beneficial therapeutic characteristics in addition to their utility as wood and related industrial items (Yadav et al., 2013: He etal., 2016). Paulownia leaves that have fallen to the ground enhance soil quality by adding organic matter, and the nectar-bearing flowers offer paulownia leaves a plentiful supply of nourishing honey. Paulownia leaves could be used as livestock fodder, but this has gotten less attention thus far. *P. tomentosa*, *P. fortunei*, and *P. elongata* lamina have reportedly been described as tasty and adding to nutritional values suited for goat browsing (Mueller et al., 2001). Moreover, goats are more effective browsers than sheep and cattle, can adapt to hard conditions, and can utilize woody species and low-quality forages more effectively (Silanikove, 2000: Salem, 2004). A Paulownia tree that has already grown up can regenerate from stump sprouts (coppicing), eliminating the need for repeated plantings. Compared to many other tree species, which lack this characteristic, this is a cost-benefit. Its coppicing ability is a crucial benefit in the production of fodder because it enables the plants to be chopped down as many times as necessary during the growing season.

Paulownia

One of the most widely used medicinal plants is paulownia (*P. tomentosa*), which is native to China, Japan, and other Far Eastern Asian nations (Móricz et al., 2019; Alagawany et al., 2022). On top of that, it has been utilized in traditional Chinese medicine to cure or prevent a variety of infectious disorders (Zima et al., 2010). He et al. (2016) reported that each of the paulownia's parts (seeds, roots, wood, fruits, flowers, bark, and leaves) had been shown to contain one or more bioactive molecules, such as matteucinol and ursolic acid in the case of the leaves, sesamin, and paulownia in the case of the wood, and catalpinoside and syringin in the case of the fruits (bark). Paulownia elongata leaf extracts, both dried and fresh, have a high flavonoid concentration, indicating that this plant may have novel therapeutic uses against a variety of oxidative illnesses (Alagawany et al., 2022). Paulownia leaves, fruits, and flowers (which are a byproduct of wood) are thus the most significant plant parts used in

traditional herbal therapy (Yang et al., 2019: Chen et al., 2021). Paulownia bark could be used to cure hemorrhoids and worm infections, while the flowers could be used to relieve swelling and encourage hair growth, according to a Chinese medical text authored by Li Shizhen in 1578. (Chen et al., 2021). Also, because of their varied biochemical characteristics, paulownia leaves could be used as an alternative feed component for a range of animals (Alagawany et al., 2022). Paulownia's primary bioactive components, which include phenolic compounds, glycosides, flavonoids, lignans, saponins, syringin, and triterpenoids, have been shown to have some positive health effects on both humans and animals (Adach et al., 2020: Chen et al., 2021). As antibacterial, anti-inflammatory, thirst-quenching, diuretic, antihypertensive, hemostatic, and insecticidal agent, paulownia and its extract also demonstrated several therapeutic benefits (Wang et al., 2019: Dzugan et al., 2021). Additionally, in different quantities in animal diets, it could be regarded as a growth promoter and immunostimulant agent (Al-Sagheer et al., 2019). Also, many recent studies have demonstrated the antibacterial and antioxidant properties of compounds produced from Paulownia leaves that are loaded with chitosan or calcium alginate, as well as their specialized application in meat preservation (Zhang et al., 2019: Zhang et al., 2022). In the same context, a wood by-product of the paulownia tree has been used as an alternative feed ingredient for different animals due to its good nutritional value present in leaves and other parts. In addition, their varied biochemical properties are recognized for medical applications. Paulownia leaves, as a potential feed ingredient for domestic animals is a relatively new approach and research field (Ganchev et al., 2019). Yet, very little research has been done on the beneficial effects of the bioactive compounds found in Paulownia leaves on animal health. According to our hypothesis, paulownia leaves can significantly reduce oxidative stress, increase immunity, and promote growth in broiler chicks. This is because of their powerful antioxidant activity. Determining the bioactive components in paulownia leaves and assessing the viability of sup Paulownia leaves minting broiler chicken diets with paulownia leaves as a natural growth enhancer are therefore crucial (Sakr et al., 2022 a).

Chemical composition

According to Stewart et al. (2018), Paulownia leaves were dried and analyzed for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), fat, gross energy, and ash content. The CP, NDF, ADF, ADL, fat, and ash content ranged from 14% - 23%, 29% - 55%, 18% - 42%, 10% - 22%, 2% - 4%, and 6% - 9%, respectively. And when making a comparison between the paulownia plant and other plants, it was found that the Paulownia excels in many important nutrients in feeding chickens Stewart et al. (2018), so it can be a successful feed alternative (table 1).

Table (1): a comparison of significant nutritional markers in well-known feed sources using *P. elongata* leaf analysis (Stewart et al., 2018).

Ingredients	Alfalfa (Dairy quality)	Grass (Hay)	Mulberry	Paulownia
CP%	18	8.44	18.9	17.20
TDN%	60	53	75.30	61.36
Crude fiber % (NDF)	43.45	31.4	31.1	44.68
ADL (Lignin) %	8.8	2.9	5.5	15.16
P%	0.22	0.19	0.21	0.20
Ca %	1.41	0.54	2.98	1.55
Mg %	0.33	0.12	5.28	2.80
K%	2.25	1.33	15.93	1.29
Zn (mg- Kg^{-1})	0.92	21	26.8	15.25

Paulownia leaves are abundant in minerals including calcium (2.1%), phosphorus (0.6%), zinc (0.9%), and iron (0.6%), according to El-Showk & El-Showk (2003). Paulownia leaves contain 15.1% cellulose and 8.8% crude protein, according to Koleva et al. (2011a). Paulownia leaves may be utilized as a feed additive for some monogastric animals, according to Koleva et al., (2011b). Meanwhile**,** Al-Sagheer et al., (2019) studied the amino acid compositions of paulownia and reported that the contents of tyrosine, methionine, and histidine were 3.6%, 3.0%, and 4.8% of CP in paulownia. While many studies have been conducted to study the chemical composition of the paulownia plant, it has been shown that there are some effective compounds shown in Table: 2.

Table (2): shows some of the active compounds in the different parts of the paulownia plant

	Chemical compounds	Plant part	References
P. tomentosa	6-Isopentenyl-3′-O-methyltaxifolin	Fruit	Šmejkal et al. 2007)
	Mimulone (syn. 6-geranylnaringenin, bonannione A) (2S)	**Fruit and flower**	(Navrátilová et al. 2013)
	Matteucinol (syn. 4′-O-methylfarrerol) (2S)	**Leaves**	Zhu et al. 1986
	Apigenin		(Zhao et al. 2012)
	Kaempferol		(Si et al. 2008)
	Luteolin		
	(−)-Epicatechin		
	Taxifolin		
	Homoeriodictyol (syn. hesperetin)		
	(+)-Catechin		
	Quercetin		
	7,3′-Dimethylquercetin (syn. rhamnazin)		(Wollenweber et al. 2008)

Dzugan et al., (2021) used eighteen breeding clones of Paulownia spp. and were tested in terms of their antioxidant activity and total polyphenolic contents, and the 50% ethanolic extracts (2 g/30 mL) of leaves and petioles were compared in the screening step. Eight Paulownia clones were selected for detailed analyses including HPTLC polyphenolic profile, verbascoside content, and antibacterial activity against five bacteria species (*S. aureus, B. cereus, E. coli, Y. enterocolitica, S. enterica*). The species-specific differences in terms of antioxidant activity correlated with phenolic compounds were found mainly in the case of leaf blade extracts, the highest for *P. tomentosa* × *P. fortunei* and the lowest for *P. elongata* × *P. fortunei* clones. The P. tomentosa clones varied greatly in this regard. In the HPTLC polyphenolic profile, the occurrence of some polyphenols was proved and the specific verbascoside content was quantified (70 to 225 mg/g DW), the P. tomentosa × *P. fortunei* hybrids had the highest inhibitory activity, mainly against Gram-positive bacteria, whereas only slight inhibition of *S. aureus* growth was observed for *P. elongata* × *P. fortunei* clones. The obtained results indicate diverse suitability of Paulownia clones as a source of active ingredients.

Effect of paulownia on chicken performance

Yang et al., (2019) found that the extracts of *P. tomentosa* leaves exhibit multi pharmacological activities, *P. tomentosa* flower polysaccharides (PTFP) were extracted by water decoction and ethanol precipitation, and the immunologic modulations of PTFP against Newcastle disease (ND) vaccine was investigated in chickens. The results showed that in a certain range of concentrations, PTFP treatment

can dose-dependently enhance lymphocyte proliferation. Then, 280 14-day-old chickens were randomly divided into 7 groups and vaccinated with ND vaccine except for the blank control (BC) group. At the first vaccination, chickens were orally administrated with PTFP at a concentration ranging from 0 to 50 mg/kg once a day for three successive days, and the BC group was treated with physiological saline. The lymphocyte proliferation rate, serum antibody titer, and levels of interferon-gamma (IFN-γ) were respectively measured on days 7, 14, 21, and 28 after the first vaccination. The results showed that PTFP at suitable doses could significantly promote lymphocyte proliferation, enhance serum antibody titer and improve serum IFN-γ concentrations. Taken together, these data indicated that PTFP could improve the immune efficacy of ND vaccine in chickens, and could be the candidate of a new-type immune adjuvant. By boosting the levels of IL-2 and IFN-, as well as the duodenal sIgA content, Wang et al. (2019) demonstrated that the polysaccharide from *Paulownia fortunei* flowers can increase cellular and humoral immunity in hens given the ND vaccination.

Sakr et al., (2022a) used, two hundred 1-day-old male Cobb500 chicks to be allocated randomly into four equal treatments with 5 replicates. The first treatment served as a control and was fed the basal diet only, while the other treated treatments were fed on the basal diet sup paulownia leaves mounted with 0.1, 0.3, and 0.5 g/kg diet of *Paulownia*, respectively. The performance results showed significant increments in live body weight, weight gain, and European production efficiency factors with increasing levels in broiler diets. At the same time, feed conversion ratio and livability percentages were numerically enhanced under the effects of *Paulownia* sup-Paulownia leaves mentation. Moreover, a notable increase in oxidative remarks activity (GSH, glutathione; SOD, super oxide-dismutase and CAT, catalase) and elevated levels of immunoglobulin (IgM, immunoglobulin M, and IgG, immunoglobulin G) were noted for treatments fed with paulownia leaves in a dose-dependent manner. Also, a dramatic linear increase was observed in mRNA expression of IGF-1, GHR, IL-1β, and IL-10 genes of broiler chickens, this study concluded that enriched broiler feeds with 0.5 g/kg *Paulownia* might be a beneficial strategy to promote broiler health and production. In addition Sakr et al., (2022 b) studied the effects of feeding corn-soybean-based diets supplemented with different levels of paulownia leaves (0, 0.1, 0.3, and 0.5 g /kg) to one-day-old male chicks (Cobb) on their growth performance. The results showed that the inclusion of up to 0.5 g /kg Paulownia leaves in the diet of broiler chickens significantly improved the live body weight, carcas weight, and weight of (liver, heart, and gizzard) compared to the control group. Broiler diets enriched with 0.5 g/ kg of Paulownia leaves significantly reduced collagen and lipid content as well as increased total protein levels in both breast and thigh muscle compared to the un-supplemented group, Subjective evaluation of the breast meat showed a significant linear improvement in flavour and juiciness of meat samples from birds fed with dietary Paulownia leaves in a dose-dependent manner, Supplementation with different levels of paulownia leaves significantly improved the sensory attributes (flavour, tenderness, juiciness, and overall acceptability) of thigh meat in a dose-dependent manner, Total potential return and net profit were significantly increased in all groups fed Paulownia leaves compared to the control group. Birds that received Paulownia leaves-supplemented diets at a level of 0.5 g /kg had the highest economic efficiency. In conclusion, supplementation with 0.5 g Paulownia leaves /kg in broiler diets could improve meat quality and economic efficiency.

Conclusion

In this review, it was shown that the Paulownia plant could become a success as a feed additive in poultry feed. It is possible to use a feed additive of Paulownia leaves powder in poultry feed to improve growth performance and immunity**.**

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استخدام نبات البولونيا كإضافة علفية في تغذية الدواجن: مراجعة

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الملخص:

أدت التغيرات السريعة في مسار دول العالم إلى زيادة أسعار المواد العلفية بشكل كبير، اذ أصبح من الضروري البحث عن بدائل علفية توفر متطلبات الدواجن من الطاقة والبروتين والفيتامينات والعناصر المعدنية، نبات البولونيا أو شجرة الأميرة (الاسم العلمي: *P. tomentosa*) تستخدم لإنتاج الأخشاب الصلبة ، تتميز بأزهار عطرة، تعتبر شجرة بولونيا شجرة سريعة النمو ، ويمكن أن تعيش شجرة بولونيا من 85 إلى 100 عام ، وتصبح شجرة بولونيا مظللة بكثرة في غضون 16 إلى 18 شهرًا ، ويصل ارتفاعها إلى 9 أمتار في ثلاث سنوات. تزهر الأشجار الكبيرة الزهور مثل اللافندر والياسمين ، والزهور تضيف إلى السلطة اليومية لبعض الناس. تستخدم بعض البلدان الأوراق لإطعام الحيوانات، وموطنها الأصلي في الصين، لاحتوائها على مستويات جيدة من الطاقة والبروتين والبوتاسيوم والمنغنيز والكالسيوم والفوسفور والزنك. يمكن أن تكون بولونيا مفيدة جدًا في غذاء الدجاج ، حيث تحتاج هذه السلالات إلى كميات قليلة من البروتين. لذلك ، تهدف المراجعة الحالية إلى إلقاء الضوء على بعض الدراسات التي تناولت أهمية بولونيا كمادة مضافة علفية للدواجن.