International Journal of Plant and Environment
Vol. 3, No. 2 (2017), 51-58

Economical and Environmental Importance of Mulberry: A Review

Ashmita Ghosh, Debnirmalya Gangopadhyay* and Tanmay Chowdhury

Department of Sericulture, Raiganj University, Raiganj-733134, West Bengal, INDIA

Publication Info

***Article history*:**
Received : 18.04.2017
Accepted : 30.06.2017
DOI : https://doi.org/10.18811/ijpen.v3i02.10437

***Key words*:**
Ecology
Environment
Medicinal value
Mulberry
Pharmacological compounds

Corresponding author:
Dr. Debnirmalya Gangopadhyay
Tel.: +91-9873359143
Email: deb_ganguly2003@yahoo.com

Abstract

Mulberry is a very hardy and fast growing perennial plant belonging to the genus *Morus* of the family Moraceae. The leaf of mulberry is solely used for feeding and rearing of the silkworm, *Bombyx mori* for the production of silk yarn. It is estimated that mulberry silk contributes around 90 % of the total global raw silk production and it is a very attractive economic activities mostly to the rural people. In addition to the utilization of mulberry leaves as silkworm feed, it is being used for many other purposes also. For example, the mulberry fruit due to its high nutritive value and delicious taste is getting importance as valuable foodstuff. The mulberry bark and wood are also useful for manufacturing of paper and sports goods items. Recently, evaluation of several pharmacological compounds of medicinal importance present in mulberry plant opens up new avenues of research in the medical science. This paper reviews the economical as well as environmental importance of mulberry taking into account several aspects of its role as animal feed, foodstuff, phytomedicine and remediation of polluted soils and atmosphere etc. Finally, an outline of environmental friendly ecological model combining sericulture with animal husbandry recycling the waste resources has been proposed from economic point of view.

1. Introduction

The mulberry is a fast growing hardy perennial woody plant belonging to the genus *Morus* of the family Moraceae (Pan and Lou, 2008; Yang *et al.,* 2010). It possesses several important characteristics like higher foliage yield, shorter gestation period and stronger environmental adaptability etc. Generally, more than 15 species of the genus *Morus* are found in subtropical, tropical and temperate regions of Asia, Africa and North America (Pérez-Gregorio *et al.,* 2011). The major ones include *Morus alba, Morus nigra, Morus rubra, Morus australis, Morus atropurpurea, Morus cathayana, Morus notabilis* and *Morus mesosygia*.

Mulberry is widely recognized for its economical importance. The mulberry leaves are extensively used for feeding and rearing of the silkworm, *Bombyx mori* for the production of silk yarn. Basically, the protein contained in the mulberry leaf is converted into the silk protein (*viz.,* fibroin and sericin) by the silkworm. The silk thus, produced is used commercially for making excellent silk garments. It is estimated that mulberry silk contributes around 90% of the total global raw silk production, helping significantly to the livelihoods of many people across the globe. Apart from this, many nutritional benefits and medicinal values are attributed to the mulberry plant. The mulberry leaves and fruits rich in protein and vitamins are long being exploited as animal feed/food products in several countries. Several studies have shown antioxidant, antiviral, anti-inflammatory, hypolipidemic, anti-hyperglycemic, neuroprotective (Pan and Lou, 2008), anti-HIV, anti-hypotensive and cytotoxic activities of different species of *Morus* (Du *et al.,* 2003). The leaves of *Morus alba* bestowed with precious phytochemicals such as coumarins, flavonoids and phenols are found to be useful in reducing blood pressure and cholesterol level in human body (Sheng-qin and Wu, 2003; Zhang *et al.,* 2009). A wildly growing rustic mulberry plant, *Morus nigra* is reported to have medicinal values particularly in treating arthritis, diabetes and rheumatis (Pérez-Gregorio *et al.,* 2011). Two new flavonoids have also been isolated from the leaves of this plant species (Wang *et al.,* 2009). The phytochemical constituents isolated from the leaves and fruit extracts of *Morus rubra* have been reported (Sharma *et al.,* 2010). Recently, the antioxidant potential of the extracts obtained from different mulberry plant parts *viz.,* leaves, branches, roots and fruits was investigated by several researchers (Andallu *et al.,* 2001; Andallu and Varadacharyulu, 2002; Arfan *et al.,* 2012). Among the 28 fruits commonly consumed in China, mulberry pulp was characterized by one of the highest values of the ferric reducing antioxidant power (FRAP) at 4.11 m. mol/100 g wet weight (Guo *et al.,* 2003).

At present, the occurrence of increased level of toxic pollutants to the atmosphere, soil and ground water has caused serious threats to the environment, ecology and human health. It may be due to rapid industrialization, deforestation, transportation and

over intensive urban population. The utilization of perennial woody mulberry plant with its salient characteristic features like extensive root system, high biomass production and strong environmental adaptability demonstrated an encouraging result to stabilize the adverse effects of heavy metals in the diverse polluted soils (Peng *et al.,* 2012; Delplanque *et al.,* 2013; Zhou *et al.,* 2015). Mulberry leaf with its strong absorption ability found to be useful in controlling atmospheric pollution. The water retention capacity in the mulberry garden is reported to be higher than that of the open land. This paper reviews the economical and environmental importance of mulberry taking into account several aspects of its role as animal feed, foodstuff, phytomedicine and remediation of polluted soils and atmosphere etc. Finally, an outline of environmental friendly ecological model combining sericulture with animal husbandry recycling the waste resources has been proposed from economic point of view.

2. Economical Importance of Mulberry

Mulberry has been cultivated in many countries for a very long time with the sole purpose of feeding the monophagous silkworm, *Bombyx mori* L. In addition to the major utilization of mulberry leaves as silkworm feed, it is being used for many other purposes. The importance of mulberry as animal feed and its medicinal values has been widely recognized (Sujathamma *et al.,* 2013). This section discusses about various economical uses of mulberry other than silkworm feed.

2.1. Mulberry as animal feed

Scarcity of land particularly the grazing land to graze animals becomes a common phenomenon in most of the developing countries mainly due to rapid industrialization, deforestation and increase in population. In India, there is no exception. As a result, the households who attempted to make animal husbandry a primary activity has suffered. The mulberry rich in protein content can be effectively used as animal feed. Generally, the tender leaves and whole shoot of mulberry are used to feed the young and late aged instars during silkworm rearing. However, the mulberry leaf stalks and leftovers (like twigs and shoots) considered as wastage during this process can serve as excellent feed for cows, sheep and other lives stock. Besides, mulberry being a hardy plant can be grown in barren land, along the roadside and canal etc. Thus it can serve the dual purpose rendering animal husbandry a profitable business ventures to the small and marginal farmers and in effective management of scarce land resources. Mulberry fodder with balanced nutritive compositions of N, Ca and P served as excellent animal feed (Majumdar *et al.,* 1967). Rao *et al.* (1971) reported increase in body weight and milk production in animals fed with left over mulberry leaf stalk. Deshmukh *et al.* (1993) witnessed an encouraging result (like faster growth rate and better quality flush) when rabbits were fed with mulberry as the main feed stuff in the diet. Moreover, improvement in the yolk color, increase in vitamin k and beta-carotene has been reported in the eggs of poultry birds fed with mulberry leaf meal (Sudo *et al.,* 2000). Machii (2000) proposed an integrated poultry farming model with mulberry garden highlighting the beneficial effects of poultry chicks in natural weeding and production of organic fertilizer while the low cost mulberry leaf meal rich in protein content in increasing the quantity of poultry products, thus saving time, labour and expenditure.

2.2. Mulberry as foodstuff

Mulberry fruits are edible and well known for its delicious taste. They can be consumed directly or can be used in the preparation of wine, jam or soft drinks. Mulberry fruits have many excellent characters like nice taste, moderate size, attractive color and high nutritive and medicinal values. Fresh mulberry fruits are rich in amino acids, vitamins and mineral such as Zn, Mn, Fe, Ca that are indispensable for the human body. In addition to this, mulberry fruits also rich in pectin and fibrin. The utilization of mulberry fruits as coloring and flavoring agent was also explored (Shiva Kumar *et al.,* 1996). In India, utilization of mulberry leaf in making various foodstuffs like tea, pakoda, dhokla and cakes has also been tried and witnessed high rate of acceptability due to high nutritive value and taste (Srivastava *et al.,* 1997).

2.3. Mulberry as medicine

The role of mulberry plant in the traditional medicine has been widely recognized. Several plant parts of mulberry are being used from time immemorial due to the presence many important bioactive substances including polyphenol and antioxidative flavonoid compounds. The pharmacological compounds present in different plant parts of mulberry and their medicinal importance is given in Table 1. The medicinal properties of the extracts obtained from mulberry leaves and fruits were investigated by several authors (Arfan *et al.,* 2012; Murthy *et al.,* 2013). Mulberry plant contains moranolin (DNJ), moran (glycopeptides), hydrophobic flavonoids (flavones and flavonone) and 2-

Table 1: Medicinal importance and pharmacokinetics principles of mulberry

Sl.No.	Pharmacokinetics actions	Pharmacokinetics principles	References
1.	Hypoglycemic activity	Moranolin (DNJ), Moran (glycopeptides), Hydrophobic flavonoids (flavones and flavonone), 2- Arylbezofuran	Singab *et al*. (2005), Fallon *et al*. (2008), Singhal *et al*. (2010)
2.	Anti- obesity action	Ethanolic extract	Oh *et al*. (2009)
3.	Lipid- lowering action	Flavonoids	Li *et al*. (2005)
4.	Antioxidants action	Polyphenols, Carotenoids, Vitamins A, C and E, Ouercetin 3(6- malonylglucoside) and Rutin.	Andallu *et al*. (2001, 2009), Katsube *et al*. (2006)
5.	Anti- inflammatory actions	Flavonoids	Chai *et al*. (2005)
6.	Antiallergic action	Flavonoids	Chai *et al*. (2005)
7.	Vasoactive action	Ethylacetate, Morin	Xia *et al*. (2008), Fang *et al*. (2005)
8.	Neuroprotective action	Cyanidin-3-O-beta-D glucopyranoside, γ-aminebutyric acid	Kang *et al*. (2005)
9.	Anticancer action	Flavanics	Zhang *et al*. (2009)

arylbenzofuran which play important role in hypoglycemic action (Singab *et al.,* 2005; Fallon *et al.,* 2008). Hypoglycemia is a condition that occurs when blood sugar level is too low in body. Katsube *et al.* (2006) conducted a study on mulberry leaf extract and found that mulberry leaf extract acts as natural inhibitor of α-glucosidase due to deoxynoyirimycin (DNJ) and its derivatives.

Fagomine, one of the components present in mulberry leaves is capable of inducing insulin secretion in isolated rat islet cells (Taniguchi *et al*., 1998). In patients with type- II diabetes, treating with mulberry resulted in an improvement in glycemic control and reduction in VLDL production (Andallu *et al.,* 2001). Retardation of starch digestion by inhibition of α-amylase, the key enzyme catalyses the initial step in the hydrolysis of starch to smaller oligosaccharides plays a key role in the control of diabetes. On the other hand, diabetes caused by decreased amount of sugar absorbed in blood has positive consequences on obesity. The extract prepared from the leaf of *Morus alba* rich in tannins exhibits significant α- amylase inhibitory activity, thus, useful for treating both the diabetes (Sudha *et al.,* 2011). The effect of mulberry extract experimented on mice exhibited an antagonistic action on melanin concentrating hormone receptor which showed positive correlation with decrease in body weight (Oh *et al.,* 2009). Further, the study revealed that ethanolic extract obtained from mulberry leaves has anti-obesity action on diet-induced mice.

Li *et al.* (2005) observed that mulberry leaf extract rich in flavonoids can serve as the scavenger of blood lipid radicals in sugar metabolism and antioxidation experimented in rats. Further, the hypolipidemic effect of mulberry extract in regulating the low density lipoprotein receptor (LDLR) gene expression was reported (Liu *et al.,* 2009). Andallu *et al.* (2001) showed the potential of mulberry leaf extract in dealing with lipid peroxidation in treating glibenclamide. Several important phytochemical components extracted from root and bark of mulberry plant showed hypocemic function possessing defensive consequences on pancreatic β cells (Singab *et al*., 2005). The leaf and root epidermis of *Morus alba* also shown to have anti-inflammatory effects (Chatterjee *et al.,* 1983).

The neurotoxicity in alzheimers disease is associated with the accumulation of amyloid beta-peptides that forms a plaque in the brain. The methanol extract of mulberry leaf contains compounds such as kaempferol-3-O-glucoside and kaempferol-3-O glucoside which inhibits the formation of amyloid beta-peptide fibrils *in vitro* and protects hippocampal neurons from amyloid beta-peptide induced cell death (Niidome *et al.,* 2007; Khaengkhan *et al.,* 2009). Xia *et al.* (2008) demonstrated function of ethyl acetate extract obtained from the leaves of *Morus alba* in regulating blood pressure experimented on mice.

Kuete *et al.* (2009) reported the function of methanolic extract obtained from the root bark of *Morus mesozygia* in treating infections associated with microorganisms. Prenylated flavonoids isolated from *Morus alba* showed antibacterial, antifungal and antiviral activities (Du *et al.,* 2003; Sohn *et al.,* 2004). The extract obtained from the leaves/root bark of *Morus alba* showed free radical scavenging and antioxidant activities and proved to be beneficial for de-pigmentation (Andallu and Varadacharyulu, 2003). In addition to this, the role of mulberry in dealing with inflammation and cancer in human body was found very significant. For example, the methanolic extract of mulberry leaves exhibited efficient cyto-toxic behavior against cancer cells. Zhang *et al.* (2009) conducted a short- term study on root- bark of *Morus alba* and isolated glycosides, 5-2'-dihydroxiflavanone-7, 4'-di-O-D-glucose which prevents cell proliferation of human ovarian cancer cell HO-8910.

3. Environmental Importance of Mulberry

Rapid industrialization coupled with increase in population number has adversely impacted on environment. Global warming, incidences of natural calamities (like flood and drought etc.), abrupt soil erosion, high rate of disease outbreak are some of the phenomena assumed to have direct consequences with environmental pollution. Mulberry possesses several important characteristic features and reported to be useful in controlling environmental pollution (Jian *et al.,* 2012). For instance, mulberry plantation demonstrated encouraging results in improving air quality, increasing water retention capacity, remediation of heavy metals from polluted soils, atmosphere and nurturing beneficial soil micro flora and fauna (Lu *et al.,* 2004; Yao *et al.,* 2004; Chen *et al.,* 2006). This section illustrates environmental importance of mulberry to mitigate the challenges emerged due to environmental pollution.

3.1. Improvement of air quality

Mulberry trees are good carbon sink plants. It is estimated that 1 mμ mulberry tree is able to absorb about 4162 kg of carbon dioxide and release 3064 kg of oxygen each year. Mulberry leaves have also high absorption capacity to assimilate certain air pollutants like chlorine, hydrogen fluoride and sulphur-di-oxide etc. It is observed that mulberry leaves remained undamaged under higher level of chlorine pollution to the atmosphere, thus mulberry plant considered to have natural resistance to chlorine (Lu *et al.,* 2004).

3.2. Adaptability to soil, water conservation and consolidation

Mulberry trees have high adaptability to soil. Mulberry trees could flourish in deep, porous and fertile soil but also grow in barren soil with poor nutrients (Han, 2007). Mulberry has very strong root system. Its roots form a greatly tangled and dense network in the soil. Mulberry plantation is highly capable of suppressing sand storm and conserving water and soil. It is estimated that the runoff co-efficient can be reduced by 10-20 % in mulberry in comparison to the traditional planting pattern system. It is also reported that mulberry tree hedgerow had significant effect in reducing total runoff and enrichment ratio of nutrients (Shi *et al.,* 2005). Du *et al.* (2001) experimentally proved that mulberry trees have significant effect in preventing soil erosion. For instance, the annual runoff volume was reduced by 38 and 91% under the 5 and 10 year old mulberry bush belt respectively than the agricultural slope land. Mulberry root system can effectively improve the shear strength of purple soil and increase anti-erosion capacity of soil. According to the experiments in mulberry field of Shibao Town, Zhong Country of Chongqing City, soil shear strength was increased from 75.2 kPa to 138.4 kPa while soil layer was deepened from 0 - 10 cm to 30 - 40 cm in the mulberry field (Nan *et al.,* 2011).

3.3. Survivability to drought and water logging condition and wide genetic plasticity

Mulberry trees have very strong survivability and vitality. For example, mulberry can grow well under natural arid and semiarid desert area with annual rainfall less than 300-600 mm. Dai *et al.* (2009) reported higher ability of mulberry to adapt in desert area with annual rainfall below 150 mm. Investigations showed that adult mulberry trees could survive from an inundation of 20 d during their growth period. This is very rare among other xerophytic plants. Mulberry trees have very strong endurance to water logging in dormant stage. Mulberry trees proved to have wide genetic plasticity to adapt in varied agro-climatic condition. Dormant mulberry trees have the highest resistance against chilling (Yao *et al.,* 2004; Chen *et al.,* 2006). This very nature of hardy characteristic feature of mulberry is evidenced through its distribution pattern across the world ranging from temperate to tropical.

3.4. Mulberry in phytoremediation

Phytoremediation is one of the most effective methods to remediate heavy metals in soils. Mulberry has the potential to remediate heavy metals contaminated soils (Zhou *et al.,* 2015). The developed root system of mulberry is helpful to absorb soil nutrients, to a certain extent also conductive to the

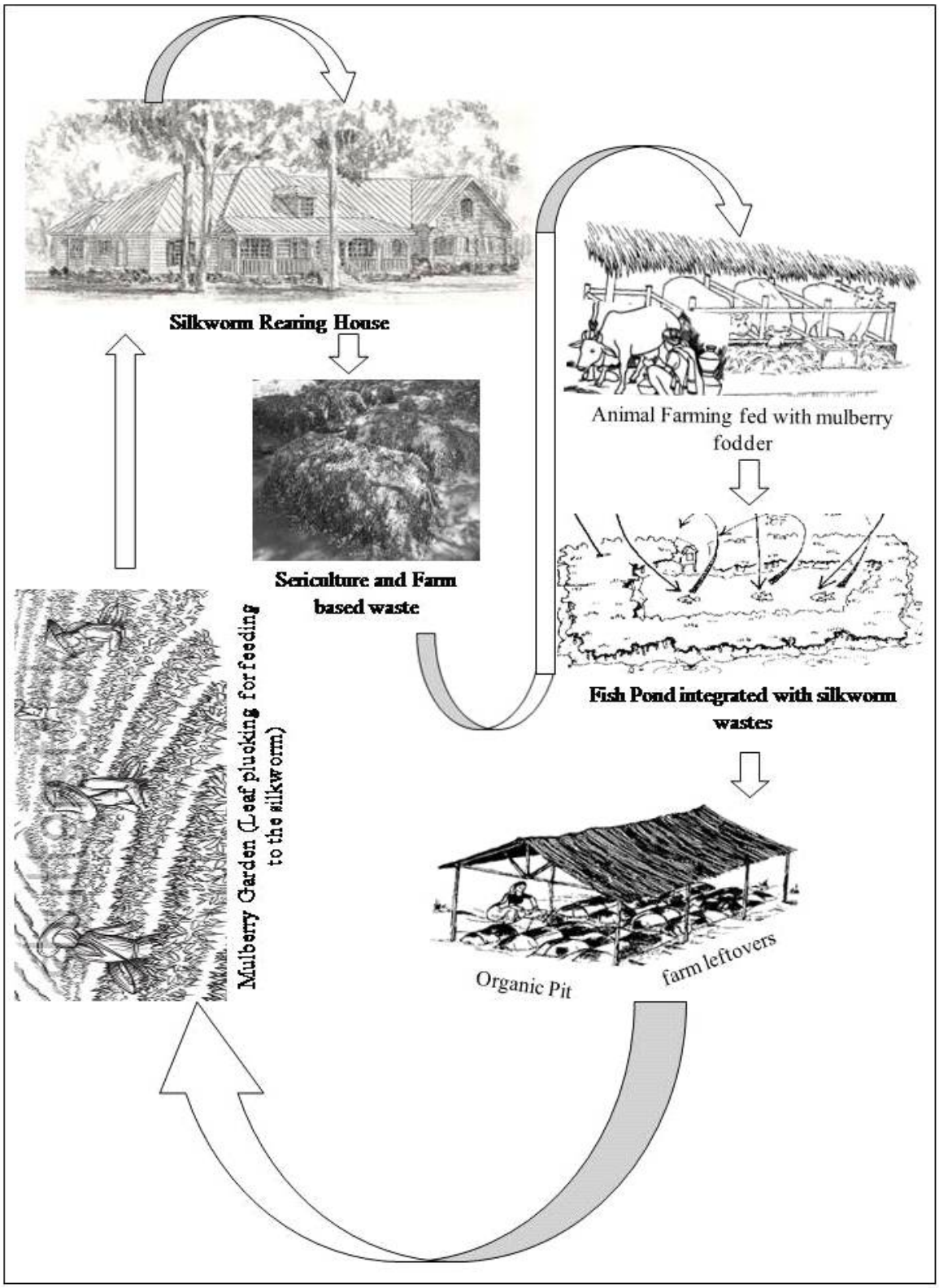

Fig. 1: An integrated environment friendly ecological model combining sericulture with animal husbandry utilizing sericulture waste resources

absorption of metals in the soil (Jothimani *et al.,* 2013). Heavy metals like Pb, Cd, Cu mainly are remediated *via* different species of mulberry.

4. Conclusion

Mulberry plant is one of the traditional herbs not only used as silkworm feed but also as animal fodder and medicine in many countries from centuries. Of late, mulberry is regarded as one of the sacred plants due to its distinctive pharmacological properties. The extract obtained from different plant parts of mulberry proved to be beneficial in protecting liver, improving eyesight, facilitating discharge of urine, lowering of blood pressure, anti-diabetic and controlling weight in humans as well as in animal models.

A huge amount of sericultural waste (such as leftover mulberry plant parts and silkworm excreta) rich in nutritive value is generated during the time of rearing the silkworm fed with mulberry leaves. It is estimated that 15 MT of waste (including both the rearing and other farm waste) is generated from one hectare of mulberry farm annually. Proper utilization of this sericultural wastage may open up new avenues for enhanced income generation to the sericultural farmers. In this direction, an outline of environmental friendly ecological model combining sericulture with animal husbandry recycling the waste resources has been proposed from economic point of view (Fig. 1). Preparation of vermicompost utilizing leftover mulberry parts unutilized during silkworm rearing can help in mulberry leaf quality improvement bringing down substantially the expenditure on chemical fertilizers. In addition, the mulberry dyke-fish pond model developed in China can be beneficial to increase fish production recycling the sericultural residues more judiciously. In the mulberry dyke-fish pond model, the mulberry is planted in the dyke around the fishpond and the pond mud is dredged for the mulberry, mulberry leaves feed the silkworm and silkworm waste goes as fish food. Moreover, integration of poultry farming with mulberry garden may have beneficial effects. For example, the poultry chicks can act as natural weeder while the excreta generated by them may serve as useful ingredients for organic fertilizer production. At the same time, low cost mulberry leaf meal rich in protein content as feed for the poultry chicks can be useful in increasing the quantity of poultry products, thus saving time, labour and expenditure.

References

Andallu, B. and Varadacharyulu, N. 2002. Control of hyperglycemia & Retardation of cataract by mulberry (Morus *indica* L.) leaves stroptozotocin diabetic rats. *Indian Journal of Experimental Biology* **40**:791-795.

Andallu, B., and Varadacharyulu , N.C. 2003. Antioxident role of mulberry (*Morus indica* L.) cv. Anantha leaves in streptozotocin- diabetic rats. *Clinica Chimica Acta* **338**:3-10.

Andallu, B., Suryakantham, V., Lakshmi Srikanthi, B. and Reddy, G.K. 2001. Effect of mulberry (*Morus indica* L.) therapy on plasma and erythrosite membrane lipids in patients with type 2 diabetes. *Journal of Clinica Chimica Acta* **314**:47-53.

Andallu, B., Vinay Kumar, A.V. and Varacharyulu, N. 2009. Lipid abnormalities in streptozotocin–diabetes: Amelioration by *Morus indica* L. cv Sugna leaves. *International Journal of Diabetes in Developing Countries* **29**(3):123-128.

Arfan, M., Khan, R., Rybarczyk, A. and Amarowicz, R. 2012. Antioxydant Activity of Mulberry Fruit Extract. *International Journal of Molecular Science* **13:** 2472-2480.

Chai, O.H., Lee, M.S., Han, E.F., Kim, H.T. and Song, C.H. 2005. Inhibitory effects of *Morus alba* on compound 48/80-induced anaphylactic reactions and anti-chicken gamma globulin IgE-mediated mass cell activation. *Biological and Pharmaceutical Bulletin* **28**(10):1852-1858.

Chatterjee, G.K., Burman, T.K., Nagachaudhuri, A.K. and Pal, S.P. 1983. Anti-inflammatory and anti-pyretic activities of *Morus indica*. *Planta Medica* **48**:116-119.

Chen, M.G., Jin, P.H. and Huang, L. X. 2006. Energy analysis of mulberry-silkworm ecosystem in China. *Chinese Journal of Applied Ecology* **17**:233-236.

Dai, Y.W., Zhu, H. and Du, H.Z. 2009. An evaluation on economic value and ecological function of mulberry resources. *Journal of Protection Forest Science and Technology*, **1:**78-80.

Delplanque, M., Collet, S., Gratta, F.D., Schnuriger, B., Gaucher, R., Robinson, B. and Bert, V. 2013. Combustion of Salix used for phytoextraction: The fate of metals and viability of the processes. *Journal of Biomass Bioenergy* **49**:160-170.

Deshmukh, S.V., Pathak, N.V. and Takalikar, D.A. 1993. Nutritional effect of mulberry (*Morus alba*) leaves as sole ration of adult rabbits. *Journal of World Rabbit Sciences* **1**: 67-69.

Du, J., He, Z.D., Jiang, R.W., Ye, W.C. and Xu, H.X. 2003. Antiviral flavonoids from the root bark of *Morus alba* L. *Journal of Phytochemistry* **62**:1235-1238.

Du, Z.H., Liu, J.F. and Liu, G. 2001. Study on mulberry trees as both water and soil conservation and economy trees. *Journal of Guangxi Sericulture* **38**:10-12.

Fallon, E., Zhong, L., Furne, J.K. and Levitt, M.D. 2008. A mixture of extracts of black and green teas and mulberry leaf did not reduce Weight gain in rats fed a high fat diet. *Alternative Medical Review* **13**:43-49.

Fang, S.H., Hou, Y.C. and Chao, P.D. 2005. Pharmacokinetic and pharmacodynamic interections of morin and cyclosporin. *Toxicology and Applied Pharmacology* **205**:65-70.

Guo, C., Yang, J., Wei, J., Li, Y., Xu, J. and Jiang, Y. 2003. Antioxidant activities of peel, pulp and seed fractions of common fruits as determined by FRAP assay. *Journal of Nature and Research* **23**:1719-1726.

Han, S.Y. 2007. The ecological value of mulberry and its ecological cultivation models for planting mulberry from eastern to western areas in Guizhou. *Journal of Guizou Agrical Sciences* **35**:140-142.

Jian, Q., Ningjia, H., Yong, W. and Zhonghuai, X. 2012. Ecological issues of mulberry and sustainable development. *Journal of resources and ecology* **3**:330-339.

Jothimani, P., Ponmani, S. and Sangeetha, R. 2013. Phytoremediation of heavy metals - A review. *International Journal of Research*: *Studies in Biosci*ence **1**:17-23.

Kang, T.H., Oh, H.R., Jung, S.M., Ryu, J.H., Park, M.W., Park, Y.K. and Kim, S.Y. 2005. Enhancement of neuroprotection of mulberry leaves (*Morus alba* L.) prepared by the anaerobic treatment against ischemic damage. *Biological and Pharmaceutical Bulletin* **29**(2):270-274.

Katsube, T., Imayaka, N., Kawano, Y., Yamazaki, Y., Shiwaku, K. and Yamane, Y. 2006. Anti oxidant flavonol glycosides in mulberry (*Morus alba* L.) Leaves isolated based on LDL antioxidant activity. *Journal of Food Chemistry* **97**:25-31.

Khaengkhan, P., Nishikaze, Y., Niidome, T., Kanaori, K., Tajima, K., Ichida, M., Harada, S., Sugimoto, H. and Kamei, K. 2009. Identification of an anti-amyloidogenic substance from mulberry leaves. *Journal of Neuro Report* **20**:1214-1218.

Kuete, V., Fozing, D.C., Kapche, W.F.G.D., Mvaveng, A.T., Kuiate, J.R., Ngadjui, B.T. and Abegaz, B.M. 2009. Anti microbial activity of the methanolic extract and compounds from *Morus mesozygia* stem bark. *Journal of Ethnopharmacol* **124**:551-555.

Li, X.R., Fang, X. and Yu L.Y. 2005. Effects of flavonoids from mulberry leaves on ant oxidative enzyme and album in glycosylation on diabetic rat. *Journal of Zhejiang University Agriculture & Life Science* **31**:203-206.

Liu, L.K., Chou, F.P., Chen, Y.C., Chyau, C.C., Ho, H.H. and Wang, C.J. 2009. Effects of mulberry (*Morus alba* L.) extracts on lipid homeostasis invitro and invivo. *Journal of Agriculture food chemistry* **57**:7605-7611.

Lu, M., Wang, R.Q. and Qi, X.S. 2004. Reaction of planting tree species on chlorine pollution in the atmosphere. *Journal of Shandong University* **39**: 98-101.

Machii, H. 2000. Evaluation and utilization of mulberry for poultry production in Japan, Mulberry for animal production. *Journal of Animal production and Health Series* **147**: 237-247.

Majumdar, B.N., Momin, S.A. and Kehar, N.D. 1967. Studies on tree leaves as cattle fodder. 1. Chemical composition as affected by the stage of growth. *Indian Journal of Veterinary Science* **37**:217-223.

Murthy, V.N., Ramesh, H.L., Lokesh, G. and Munirajappa, D.Y.B. 2013. Leaf quality evaluation of ten mulberry (*Morus*) germplasm varieties through phytochemical analysis. *International Journal of Pharmaceutical Sciences Review and Research* **21**:182-189.

Nan, H.W., He, X.B. and Bao, Y.H. 2011. Influence of root system of *Morus alba* to shearing resistance of purple soil. *Soil and Water Conservation in China* **8**:48-51.

Niidome, T., Takahashi, K., Goto, Y., Goh, S., Tanaka, N., Kamei, K., Ichida, M., Hara, S., Akaike, A., Kihara, T. and Sugimoto, H. 2007. Mulberry leaves extract prevents amyloid β-pepide fibril formation and nurotoxicity. *Nuroreport* **18:**813-816.

Oh, K.S., Ryu, S.Y., Lee, S., Seo, H.W., Oh, B.K., Kim, Y.S. and Lee, B.H. 2009. Melanin-concentrating hormone-1 receptor antagonism and anti-obesity effects of ethanolic extract from *Morus alba* leaves in diet-induced obese mice. *Journal of Ethnopharmacology* **122**:216-220.

Pan, G. and Lou, C.F. 2008. Isolation of an 1-aminocyclopropane-1-carboxylate oxidase gene from mulberry (*Morus alba* L.) and analysis of the function of this gene in plant development and stresses response. *Journal of Plant Physiology* **165**:1204-1213.

Peng, X., Yang, B., Deng, D., Dong, J. and Chen, Z. 2012. Lead tolerance and accumulation in three cultivars of Eucalyptus urophyllaXE. grandis: implication for phytoremediation. *Environmental Earth Sciences* **67**:1515-1520.

Pérez-Gregorio, M.R., Regueiro, J., Alonso-González, E., Pastrana-Castro, L.M. and Simal-Gándara, J. 2011. Influence of alcoholic fermentation process on antioxidant activity and phenolic levels from mulberries (*Morus nigra* L.). *LWT-Food Science and Technology* **44**:1793-1801.

Rao, A.S., Kumar, M.A. and Sampath, S.R. 1971. Studies on mulberry (*Morus indica*) leaf-stalkpalatability, chemical composition and nutritive value. *Indian Veterinary Journal* **48**:853-857.

Sharma, S.B., Tanwar, R.S., Rini, A., Singh, U.R., Gupta, S. and Shukla, S.K. 2010. Protective effect of *Morus rubra* L. leaf extract on diet-induced atherosclerosis in diabetic rats. *Indian Journal of Biochemistry and Biophysics* **47**:26-31.

Sheng-qin, Z.O.U. and Wu, C.H.E.N. 2003. A review on chemical constituents, pharmacological activity and application of mulberry leaves. *Journal of Chemical Industry of Forest Products* **1**:1-8.

Shi, D.M., Lu, X.P. and Liu, L.Z. 2005. Study on functions of soil and water conservation by mulberry hedgerow intercropping of purple soil slopping farmland in three gorges reservoir region. *Journal of Soil Water Conservation* **19**:75-79.

Shiva Kumar, G.R., Anantha Raman, K.V., Magadum, S.B. and Datta, R.K. 1996. Medicinal values of mulberry. *Indian Silk* **34**:15-16.

Singab, A.N.B., El-Beshbishy, H.A., Yonekawa, M., Nomura, T. and Fukai, T. 2005. Hypoglycemic effect of Egyptian *Morus alba* root bark extract: effect on diabetes and lipid peroxidation of streptozotocin-induced diabetic rats. *Journal of Ethnopharmacology* **100**:333-338.

Singhal, B.K., Khan, M.A., Dhar, A., Baqual, F.M. and Bindroo,

B.B. 2010. Approaches to industrial exploitation of mulberry fruits. *Journal of Fruit and Ornamental Plant Research* **18**(1):83-99.

Sohn, H.Y., Son, K.H., Kwon, C.S., Kwon, G.S. and Kang, S.S. 2004. Antimicrobial and cytotoxic activity of 18 prenylated flavonoids isolated from medicinal plants: *Morus alba* L., *Morus mongolica Schneider, Broussnetia papyrifera* (L.) Vent, S*ophora flavescens Ait and Echinosophora koreensis Nakai*. *Journal of Phytomedicine* **11:**666-672.

Srivastava, S., Kapoor, R. and Srivastava, R.P. 1997. Delicious delicacies from nutritious mulberry. *Indian Silk* **36**:39-40.

Sudha, P., Zinjarde, S.S., Bhargava, S.Y. and Kumar, A.R. 2011. Potent α-amylase inhibitory activity of Indian Ayurvedic medicinal plants BMC. *Journal of Complementary Alternative Medicine* **11**:5-15.

Sudo, M., Kuramoto, H. and Iso, M., 2000. Studies on functional poultry eggs. Effects of mulberry leaves on quantity of eggs. *Bull Ibaraki Prefectural Poultry Experiment Station* **33**:21-34.

Sujathamma, P., Savithri, G. and Kavyasudha, K., 2013. Value addition of mulberry (*Morus* spp). *International Journal of Emerging Technologies in Computational and Applied Sciences* **5**:352-356.

Taniguchi, S., Asano, N., Tomino, F. and Miwa, I., 1998. Potentiation of glucose-induced insulin secretion by fagomine, a pseudo-sugar isolated from mulberry leaves. *Hormone and metabolic research* **30**:679-683.

Wang, L., Gong, T. and Chen, R.Y. 2009. Two new prenylflavonoids from *Morus nigra* L. *Journal of Chinese Chemistry* **20**:1469-1471.

Xia, M., Qian, L., Zhou, X., Gao, Q., Bruce, I.C. and Xia, Q. 2008. Endothelium-independent relaxation and contraction of rat aorta induced by ethyl acetate extract from leaves of *Morus alba* (L.). *Journal of ethnopharmacology* **120**:442-446.

Yang, X., Yang, L. and Zheng, H. 2010 Hypolipidemic and antioxidant effects of mulberry (*Morus alba* L.) fruit in hyperlipidaemia rats. *Journal of Food Chemistry and Toxicology* **48:**2374-2379.

Yao, F., Yu, W.Z. and Yang, X.E. 2004. Genotype resources and ecological adaptation of mulberry plants *(Morus indica* L.) and their application foreground. *Bulletin of Science and Technology* **20**:289-297.

Zhang, M., Chen, M., Zhang, H.Q., Sun, S., Xia, B. and Wu, F.H. 2009. In vivo hypoglycemic effects of phenolics from the root bark of *Morus alba. Journal of Fitoterapia* **80**:475-477.

Zhou, L., Zhao, Y., Wang, S., Han, S. and Liu, J. 2015. Lead in the soil-mulberry (*Morus alba* L.)-silkworm (*Bombyx mori*) food chain: translocation and detoxification. *Chemosphere* **128**:171-177.