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USAGE POSSIBILITIES OF MULBERRY LEAVES IN POULTRY NUTRITION

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Abstract

Mulberry is a popular medicinal plant belongs to family Moraceae and genus Morus. Genus Morus (Mulberry) is an example that contains more than 150 species, Morusalba L. (White mulberry) is dominant specie among them. The leaves of mulberry are mainly used as food for the silkworms and they are some times eaten as vegetable or used as cattle fodder in different parts of the world. Mulberry leaves contain moisturizer from 71.13 to 76.68%, protein from 4.72 to 9.96%, fat from 0.64 to 1.51% and carbohydrates from 8.01 to 13.42%. While in dried mulberry leaves the moisture content decreases and it ranged from 5.11 to 7.24%, from 15.31 to 30.91% for protein, from 2.09 to 4.93% for fat and from 9.70 to 29.64% for carbohydrates. Also, they are very good source of ascorbic acid, β-carotene, antioxidant components, which includes rutin. Mulberry leaves are nontoxic natural therapeutic agents known to possess antidiabetic, antimicrobial, antimutagenic, antioxidant, anticancer, anxiolytic, anthelmintic, antistress, immunomodulatory, hypocholesterolemic, nephroprotective, hepatoprotectiveactivities. The purpose of this review is to explicate the usage possibilities of mulberry leaves in poultry nutrition by revealing the important Pharmacological activities.

Key words: *mulberry leaves, pharmacological activities, usage possibilities, poultry, nutrition.*

INTRODUCTION

Poultry industry is very important sector that provides the cheapest animal protein source for human consumption within the shortest production period. Poultry industry is highly dependent on the feed price because of feed costs have a major proportion ranging between 60-70% of poultry production costs. In view of these circumstances, alternative feed sources seeking instead of especially expensive protein sources like soybean meal and fish meal have accelerated in recent years. Mulberry leaves have a great potential as an alternative protein source for poultry industry due to rich protein, minerals, metabolizable energy contents and negligible anti-nutritional factors like tannic acid (Saddul et al., 2004; Srivastava et al., 2006; Al-Kirshi et al., 2010; Simol et al., 2012; Kamruzzaman et al., 2012; Olmo et al., 2012). Besides the nutritive value, mulberry leaves are nontoxic natural therapeutic agents known to possess antidiabetic, antimicrobial, antimutagenic, antioxidant, anticancer, anxiolytic, anthelmintic, antistress, immunomodulatory, hypocholesterolemic, nephroprotective, hepatoprotective activities (Yang et al., 2012; Devi et al., 2013). The purpose of this review is to explicate the usage possibilities of mulberry leaves in poultry nutrition by revealing the important pharmacological activities.

CLASSIFICATION OF MULBERRY

Mulberry belongs to the genus *Morus* contains 16 species family of Moraceae and 11 species are found in China. Genus Morus is one of such example that consists of over 150 species, among these *Morus alba* L. is dominant (Srivastava et al., 2006, Imran et al., 2010). Classification of mulberry has beenshown in Table 1.

Table 1 Classification of mulberry

Kingdom	Plantae – Plants
Subkingdom	Tracheobionta – Vascular plants
Superdivision	Spermatophyta – Seed plants
Division	Magnoliophyta – Flowering plants
Class	Magnoliopsida – Dicotyledons
Subclass	Hamamelididae
Order	Urticales
Family	Moraceae – Mulberry family
Genus	Morus L. – mulberry
Species	Morus alba L. – white mulberry

*USDA, NRCS. 2015. The PLANTS Database. (http://plants.usda.gov, 19January 2015)

NUTRITIONAL VALUE OF MULBERRY LEAVES

Mulberry leaves contain significant levels of protein with good amino acid profile, carbohydrates, fats, minerals, fibers, metabolizable energy and vitamins such as β-carotene and ascorbic acid (Saddul et al., 2004; Srivastava et al., 2006; Butt et al., 2008; Al-Kirshi et al., 2010). Srivastava et al. (2006) reported that fresh mulberry leaves contain 71.13-76.68% moisture, 4.72-9.96% crude protein, 4.26-5.32% total ash, 8.15-11.32% neutral detergent fiber (NDF), 0.64-1.51% crude fat, 8.01-13.42% carbohydrate, 69-86 kcal/100 g energy, 160-280 mg/100 g ascorbic acid, 10.000-14.688 µg/100 gβ-carotene, 4.70-10.36 mg/100 g iron, 0.22-1.12 mg/100g zincand 380-786 mg/100 g calcium. Also it was reported that dried mulberry leaves contain 5.11-7.24% moisture, 15.31-30.91% crude protein, 14.59-17.24% total ash, 27.60-36.66% NDF, 2.09-4.93% crude fat, 9.70-29.64% carbohydrate, 113-224 kcal/100 g energy, 100-200 mg/100 g ascorbic acid and 8438-13.125 µg/100 gβ-carotene, 19.00-35.72 mg/100 g iron, 0.72-3.65 mg/100 g zincand 786.66-2226.66 mg/100 g calcium. Composition of mulberryleaves is summarized in Table 2.

Table 2 Composition of MulberryLeaves (Dryweightbasis)

Mouisture, %	5.11-10.75
Crude protein, %	15.31 - 30.91
Crudefat, %	2.09 - 6.90
Crude fiber, %	9.9 - 13.85
Total ash, %	8.91 - 11.81
Carbohydrates, %	9.70 - 39.70
AcidDetergent Fiber (ADF), %	17.33 - 28.00
NeutralDetergent Fiber (NDF), %	19.38 - 35.77
AcidDetergent Lignin (ADL), %	3.4 - 8.10
Hemicellulose, %	2.5 - 12.80
Ascorbicacid, mg/100 g	100 - 200
β-carotene, mg/100 g	8.44 - 13.13
Iron, mg/100 g	19.00 - 35.72
Zinc, mg/100 g	0.72 - 3.65
Calcium, mg/100 g	786.66 - 2226.66
Phosphorus, mg/100 g	970
Magnesium, mg/100 g	720
AntinutritionalFactors	
Oxalates, mg/100 g	183
Phytates, mg/100 g	156
Tannicacid, %	0.13 - 0.36

*Yen et al., 1996; Saddul et al., 2004; Srivastava et al., 2006; Butt et al., 2008; Lin and Lai, 2009; Guven, 2012; Iqbal et al., 2012; Al-Kirshi et al., 2013.

PHYTOCHEMISTRY OF MULBERRY

Mulberry contains various phytochemicals such as alkaloids, anthocyanins, flavonoids, saponins, stilbenes, triterpens (lupeol), sterols (β-Sitosterol), coumarinsand phenolic acids (Zhishen et al., 1999;Omidiran et al., 2012; Thabti et al., 2012; Ahmad et al., 2013; Chen et al., 2013; Devi et al., 2013; Lakshmi et al., 2013; Ramesh et al., 2014). 1-deoxynojirimycin (DNJ), an alkaloid component found in leaves (Oku et al., 2006; Nuengchamnong et al., 2007; Nakagawa et al., 2010). The predominant anthocyanins in mulberry are cyanidin 3-rutinoside and cyanidin 3-glucoside (Du et al., 2008; Sarikaphuti et al., 2013). Resveratrol, Oxyresveratrol and Mulberroside A are stilbenes found in mulberry (Chung et al., 2003; Song et al., 2009; Zhou et al., 2013; Ramesh et al., 2014). Identified major phenolic acids in the mulberry leaves are chlorogenic acid, caffeic acid, vanillic acid, p-hydroxybenzoic acid, p-coumaric acid, sinapic acid, protocatechuic acid and ferulic acid (Memon et al., 2010; Radojković et al., 2012; Flaczyk et al., 2013). Flavonoids exist widely in the plants. Mulberry leaves contain rutin, izoquercitrin (quercetin 3-β-D-glucoside), quercetin-3-O-glucoside, quercetin-3-O-rhamnoside-7-O-glucoside, quercetin-3,7-D-O-β-D-glucopyranoside, quercetin-3-O-(6-malonyl)-β-D-glucopyranoside, quercetin-3-O-glucoside-7-O-rhamnoside, kaempferol-7-O-glucoside, kaempferol-3-O-glucopyranosyl-(1,6)-β-D-glucopyranoside (Astragalin), kaempferol-3-O-(6-malonyl) glucoside (Kim et al., 1999; Katsube et al., 2006; Katsube et al., 2009; Song et al., 2009; Flaczyk et al., 2013; Thabti et al., 2012). Also, Yang et al. (2011) isolated new arylbenzofuran, 3',5'-dihydroxy-6-methoxy-7-prenyl-2-arylbenzo-furan from *Morus alba var. multicaulis* Perro. (Moraceae) white and a total of 89 Diels-Alder-type adducts have been isolated from Chinese Morus plants (Yang et al., 2014).

PHARMACOLOGICAL PROPERTIES OF MULBERRY

Various pharmocological activities such as antimicrobial, antioxidant, antidiabetic, hypocholesterolemic, hepatoprotective activity and immunomodulatory activity of mulberry have been reported.

ANTIMICROBIAL ACTIVITY

Mulberry shows strong antimicrobial activity against pathogens due to contains substances like kuwanon C, mulberrofuran G, mourin and albanol B (Park et al., 2003; Sohn et al., 2004; Yang and Lee, 2012). Previous studies conducted in vitro and in vivo shown that various fractions of mulberry had antimicrobial effect against *Staphylococcus aureus, B. subtilis, B. cereus, Escherichia coli, Streptococcus faecalis, Mycobacterium smegmatis, Streptococcus mutans, Streptococcus sobrinus, Streptococcus sanguis, Porpyromonas gingivalis, A. tamari, P. vulgaricus, Pseudomonas aeruginosa, A. niger, F. oxysporum, P. oxalicum,* and some mold species (Ayoola et al., 2011; Manjula and Shubha, 2011; Omidiran et al., 2012; Anis et al., 2012; Kostić et al., 2013; Salem et al., 2013).

ANTIOXIDANT ACTIVITY

There are many methods used to evaluate the antioxidant activities of biological samples including DPPH (1,1-diphenyl-2-picrylhydrazyl Scavenging Activity), ABTS[2,2'-azinobis-(3-ethylbenzthiazoline-6-sulphonic acid) radical cation scavenging capacity], FRAP (Ferric Ion Reducing Antioxidant Power), SSA (Superoxide Radical Scavenging Activity) and HSA (Hydroxyl Radical Scavenging Activity) (Imran et al., 2010; Zou et al., 2012; Iqbal et al., 2012). Mulberry is a good source of polyphenolic compounds especially flavanoids and among the flavanoids quercetin 3-(6-malonylglucoside) is most important for antioxidant potential (Katsube et al., 2006; Butt et al., 2008). A strong correlation between free radical scavenging and the phenolic contents has been reported for mulberry (Yen et al., 1996; Zhishen et al., 1999; Enkhmaa et al., 2005; Bae and Suh, 2007; Arabshahi-Delouee and Urooj, 2007; Imran et al., 2010; Radojković et al., 2012; Zou et al., 2012; Chao et al., 2013; Flaczyk et al., 2013)

ANTIDIABETIC ACTIVITY

Diabetes in general is a syndrome characterized by high blood glucose level and altered insulin metabolism (Butt et al., 2008). 1-deoxynojirimycin (DNJ) and its derivatives isolated from mulberryhave significant α-glycosidase inhibitors activity and therefore suppress the response of both blood glucose and insulin secretion resulting in a decrease of blood glucose level (Oku et al., 2006; Nuengchamnong et al., 2007; Nakagawa et al., 2010; Sarikaphuti et al., 2013). Results of studies conducted in diabetic human and mice indicated that mulberry decreased the blood glucose level (Kimura et al., 2007; Park et al., 2009; El-Sayyad et al., 2011; Nakamura et al., 2011; Mohammad and Naik, 2012; Banu et al., 2014).

HYPOCHOLESTROLEMIC AND ANTIATHEROGENIC ACTIVITY

Hyperlipidemia is lipid metabolism disorder characterized as high level serum triglyceride and cholesterol (Liu et al., 2009). High triglyceride and cholesterol levelshave been identified as a risk factor for atherosclerosis and cronary heart disease (hypotriglycemic). Although low high density protein (HDL) and oxidative modification of low density lipoprotein (LDL) are associated with increased cronary artery disease (Toth, 2004; Enkhmaa et al., 2005; Liu et al., 2009). Many studies indicated that flavonoids and anthocyanins contents in mulberry help to prevent atherosclerosis and cronary heart disease via scavenging the radicals, inhibition LDL oxidation and decreasing blood triglyceride and cholesterol levels (Zhishen et al., 1999; Chen et al., 2005; Enkhmaa et al., 2005; Katsube et al., 2006; Du et al.,2008; Liu et al., 2009; Yang et al., 2010; Zeni and Molin, 2010; Valacchi et al., 2014).

HEPATOPROTECTIVE ACTIVITY

The liver is the major organ controlling all the biochemical pathways and hepatotoxins such as aflatoxin impair the liver function (Muhammad et al., 2012). Mulberrycontains flavonoids, coumarine and stilbene that possess hepatoprotective activity (Oh et al., 2002). It was reported that mulberry had hepatoprotective potential against hepatotoxicity induced by carbon tetrachloride (CCL_4) (Zeni and Molin, 2010; Hogade et al., 2010; Hussein et al., 2010)

IMMUNOMODULATORY ACTIVITY

Immune system is the main regulatory system controlling homeostasis of the body and has animportant role in the progression of entire life from birth to death (Awais and Akhtar, 2012). Different methods such as clearance test, cyclophosphamide induced neutropenia, neutrophil adhesion test, effect on serum immunoglobulins, mice lethality test and indirect haemagglutination testare used for evaluate to effects of mullberry on the immun system (Devi et al., 2013; Sharma et al., 2013). Kim et al. (2000) reported that polysaccharide isolated from mulberry had immunomodulatory activity. Also other studies indicated that aqueous and methanolic extracts of mulberry leaves increased serum immunoglobulin levels and decreased mortality rate (Venkatachalam et al., 2009; Bharani et al., 2010; Hou et al., 2011).

USE OF MULBERRY LEAVES IN POULTRY NUTRITION

Although mulberry leaves generallyuse to feed the silkworms,many researchers have studied it as an alternative food source for animals due to the high fiber content (Saurabh Bajpai et al., 2012; Simol et al., 2012; Sujathamma et al., 2013; Vijeyan et al., 2014). Several studies have shown that mulberry leaves can be used to nutrition of cattle (Saddul et al., 2005; Vu et al., 2011; Huyen et al., 2012; Tan et al., 2012; Zhou et al., 2012), sheep (Liu et al., 2001; Tudaro et al., 2007; Yulistiani et al., 2008; Kandylis et al., 2009), goats (Omar et al., 1999; Azim et al., 2002; Kouch et al., 2003), rabbits (Deshmukh et al., 1993; Prasad et al., 2003; Bamikole et al., 2005) and fish (Mondal et al., 2012; Sheikhlar et al., 2014). Mulberry leaves powder have also been used to feed poultry (Simol et al., 2012). Digestibility of mulberry leaves is very high by ruminants (Saddul et al., 2005; Todaro et al., 2007; Huyen et al., 2012). However, digestibility of mulberry leaves dry matter is poor (35-37%) by poultry due to the high neutral detergent fiber (NDF) content. Despite poor utilization of mulberry leaves dry matter, crude protein and ether extract are highly digested (73% and 88%, respectively) by poultry (Al-Kirshi et al., 2013). Therefore, various studies were conducted to assess the effects different levels of mulberry leaves powder on performance of broilers (Mulla et al., 2003; Chowdary et al., 2009; Olmo et al., 2012; Simol et al., 2012; Has et al., 2013; Panja, 2013; Islam et al., 2014), layers (Lokaewmanee et al., 2009; Al-Kirshi et al., 2010; Kamruzzaman et al., 2012; Olteanu et al., 2012; Panja, 2013) and quails (Hermana et al., 2014). Different results were observed in studies conducted with broilers. Mulla et al. (2003) reported that broiler performance was negatively affected by supplementation of mulberry leaf meal at 2% of diet. Olmo et al. (2012) and Has et al. (2013) observed similar results with addition of mulberry leaf meal at 10, 20 and 30 % of diet. Panja (2013) showed that there was no significant improvement of body weight gain, feed intake and feed conversion ratio (FCR) in broilers supplemented with mulberry leaves at 0, 0.5, 1.0, 1.5 and 2.0 % of diet. However, Islam et al. (2014) observed that supplementation of mulberry leaf meal between 2.5 and 3.5% significantly improved the broiler performance and decreased serum total cholesterol and triglyceride levels. Similarly, it was reported that the highest body weight was observed in 10% mulberry leaf meal addition (Chowdary et al. 2009). Additionally, Simol et al. (2012) reported that mulberry leaf addition up to 30% decreased starter and grower feed cost (24.82 and 26.09%, respectively) without any adversely effect.

The results of studies conducted with layers and quails indicated that mulberry leaves supplementation up to 10% did not affect the productive performance and egg quality. Also mulberry leaves decreased yolk cholesterol and increased pigmentation of egg yolk (Lokaewmanee et al., 2009; Al-Kirshi et al., 2010; Kamruzzaman et al., 2012; Olteanu et al., 2012; Panja, 2013; Hermana et al., 2014).

CONCLUSIONS

Reducing the feed prices which make up the majority of production costs plays key role for the poultry industry. In this context, mulberry leaves have a great potential. Mulberry leaves can be used instead of expensive protein

sources such as soybean meal and fish meal used in poultry diets in limited levels.

Using mulberry leaves as an alternative protein source instead of expensive protein sources like soybean meal and fish meal in poultry diets plays an important role for poultry industry due to it reduces feed costs. Studies conducted with poultry indicated that addition of mulberry leaves are possible by up to 10% in poultry diets without any adversely effect on performance of poultry.

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