Int.J.Curr.Microbiol.App.Sci (2017) *6*(7): 2207-2217

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 7 (2017) pp. 2207-2217**
Journal homepage: http://www.ijcmas.com

Review Article https://doi.org/10.20546/ijcmas.2017.607.259

Biochemical Composition and Pharmacological Properties of Mulberry (*Morus* spp.) - A Review

D.S. Mahesh[1*], B.S. Vidhathri[1], D.N. Vidyashree[1], T.K. Narayanaswamy[1], C.T. Subbarayappa[2] and R. Muthuraju[3]

[1]Department of Sericulture, [2]Department of Soil Science and Agricultural Chemistry, [3]Department of Agricultural Microbiology, University of Agricultural Sciences, GKVK, Bengaluru-560 065, India
**Corresponding author*

Keywords

Mulberry leaves, Biochemical, Antioxidant, Phytochemical, Mineral, Flavonoids, Hypoglycemic activity, Moranolin, Pharmaceutical industry.

Article Info

Accepted:
21 June 2017
Available Online:
10 July 2017

A B S T R A C T

Mulberry leaves contains (g kg^{-1} on dry matter basis) 163 g kg^{-1} ash, 201 g kg^{-1} crude protein, 120g kg^{-1} crude fibre and chemical analysis indicated highest crude protein and the lowest non digestive factor contents (22.3 and 31.1% dry matter, respectively) among the four forages tested. The caloric values were calculated as 241.05 Kcal./100g. Among minerals, mulberry leaves contains calcium 1493.22, iron 27.06 and zinc 2.18 mg/100g. Magnesium, phosphorus, sodium and potassium content were 533.24, 370.91, 58.62 and 1239.07 mg/100 gm, respectively. Concentrations of total phenolic compounds like tannins, alkaloids and saponins were within safe range. Analyses of mineral composition indicated that potassium was the main mineral of fruit followed by sodium and phosphorus. Carbohydrate content is highly significant in apical leaf ($f<0.05$) and less significant in middle and bottom leaf ($f>0.05$). Antioxidant activities ranged from 22.85–76.88 µmol/100g quercetin equivalents. Anti HIV and chemo-protective activities have also been reported. The wide range of important pharmacological activities including antidiabetic, antimicrobial, antioxidant, anticancer, hypocholesterolemic, nephroprotective and various other effects like adaptogenic effect, effect on hyperlipidemia, inhibition of melanin biosynthesis used in psychiatric disorder also in gut and airways disorders. The plant is a very good source of ascorbic acid of which over 90% is present in a reduced form, and also contains carotene, vitamin b1, folic acid, folinic acid, isoquercetin, quercetin, tannins, flavonoids and saponins. Due to its chemical composition and pharmacological functions it is being utilized as a medicinal plant. Many active compounds isolated from the mulberry plants which used as medicines. Biochemical compounds such as Moranolin, Moran (glycopeptides), hydrophobic flavonoids (flavones and flavonone), 2-Arylbenzofuran and Ethanolic extract, Flavonoids, Polyphenols, Carotenoids, Vitamins A, C, E, Ethyl acetate, γ -aminobutyric acid, Flavanics are isolated from different parts of mulberry plants which play a vital role in hypoglycemic activity, anti-obesity action, lipid-lowering action, antioxidants action, anti-inflammatory actions, antiallergic action, vasoactive action, neuroprotective action, anticancer action. Mulberry plants are identified for their profitable health consequences and therefore attracted the attention of the pharmaceutical industry. The main objective of present reviews to provide the active principles of mulberry plants.

Introduction

Biochemical composition

Adeduntan and Oyerinde (2009) studied the biochemical composition of S36, S54 and K2 mulberry leaves. The crude protein content in all the samples were significantly high ($P \leq 0.05$) with 21.66%, 21.55% and 21.24% in S36, S54 and K2 respectively. The results of the biochemical analysis showed that all the selected mulberry variety leaves contained adequate level of food nutrients required for normal silkworm body functioning. Kandylis *et al.,* (2009) recorded that mulberry leaves contained (g kg^{-1} on dry matter basis): 163g kg^{-1} ash, 201 g kg^{-1} crude protein, 120 g kg^{-1} crude fibre, 37 g kg^{-1} ether extracts, 479g kg^{-1} nitrogen-free extracts, 268 g kg^{-1} neutral detergent fibre, 148 g kg^{-1} acid detergent fibre, 41 g kg^{-1} acid detergent lignin, 121g kg^{-1} cellulose and 107g kg^{-1} hemicellulose, In addition, the soluble non-protein nitrogen contributed a substantial part of total N (26.1%), the total true protein was 14.4% and the protein fractions evaluated after classical protein fractionation, were: albumins 11.1, globulins 9.7, prolamins 44.1, glutelins 8.5 and insoluble (or structural) proteins 26.6% of total N. Deshmukh *et al.,* (1993) noticed crude protein 22.13%, ether extracts 3.90%, crude fibre 5.90%, ash 13.35%, nitrogen free extracts 54.72%, neutral detergent fibre 36.35%, acid detergent fibre 31.52%, calcium 3.30% and phosphorus 1.43% in dry matter mulberry leaves. Study of chemical analysis indicated that mulberry leaves had the highest crude protein and the lowest non digestive factor contents (22.3 and 31.1% dry matter, respectively) among the four forages tested. (Vu *et al.,* 2011).Nutritive value of mulberry leaf powder was studied by Lamiaa (2014) revealed that, dry matter (DM) was 6.81%, crude protein 27.14%, ash content 15.68%, fibers content 26.47%, crude fat 1.93% and 28.78% for carbohydrates. The caloric values were calculated as 241.05 Kcal. /100g. Crude protein as the most abundant component in both fruits (10.25 %) and leaves (25.72 %). Native black mulberry fruits had higher content of total sugar (6.25 %), crude fat (5.75 %) and crude protein than those of the other berries (Koyuncu *et al.,* 2014). K-2 and S146 apical leaves protein content was 0.196 and 0.122mg/gm respectively, in middle leaves more Protein content in K-2 (0.284mg/gm)and least protein content was recorded inTR-10 (0.109mg/gm) and in bottom leaves high protein content was recorded inS-146 (0.208mg/gm) and least protein content was recorded in TR-10(0.128mg/gm) and more carbohydrate content was showed in TR-10 apical leaf (0.476mg/gm) and least carbohydrate content in S-1 (0.292mg/gm) in apical leaf while in middle leaves more carbohydrate content in TR-10 (0.547mg/gm) and least value was recorded inS-1635 (0.257mg/gm) and in bottom leaves carbohydrate content was recorded in S-1635 (0.546mg/gm) and least value was recorded in S-146(0.246mg/gm) (Anshul and Vadamalai, 2011). Thirumalaisamy *et al.,* (2009) and Jyothi *et al.,* (2014) recorded highest total sugar (16.72%), total protein (26.72%), total soluble protein (111.40mg/g), total free amino acid (9.88µg/g) and total phenol (4.56%, 4.96%) content in V_1.

Nutritive value

The nutritive value of mulberry found to be superior in traditional forages. It is comparable to concentrate feeds (Benavides, 2001). Vu *et al.,* (2011) studied *in vivo* digestibility of mulberry leaves (*Morus alba*) and the effects of the partial replacement of cotton seed with fresh mulberry leaf in rations on the performance of growing Vietnamese cattle was investigated. For the *in vivo* digestibility trial, twenty castrated rams of Phanrang breed (a local prolific breed) with

an initial weight of 23-25 kg, were first assigned to four groups according to weight and then randomly assigned to one of four dietary treatments to determine digestibility of nutrients in mulberry leaves (*Morus alba*), natural Bermuda grass (*Cynodon dactylon*), elephant grass (*Pennisetumpurpureum*) and buffalo grass (*Panicum maximum*). The *in vivo* digestion trial showed the superior quality of mulberry leaves compared with the grasses. Lamiaa (2014) observed highest food conversion rate (FCR) in positive control group (0.84) then cholesterolemic rats (0.65) whereas the lowest FCR was for negative control group (0.41). For growth parameters, weight gain improved in cholesterolemic rats fed on mulberry leaves powder (16.62gm) as compared to positive control group (12.09gm).

Nutrient digestibility of the diets were high and there were no significant differences among the means for dry matter (75.67 - 82.33%), organic matter (organic matter: 77.33 - 86.67%), crude protein (76.33 - 84.00%), crude fat (79.67 - 88.67%) and ash (52.00 - 62.67%). Digestibility of ether extract (55.65 - 86.00%) and NFE (76.00 - 87.33%) significantly declined with increasing level of mulberry leaves in the rations. Weight gain of rabbits on diets containing 25 and 50% mulberry leaves (5.14 and 4.72 g/d, respectively) was not significantly different (P=0.05) from that of the all concentrate ration (5.72 g/d), but these were significantly higher than those of 25:75 and 0:100 concentrate: mulberry diets (3.43 and 2.27 g/d, respectively).

Thus, mulberry leaves can support good feed intake, digestibility and satisfactory weight gain in rabbits and could reduce and cost of expensive concentrate diets. However, some level of concentrate feeding is necessary to reach potential weight gains (Bamikole *et al.*, 2005).

Phytochemical composition

The main phenolic compounds were identified as gallic, pro- tocatechuic, p-hydroxybenzoic, vanillic, chlorogenic, caffeic, *p*-coumaric, ferulic and sinapic acids. Chlorogenic acid was the main phenolic constituent of both extracts. The flavonols fraction contained rutin, quercetin 3-β-D-*glucoside and* kaempferol 3-β-D-glucopyranoside. Total concentration of phenolic compounds were 7.9 g and 14.4 g gallic acid equivalent/100 g extract, and antioxidant activity was 137.1 and 214.1 µMolTrolox equivalent/g dry weight for the PP and L extracts, respectively (Ewa*et al.*, 2013).Lamiaa (2014) reported that, the concentrations of total phenolic compounds, tannins, alkaloids and saponin were within safe range. *Morus Alba* extract and its other compounds usually flavonoids have antioxidant properties by scavenging free radicals and protect many organs from oxidative stress (Muhammad *et al.*, 2013). The contents of total phenolics (TPC), total flavonoids (TFC) and ascorbic acid (AA) ranged between 16.21–24.37 mg gallic acid equivalent (GAE)/g, 26.41–31.28 mg rutin equivalent (RE)/g and 0.97–1.49 mg/g, respectively. The antioxidant activity values ranged between 1.89–2.12, 6.12–9.89 and 0.56–0.97 mMTrolox equivalent/g of dried leaves, respectively (Shahid *et al.*, 2012).In general, fresh mulberry showed higher contents of total phenolics (0.49–57 fold higher), flavonoids (0.02–162 fold higher), anthocyanins (6-12 fold higher) and antioxidant capacity (0.72–691 fold higher) compared to other products. Total flavonoids and phenolics showed a linear relationship with antioxidant capacity (CUPRAC: $R2$ = 0.9070 and $R2$ = 0.8959, respectively), indicating that flavonoids and phenolics were the major contributors to the antioxidant capacity (Senem *et al.*, 2013).Marija *et al.*, (2012) reported black mulberry leaf extracts

with the highest antioxidant activity and highest phenolic acids contents. All investigated mulberry dry extracts showed high content of phenolic compounds and significant antioxidant activity. Ayaz *et al.*, (2010) identified major phenolic acids like gallic, protocatechuic, p-hydroxybenzoic, vanillic, chlorogenic, syringic, *p*-coumaric, ferulic and *m*-coumaric acids. Chlorogenic acid was the prominent phenolic acid in all leaves samples collected from three mulberry species Total phenolic compounds were in the range of 3.89 to 11.79 mmol/ 100 g gallic acid equivalent, whereas antioxidant activities by DPPH assay ranged from 22.85–76.88 µmol/100 g quercetin equivalent.

Antioxidant activity

Ewa *et al.*, (2013) recorded antioxidant activity of 137.1 and 214.1 µMolTrolox equivalent/g dry weight for the PP (pilot plant) and L (Laboratory) extracts, respectively. Senem *et al.*, (2013) analyzed antioxidant capacity (0.72–691 fold higher) of mulberry leaf powder. Total flavonoids and phenolics showed a linear relationship with antioxidant capacity (CUPRAC: $R2 = 0.9070$ and $R2 = 0.8959$, respectively), indicating that flavonoids and phenolics were the major contributors to the antioxidant capacity. Shahid *et al.*, (2012) observed radical cation scavenging capacity and ferric ion reducing power and values ranged between 1.89–2.12, 6.12–9.89 and 0.56–0.97 mMTrolox equivalent/g of dried leaves, respectively. The antioxidant activity of leaf extracts was evaluated by measuring 1,1-diphenyl-2-picrylhydrazyl (DPPH•) radical scavenging activity, 2,2'-azino-bis-(3-ethylbenzthiazoline-6-sulphonic acid (ABTS•+) radical cation scavenging capacity and ferric ion reducing power and values ranged between 1.89–2.12, 6.12–9.89 and 0.56–0.97 mMTrolox equivalent/g of dried leaves, respectively. The investigated features reveal good antioxidant attributes significantly. In an another study radical scavenging activity of different parts of mulberry (*Morus alba* L.) were determined methanol extracts and their fractions dose dependently increased radical scavenging activity of mulberry branches, roots and leaves (more than 70%). Study showed that mulberry fruits exhibited the highest radical scavenging activity (Chon *et al.*, 2009).

Mineral composition

Lamiaa (2014) observed that among minerals, calcium content was 1493.22, iron content was 27.06 and zinc content was 2.18 mg/100g. Magnesium, phosphorus, sodium and potassium content were 533.24, 370.91, 58.62 and 1239.07 mg/100 gm, respectively. Koyuncu *et al.*, (2014) determined some chemical properties of completely ripe fruits and fully developed leaves of black mulberry (*Morus nigra* L.) genotypes. Black mulberry leaves were rich in sodium, calcium and potassium. Black mulberry should be more widely used because of its potential nutrient contribution for human and also for feeding animals. Adeduntan and Oyerinde (2009) showed that, the samples contain zinc in the range of 34.4 - 57.5 mg/kg, sodium 1069 – 1526 mg/kg, manganese 14.83 – 24.37 mg/kg, calcium 944 – 1467 mg/kg, potassium 1684 – 2170 mg/kg, iron 129.70 – 238.00 mg/kg and magnesium 1450 – 2196 mg/kg.

Active pharmacokinetic principles of mulberry

Hypoglycemic activity

Hypoglycemia is a condition that occurs when blood sugar level is too low in body. Diabetes mellitusis caused by the ineffectiveness of the insulin produced by pancreas. Due to inadequacy of insulin secreted by pancreas the concentration level of glucose increase in

blood which harm many body systems in specifically the history and active pharmacokinetic principles of mulberry: a review14blood vessels and nerves. So far medicinal plants have been recommended for treatment of diabetes. From the centuries ago most of the countries of world practiced the traditional medicinal systems which are based on herbal plants. Mulberry was used in old Chinese herbal medicine for reducing blood serum glucose (Andallu *et al.,* 2001). Both leaves and roots extracts of mulberry plants are having hypoglycemic properties and it is used inthe treatment of diabetes (Andallu and Varadacharyul, 2002; Kelkar *et al.,* 1996). Mulberry plants contains moranolin, moran (glycopeptides), hydrophobic flavonoids (flavones and flavonone) and 2-arylbenzofuran which play main role in hypoglycemic action (Singab, 2005) and Katsube (2006) conducted a study on mulberry leaf extract and found that mulberry leaf extract acts as a natural inhibitor of α-glucosidase due to deoxynojirimycin (DNJ) and its derivatives. According to Nakamura (2009) acarbose (Glucobay), miglitol (Diastabol), boglibose are other inhibitors which are used in therapeutics. Lemus *et al.*, (1999) conducted short term experiments and reported hypoglycemic activity of dried levels of a *Bauhiniaulrifolius*, *Galegaofficinalis*, *Morusalba* and *Rubusulnifolius*. Sachdewa and Khemani (2003) reported hypoglycemic activity of an ethanol extract of the flower of *Hibiscus rosasinensis* on diabetes-induced rats.

Anti-obesity action

Obesity is defined as abnormal or extravagant fat accumulation that extant a risk to health. An obese person has accumulated so much body fat that it might have a negative effect on their health. Obesity is related with the diabetes, hypercholesterolemia, hyperlipidemia, hepatic steatosis, and atherosclerosis and decrease the amount of sugars absorbed has consequences for body weight. Oh *et al.,* (2010) conducted a short term study on mice and exhibited an antagonistic action of mulberry extract on melanin concentrating hormone receptor, which help in decrease in body weight. They also suggested that ethanolic extract obtained from mulberry leaves showed anti-obesity action on diet-induced mice.

Hyperlipidemia Action

Hyperlipidemia is a characterized by excess cholesterol and fatty substances in the blood. Hyperlipidemia is a risk factor for heart disease. Diabetes mellitus is related with different kinds of lipidpeculiarity. According to Andallu (2009) Lipemia, cholesterol, especially LDL (low-density lipoprotein) and VLDL (Very-low-density lipoprotein) cholesterol are engaged in the growth of atherosclerosis and related abnormalities. Andallu *et al.*, (2009) conducted a study on rats and found that mulberry leaf ingredient governed glucose and improved the lipid abnormalities related with highly capable diabetes in STZ-diabetic rats with antilipids and antioxidant action. Mulberry leaf extracts contains large quantity of flavonoids which work as the scavenger of blood lipid radicals. Li *et al.,* (2005) conducted study on rats and found that mulberry leaf extract which is rich in flavonoids, work as the scavenger of blood lipid radicals in sugar metabolism and antioxidation in rats. According to Liu *et al.*, (2009) Mulberry extract showed the hypolipidemic effects which elevate LDLR (Low density lipoprotein receptor) gene expression and the clearance proficiency of LDL (Low-density lipoprotein) and a decline in the lipid biosynthesis. Andallu *et al.*, (2001) conducted a study on mulberry plants and found that mulberry is capable of against lipid peroxidation when compared with glibenclamide treatment. They observed a

consequential reduction in plasma, erythrocyte membrane, and urinary peroxides of diabetic patients with mulberry therapy. According to Andallu and Varadacharyulu (2002) mulberry leaves are delicious and capable in governing hyperglycemia and glycosuria in STZ-diabetic rats. They found that mulberry leaves have ability to quick protective outcome against lipid peroxidation by scavenging O_2 and enhance the function of antioxidant enzymes by integrity of antioxidant flavonoids (quercetins) and moracins present in the leaves and also suggested that the increased oxidative stress in diabetic rats was reduced by the mulberry leaves. According to Singab (2005) extracts from the root bark of mulberry tree contains some components which showed hypoglycemic function had defensive consequences on pancreatic β cells, obstruct their degeneration and decreased lipid peroxidation.

Role of antioxidants action

Antioxidants inhibit the oxidation process in the plant and animal organisms and play a vital role in phyto physiological process. Antioxidants are widely used in the food and drink that are regularly served or consumed and have been systematically examined for the prevention of diseases such as cancer, heart disease and general sickness. According to Andallu *et al.,* (2009) mulberry plants contains many active compounds which acts as an antioxidant like polyphenols, carotenoids and vitamin A, C, E, they found that these compounds increase the body's antioxidant status and regulate Low-density lipoprotein(LDL) oxidation through different mechanisms. Hong *et al.,* (2004) found that mulberry fruits increase the strength of the antioxidative protecting system and diminish the damaging oxidative substances in the red blood cells (RBCs) of diabetes induced rats. Katsube *et al.,* (2006) conducted a study on Low-density lipoprotein (LDL) antioxidant activity and extracted some compounds from mulberry (*Morus alba* L.) leaves. They found that quercetin 3-(6-malonylglucoside) and rutin are the chief flavonol glycosides in the mulberry leaves. Kim *et al.,* (1999) isolated nine flavonoids from mulberry leaves and examine for free radical scavenging function and confirmed to be antioxidative.

Antidiabetic

Morus Alba were studied for the starch breakdown by α-amylase in vitro *Morus Alba* [IC50=17.60 (17.39-17.80) mg/ml] revealed appreciable α-amylase inhibitory activities in a concentration-dependent manner (Bahman and Golboo, 2009). In an another study, the 50% methanolic extract of *Morus alba* was tested for its in-vitro acetylcholine esterase inhibitory activity using modified Ellmann's method. The crude methanolic extract showed acetylcholine esterase inhibitory activity in a concentration dependent manner and around 10 µg of the extract was required for 50% inhibition of the activity (Sulochana, 2012). In a histopathologic study the effects of *Morus Alba* leaf extract on the pancreas of diabetic rats were studied. The animals were treated with mulberry leaf extract at different doses for 35 days. The various parameters studied includes blood glucose, the relative body weight of the pancreas, the diameter of islets and the number of β cells in all groups. According to the histological and biochemical results it was concluded that the extract of this plant may reduce blood glucose levels by regeneration of β cells. (Jamshid and Prakash, 2012).

Anti-inflammatory and antiallergic actions

Anti-inflammatory term generally used for the property of substances that reduces swelling. The use of anti-inflammatory herbs for health improvement has a long and successful

history in traditional medicine. Plants synthesize complex, organic molecules for their structure and function, and are therefore a rich source of chemicals which often have health enhancing properties. According to Chatterjee (1983) mulberry leaves were reported to having antipyretic and anti-inflammatory effects. According to Chai (2005) flavonoids and related compounds were isolated from *Morus Alba* which exhibited the anti-inflammatory effects. They found that extract obtained from the bark of *Morus Alba* root in hot water has strong antihistaminic and antiallergic activity.

Vasoactive and neuroprotective action

Vasoactive effects result in either increasing or decreasing blood pressure. According to Xia *et al.,* (2008) ethyl acetate extract from leaves of *Morus Alba* showed vasoactive effect on studies in isolated ratthoracic ring. Mulberry juice showed anti-stress activity against mice, which inhibited the elevation of plasmalipid peroxide levels induced by stress (Sakagami *et al.,* 2006). Morin, a flavonoids found in mulberry which reduced the tissue level of cyclosporine and act as immunosuppressive agent with narrow therapeutic range and minimize the nitric oxide production by the activated macrophages (Fang *et al.*,2005). According to Kang *et al., (*2006) mulberry fruit contains the cyanidin-3-O-β-D-glucopyranoside which prevents the neuronal cell damage. They also suggest that mulberry fruit extracts having neuroprotective properties and prevent the cerebral ischemic damage caused by oxygen glucose deprivation (OGD) in PC12 cells. The anaerobic treatment of mulberry leaves makes γ -aminobutyric acid to enhance the neuroprotection effect against in *vivo* cerebral ischemia (Kang *et al.,* 2005).The effectiveness of *Morus alba* in improving the vascular reactivity of diabeticrats, the mechanism of which may associate with the abatement of oxidative stress (Naowaboot *et al.,* 2009).

Nephroprotective action

A study was designed to investigate the nephroprotective effect of hydroalcoholic extract and flavonoid fraction of *Morus Alba* leaves on cisplatin-induced nephrotoxicity in rats. Male rats were used in this study. Study involved the serum concentrations of blood urea nitrogen (BUN), creatinine (Cr) and nitric oxide testing using standard methods. Also left kidneys were prepared for pathological study. Hydroalcoholic extract was ineffective in reversing the alterations but flavonoid fraction significantly inhibited CP-induced increases of blood urea nitrogen and creatinine. None of the treatments could affect serum concentration of nitric oxide. Flavonoid fraction could also prevent CP-induced pathological damage of the kidney. It seems that concurrent use of flavonoid fraction of *Morus Alba* with CP can protect kidneys from CP-induced nephrotoxicity (Nematbakhsh *et al.,* 2013).

Anticancer action

Many medicinal plants have anti-bacterial, anti-viral, anti-inflammatory, anti-cancer, immunostimilatory and antioxidant properties as well as compounds which effect specific organs. According to Singhal *et al.,* (2010) methanolic extract of mulberry leaves showed efficient cytotoxic behavior against cancer cells. They identified many compounds like kuwanon S, 8-granilapigenin, ciclomulberrin, ciclomorusin, morusin, atalantoflavones, kaempherol with the action strong cytotoxic cell lines HeLa, MCF-7 and Hep3B. Zhang *et al.,* (2009) conducted a short-term study on root bark of *Morus alba* and isolated a flavanics i.e. glycoside,5,2 '-dihydroxiflavanone-7, 4'-di-O-D-glucoside, which prevents cell proliferation of human

ovarian cancer cellHO-8910. Therefore the authors suggested that mulberry plant is a ―kalpavraksha, which can be utilized for making silk and pharmaceutical's. Further research is needed for exploiting its highly useful medicinal properties. Antiproliferative properties of different parts of mulberry (*Morus alba* L.) were determined. The antiproliferative effect of the methanol extracts of mulberry leaves on the cell lines Calu-6 (human pulmonary carcinoma), MCF-7 (human breast adenocarcinoma) and HCT-116 (human colon carcinoma) was different and connected to the concentrations of the investigated extracts. The fermentation of the mulberry leaves did increase their methanol extract antiproliferative effect only on human gastric carcinoma (SNU-601) cell line in concentration of 1,000 mg mL^{-1} (Chon *et al.*, 2009).

In conclusion, the review revealed that, mulberry leaf with more moisture, protein, sugar, carbohydrates and less minerals and crude fibre content found to be best from the silkworm nutrition point of view. The mulberry leaf could also be used as an alternative dietary supplement in animal feed. Mulberry leaves are rich in protein and widely used in food formulations and also have neuroprotective functions, can be used against neurodegenerative disorders such as Alzheimer and Parkinsons. The major use of this medicinal plant is antidiabiatic, immunomodulatory, antimicrobial, antioxidant and anticancer. Mulberry leaves powder exhibits significant reduction in unlikely lipid profile and improving likely lipid profile contents, so it can be helpful in reducing heart attack rates in human beings. Mulberry leaves are very helpful in decreasing the absorption of blood glucose. Mulberry is rich in phenolic compounds especially flavonoids and anthocyanins and holds antimicrobial & free radical scavenging potential. Because of all these features mulberry leaves are good source of nutrition as well as it can be considered as a medicinal plant. Further research can focus on maximum utilization of mulberry as medicinal plant taking the advantage of its availability throughout the year. This may enable farmers producing mulberry to earn more income in addition to other agencies involved in silk cocoon processing, silk and medicines production. Mulberry plant is one of the traditional herbs which are used in medicine from centuries before. Due to its pharmacological properties mulberry is used as medicine currently in many countries. Mulberry is proved in protecting liver, improving eyesight, facilitating discharge of urine, lowering of blood pressure, anti-diabetic and controlling weight in humans as well as animal models. It is the need of the hour to explain its medicinal value by Indians.

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How to cite this article:

Mahesh, D.S., B.S. Vidhathri, D.N. Vidyashree, T.K. Narayanaswamy, C.T. Subbarayappa and Muthuraju, R. 2017. Biochemical Composition and Pharmacological Properties of Mulberry (*Morus* spp.) - A Review. *Int.J.Curr.Microbiol.App.Sci.* 6(7): 2207-2217.
doi: https://doi.org/10.20546/ijcmas.2017.607.259