

Recent advances in the practical usages of some trees/shrubs as ingredient of poultry diets

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Abstract The gradual ban of chemical additives in livestock and poultry feeds has stimulated research interest into alternative natural products in poultry feeding. The effect of various components from several these trees/shrubs on the growth, performance, carcass characteristics, immunity, microbial flora of the gastrointestinal tract, blood plasma constitutes, and other parameters affecting on the economic efficiency of poultry farming have been well studied. Cinnamon, cardamom, willow, dog-rose, sumac and milkvetch are trees/shrubs which have been included in the diet on account of their numerous chemical and medicinal properties. This article reviews the products from selected trees/shrubs, their uses and application in poultry feeding. The distribution, adaptation, uses and potential benefits of their supplementation on poultry are discussed. More research into the concentration of these materials, duration of feeding that will

optimize birds' performance and their possible toxicological effects is recommended.

Keywords Chemical feed additives · Plant extracts · Poultry performance · Product quality

Introduction

Chemical feed additives including antimicrobials and synthetic antioxidants have been added to poultry feed to improve the health and productivity of the birds. The use of these substances in the feed is however, gradually being banned due to their health hazards to both the animal and human consumer of animal products (Herawati 2010). This has increased research interest into natural substances with antimicrobial and antioxidant properties (Jelveh et al. 2018). For a product to be effective in this category, it must stimulate one or more mechanisms by which chemical feed additives function. A long list of products (mainly powders, essential oils and fruits) from trees/shrubs have been found to have potential as alternatives to synthetic additives used in the feed due to their content in several natural useful chemical constituents. This paper reviews the functional properties, uses, modes of action and prospects of selected products from trees/shrubs as additives in poultry feeds.

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Nutritional and medicinal properties of selected trees/shrubs

Cinnamon (*Cinnamomum verum*)

The *Cinnamomum* family is a group of small tropical tree belonging to the Lauraceae family. The tree is native to Sri Lanka but found in many humid tropical countries (Bakkali et al. 2008). Many spices of cinnamon are known to have several nutritional and health benefits. According to FAOSTAT (2008) the ground bark of cinnamon is among the three most consumed spices in the world. Cinnamon essential oil is an FDA approved food additive which is safe at approved oral doses (Kirkham et al. 2009). Antimicrobial (Mukhtar and Ghori 2012), anticancer and anti-inflammatory (Williams et al. 2015) and antioxidative ((Jayaprakasha et al. 2007) properties have been reported in cinnamon. The health and nutritional benefits of cinnamon have been attributed to several compounds present in the oil, powder and leaves including; cinnamaldehyde, benzaldehyde, limonene, linalool and eugenol (Baratta et al. 1998; Ranasinhe et al. 2002; Jayaprakasha et al. 2007). Cinnamon extract contains ethanol which is effective against both gram-positive and gram-negative bacteria (Mukhtar and Ghori 2012) and procyanidine which confers the extract its strong anticancer activity (Williams et al. 2015).

Research has shown that cinnamon can be used on type 2 diabetes, *H. pylori* and candida based infections without toxic effects. However, treating with ethanol extract from cinnamon bark reduced the weight of the liver and hemoglobin levels in animals (Buch et al. 1988).

The volatile oils of cinnamon have strong spermicidal (Browder and Williamson 1976) and depressive (Fundaro and Cassone 1980) properties. Like any spice or drug, cinnamon may be contaminated by microorganisms (Table 1).

Cardamom (*Elettaria cardamomum*)

Elettaria cardamomum is a grass-like perennial herb of the ginger family native to Southern India (Larsen 1996; Dy Phon 2000) which has several medicinal properties (Cyril 2012). The plant is now widely cultivated in the tropics and the seeds used as a common spice known as cardamom (Larsen 1996).

Cardamom is reported to be the world third most expensive spice (Williams 2014) and the second most important spice in India (Abraham 1965). It is an important ingredient in Indian curries, coffee and tea flavouring in Iran and Turkey (Larsen 1996; Dy Phon 2000; Cyril 2012). Cardamom contains phenolics and flavonoids such as catechins, gallic acid, and quercetin. It is also high in starch, protein, waxes, sterols, vitamin E, fiber and iron. Cardamom essence has more than 20 constituents the most important ones of which are arecineol and altopotinol acetate (Larsen 1996). Cardamom has antibacterial and anticancer properties and also used in the treatment of a wide range of other conditions (Larsen 1996; Kaushik et al. 2010; Cyril 2012).

There are no side effects of cardamom if it is used according to recommendations but its excess consumption is harmful to the intestine. Cardamom seeds cause spasmodic pain in people with kidney stones and it's used is not recommended in patients suffering from this condition (Table 1).

Willow (*Salix*)

Willow is a specie of deciduous trees mainly found in the cold and temperate regions of the Northern hemisphere (Mabberley 1997). Willow is an important agroforestry tree grown for biomass or biofuel/charcoal production (Aylott et al. 2008). The bark and leaves of willow have several medicinal uses including the treatment of aches and fevers (Chrubasik et al. 2000; Walsh 2002). Willow bark contains salicylic acid (Hedner and Everts 1998; Chrubasik et al. 2000) and its use is limited due to severe stomach reactions (Hedner and Everts 1998). The level of salicylic acid in the serum increases after eating willow bark. About 240 mg salicin is equivalent to 87 mg of acetyl salicylate, and is more a heat protector than an analgesic agent (Schmid et al. 2001). Since willow bark is expensive compared to non-steroidal anti-inflammatory drugs, its use is still limited. To prevent the risk of developing Rey's syndrome, its consumption is not recommended in children and patients with gastrointestinal ulcers, diabetes, and liver or kidney disease and those who are aspirin-sensitive (Chrubasik et al. 2003). These uses of the plant have led to the development of many initiatives including the Willow Biomass Project in the US, and the Energy Coppice Project in the UK (Table 1).

Table 1 Summary of the effect of selected trees/shrubs as feed supplements on poultry

Plant/shrub	Product	Class of poultry	Major findings	Sources
Cinnamon	Essential oil	Broilers	Reduced total fat content in broiler meat	Nabiela et al. (2013)
		Broilers	Marked antioxidant activity	Faix et al. (2009)
		Broilers	Enhances activity of liver enzymes and protects liver against pathological diseases	Tabatabaei et al. (2015)
	Powder	Broilers	No effect on growth	Mohamed Elamin et al. (2016)
			Reduced serum cholesterol, triglyceride, phospholipids, triglycerides and linoleic acid in egg yolk at the higher level	Gerzilov et al. (2015)
			Effective alternative to <i>Virginia micin</i> on feed efficiency and health parameters	Najafi and Taherpour (2014)
	Quails	Reduced TBA, glucose, LDL and weight of some internal organs Can be an alternative to antibiotics to maintain growth and improve meat quality.	Shirzadegan (2014) Mehdipour et al. (2013)	
Cardamom	Powder	Broilers	Cardamom and ginger powder in the diet improved the growth and profitability	Shinde et al. (2017)
Willow	Essential oil	Broilers	Improved feed intake, weight gain, feed conversion ratio, and decreased mortality rates	Al-Fataftah and Abdelqade, (2013)
Dog-rose	Fruit	Broilers	Reduced serum cholesterol, creatine, glucose, triglyceride, uric acid and chlorine levels and improved meat quality and blood parameters	Tekeli (2014)
Sumac	Essential oil	Broilers	Decreased intestinal viscosity and increased epithelial layer and the number of red blood cells	Ghasemi et al. (2014)
			Improved growth and nutrientutilization, increased appetite and digestion, and antibacterial effect.	Kamel (2001)
	Powder	Broilers	Increased breast, thigh and HDL, reduced abdominal fat and LDL	Hosseini (2011)
			Improved immune response against viral diseases, including avian influenza; good alternative to antibiotics. No effects on triglycerides, cholesterol, HDL, and LDL	Toghyani and Toghyani and Faghan (2017)
			Improved growth during the starter period under thermal stress conditions. No effects on growth and antioxidant status during the growth period	Alishah et al. (2012)
			Improved weight gain, feed conversion ratio due to increased intestinal morphology, antibody level and beneficial microbial populations	Kheiri et al. (2015)
			Reduced feed intake, no effects on weight gain, feed intake and feed conversion ratio	Cakmak et al. (2017)
			Decreased cholesterol and VLDL-c and blood glucose, but increased abdominal fat in broiler chickens.	Golzadeh et al. (2012)
			Improved nutritional composition of egg yolk	Gálik et al. (2014)
			Laying hens Decreased egg yolk cholesterol but no effects on yolk fatty acid, saturated, unsaturated and n6/n3 fatty acids	Gurbuz and Salih. (2017)
Milkvetch	Powder	Broilers	No significant effect on feed intake, weight gain and carcass weight	El-Shafei et al. (2013)
	Essential oil		Increased spleen and bursa index, weight gain and antibody titres, immunity promoters and enhancers of IBD vaccine in broiler chickens	Ma et al. (2013)

Dog-rose (*Rosa canina*)

Dog-rose is a climbing, wild woody perennial flowering plant of the family Rosaceae native to Europe, northwest Africa and western Asia. Roman naturalists believed that the root of the plant could cure the bite from mad dogs, where it got the name dog rose (Haas 1995). The plant was reported to be invasive in parts of New Zealand although not considered as a threat (Owen 1997). Dog rose is a very important agroforestry species used in the wild for soil stabilization in land reclamation and in landscaping (Vogl et al. 2013). The fruit of this plant is rich in vitamin C and the plant is grown either wild or cultivated for vitamin C production (Vogl et al. 2013). Tea from the fruit is used in the treatment of viral infections (Vogl et al. 2013). Dog-rose is used traditionally to prevent and treat various diseases such as diabetes mellitus, arthritis, rheumatism, sciatica, colds, influenza and gallstone (Falahi et al. 2015). Valuable constituents of dog-rose, carotenoids and polyphenols, are used as natural antioxidants in food and pharmaceutical industries (Saeedi and Omidbaigi 2009; Lattanzio et al. 2011). Dog-rose seed powder and some of its derived materials inhibit chemotaxis of human blood polymorphonuclear leukocytes in external conditions, resulting in a decrease in protein levels (Winther et al. 2005) (Table 1).

Sumac (*Rhus coriaria*)

Sumac, scientifically called *Rhus coriaria*, is of pistachio genus growing in the form of small shrubs and native to Europe but grown well in Mediterranean countries, North Africa, South Europe, Iran and Afghanistan (Ghorbani et al. 2015). Its leaves are fuzzy and serrated with the color tending to red in autumn. Dried and crushed sumac fruits are popular spices in the Middle East while immature fruits and seeds are eaten traditionally as food and they have lipid lowering activities (Mozaffarian, 2013). Different plant parts are used in making dyes and the seed oil in candle making. Its flowers, used in traditional medicine, are clustered at the end of the main stem (Ahmadian-Attari et al. 2008). All parts of the plant, including fruits, contain significant amounts of tannin which are responsible for its antimicrobial property (Guvenc and Koyuncu 1994; Nasar-Abbas and Halkman 2004). Because of the high tannic acid content,

sumac leaves and bark are used traditionally in tanning. Other compounds in sumac include anthocyanins (mainly delphinidin, myrtillin, and chrysin), fatty acids (oleic acid, linoleic acid and palmitic acid) and organic acids (calic, citric, fumaric and tartaric acids) (Mavlyanov et al. 1997). No adverse effects or drug interactions have been reported in sumac but like other plant materials excess use may cause poisoning (Table 1).

Milkvetch (*Astragalus*)

Milkvetch, from the family Fabaceae, is a shrubby, perennial plant originating from the Northern Hemisphere with more than 2000 species grown widely in moderate areas. According to Siwicka et al. (2011) more than 800 species of milkvetch are yet identified in Iran.

Dried roots of milkvetch are popular herbal medicines which are used to promote public health (Wang et al. 2014). It is used in the treatment of diabetes, nephritis, leukemia, gastric ulcer, high blood pressure and chronic bronchitis (El-Hawiet et al. 2010). The main constituents in milkvetch are saponins, glycosides, flavonoids and polysaccharides (Pistelli et al. 2003) (Table 1).

From the foregoing discussion it is evident that several agroforestry trees/shrubs have nutritional and nutraceutical properties and may have application in poultry feeding in place of chemical feed additives.

Utilisation of selected trees/shrubs in poultry feeding

Products (powder, extracts/essential oils) from many trees/shrubs have been included in poultry diets to take advantages of their several properties including microbicidal, antioxidant, and cholesterol-lowering. Responses of poultry to these additives have not been consistent. Factors such as product type and processing method, dietary concentrations, bird age and experimental procedure may all affect the response. The effects of selected products from trees/shrubs on different performance targets of poultry are discussed.

Cinnamon powder, essence and extract

Nabiela et al. (2013) reported significant reduction of total serum cholesterol in broiler chicks fed cinnamon or ginger compared to a control group without. Faix et al. (2009) investigated the effect of cinnamon essence on antioxidant status in broiler chicks and found that it is a suitable supplement in broiler diets. In another study, Tabatabaei et al. (2015) examined the effects of cinnamon extract on biochemical enzymes, TNF- α and NF- κ B genes expressed in the liver of broiler chicks inoculated with *Escherichia coli*. Administering cinnamon extract to chicks that had been given *Escherichia coli* herbicide was found to reduce the level of mediate inflammatory gene expression, and protect the activity of liver enzymes, thus protecting the liver against this pathological disease. Mohamed Elamin et al. (2016) investigated the performance and carcass characteristics of broiler chicks receiving different levels of cinnamon powder and found no effects on growth and carcass measurements of the birds. In another study, Symeon et al. (2014) found no beneficial effects of cinnamon oil on the growth, carcass characteristics and meat quality of broiler chicks.

Gerzilov et al. (2015) investigated the effects of a dietary supplement consisting of a mixture of garlic herbs (*Allium sativum*), cinnamon powder and strawberry, rosemary (*Rosmarinus officinalis*), thyme (*Thymus serpyllum*), basil (*Ocimum basilicum*) and pennyroyal (*Origanum vulgare*) on growth, egg production, and health of broiler chicks. The mixed herbal supplement significantly reduced serum cholesterol and triglyceride levels and decreased the phospholipids, triglyceride and linoleic acid contents in egg yolk.

Najafi and Taherpour (2014) examined the effects of ginger powder, cinnamon powder, synbiotic and antibiotic supplements on the performance of broiler chicks. Ginger and/or cinnamon powder proved to be an effective substitute for virginiamycin in respect to feed efficiency and health parameters. Another study investigating the effect of synbiotic and cinnamon powder (*Cinnamomum verum*) supplements on growth performance and quality of quail meat concluded that synbiotic and cinnamon supplements can be used as alternatives to antibiotics in quail diets to maintain growth and improve meat quality (Mehdipour et al. 2013).

Shirzadegan (2014) also observed increased body weight and reduced Thiobarbituric acid (TBA), glucose, LDL, and weight of some internal organs in broiler chicks supplemented with cinnamon powder in the diet.

Cardamom powder, essence and extract

Shinde et al. (2017) investigated the effect of cardamom and ginger powder on growth and economic performance in broiler chickens. The authors observed significant improvements in feed intake, body weight gain, feed conversion ratio and profit margins of broiler production. They concluded that cardamom powder and ginger are cheap dietary supplements in broiler diets.

Willow (*Salix*) powder, essence and extract

Al-Fataftah and Abdelqade (2013) studied the effect of *Salix babylonica*, *Populus nigra* and *Eucalyptus camaldulensis* in drinking water on the performance and thermal tolerance of broiler chicks subjected to thermal stress. The results showed that *Eucalyptus camaldulensis* extract had the least effect during heat stress, but using *Salix babylonica* and *Populus nigra* extracts improved feed intake, weight gain and feed conversion ratio, and decreased mortality rates in heat stressed birds, suggesting that these extracts can be used in place of synthetic acetylsalicylic acid.

Dog-rose powder, essence and extract

Tekeli (2014) investigated the effects of dog-rose (*Rosa canina*) fruits as natural sources of carotene and vitamin C on some blood biochemical properties, carcass characteristics and meat quality in broiler chickens. They concluded that the use of dog-rose fruit in the diet has beneficial effects on meat quality and blood parameters of the chickens.

Sumac (*Rhus coriaria*) powder, essence and extract

Ghasemi et al. (2014) investigated the effects of dietary sumac (*Rhus coriaria*) extract on the performance and characteristics of the intestine of broiler chickens and found that increasing the extract in the diet reduced the viscosity in the intestine and increased the epithelial layer and the number of red blood cells.

In another study, Hosseini (2011) found that inclusion of sumac powder significantly improved breast, thigh and HDL and reduced percentage of abdominal fat and LDL in broiler chickens. Kamel (2001) reported better intestinal development in broiler chickens fed sumac extract and attributed this to improved nutrients utilization, increased appetite and enzymes secretion and the plant's antibacterial effects. Toghyani and Faghan (2017) observed that dietary sumac powder improved immune responses against viral diseases, including avian flu but triglyceride, cholesterol, HDL, and LDL were not affected by the diet. The antioxidant properties of sumac fruit powder have also been reported by Alishah et al. (2012). These authors found that the fruit powder improves the performance of broiler chickens under thermal stress conditions during the starter period, but had no effect on the growth performance and antioxidant status during the growth period.

Kheiri et al. (2015) reported improvements in body weight gain, feed conversion ratio, increased intestinal morphology, antibody level and the population of some beneficial microbes in broiler chickens supplemented with sumac powder and dry curd.

Cakmak et al. (2017) conducted a study to evaluate the effect of sumac (*Rhuscoriaria*) powder dietary supplement on growth performance, serum biochemistry and intestine microbiology in broiler chickens under different stocking densities. The results showed that weight gain and feed intake were significantly lower in the chickens growing in high density. On the other hand, dietary supplements containing sumac powder had no significant effects on body weight gain, feed intake and feed conversion ratio.

While sumac powder (*Rhuscoriaria*) has a decreasing effect on cholesterol and VLDL-c and blood glucose, it increases abdominal fat in broiler chickens. The reducing effect of VLDL-c can be related to the reduction of the activities of HMG-CoA reductase and α -amylase. The higher fat content of the abdomen of birds fed sumac powder is probably related to the changes in energy storage versus fat deposits (Golzadeh et al. 2012).

Gurbuz and Salih (2017) investigated the effect of sumac powder (*Rhuscoriaria*) and ginger (*Zingiber officinale*) on fatty acid, cholesterol and egg yolk parameters in laying hens. They found that cholesterol levels in egg yolk decreased on sumac seeds powder and ginger root powder but those of total fatty acids,

saturated and unsaturated fatty acids and n6/n3 ratio were not affected. Gálik et al. (2014) also reported beneficial effects of sumac (*Rhuscoriaria*) supplementation of laying hens' diets on the nutritional composition of egg yolk.

Milkvetch (*Astragalus*) powder, essence and extract

El-Shafei et al. (2013) found no significant effects of milkvetch root powder on final weights, daily weight gain, daily feed intake and feed conversion ratio in broiler chickens. Ma et al. (2013) reported significant increase in body weight gain, antibody coefficient, spleen weight and indices of bursal infectious disease vaccinated broilers fed *Echinacea purpurea* and milkvetch extracts.

Conclusion

There has been increased use of products (powder, extracts/essential oils) from trees/shrubs as alternatives to chemical feed additives in poultry feed. Many such products have been included in the diet with beneficial effects on growth, feed efficiency and cholesterol reduction in meat and egg. As phytobiotics may have toxic properties more research is needed in the concentration, age of the birds and duration of the feeding period for optimum welfare.

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