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The Properties And Nutritional Uses Of Mulberry (Morus Alba): A Review

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Abstract:

Morus alba, a well-known medicinal plant in the Moraceae family, has long been employed in Ayurvedic and other traditional medical systems. The review demonstrates a wide range of essential Pharmacological actions, including antidiabetic, antibacterial, antioxidant, antistress properties. The plant contains carotene, vitamin B1, folic acid, folinic acid, isoquercetin, quercetin, tannins, flavonoids, and saponins, as well as ascorbic acid, of which over 90% is present in a reduced form. These issues are being treated with a variety of ancient and modern therapeutic treatments. One example is the use of natural remedies. The purpose of this study was to see how the mulberry is the medicinal miracle.

Keywords:

Mulberry, Morus alba, Flavonoids, Moraceae, Antioxidant, Anti-cancer.

Introduction:

Important role in orchestrating the development of the faculty of medicine. Humans put their faith in tried-and-true home medicines that have been passed down through generations. Herbal preparations made from medicinal plants are one of humanity's oldest and most valuable health-care tools. Herbal formulations are the foundation of modern medicine. Ancient civilizations, as well as many contemporary cultures around the world, relied on herbs(1).

Medicinal plants form the foundation of India's traditional medical systems. The importance of medicinal plants as a possible source of bioactive chemicals has been recognised in pharmacological investigations. Individuals and communities benefit greatly from the use of medicinal plants. Plants have medical value because they contain chemical compounds that have a specific physiological function on the human body. Medical plants, according to the World Health Organization, would be the best source of a range of pharmaceuticals. Traditional medicine, which contains substances derived from medicinal plants, is used by almost 80% of people in developed countries. Plant extracts and phytochemicals, both of which have antibacterial characteristics, can be very useful in therapeutic therapy. Many plants have been employed for

their antibacterial properties, which are related to chemicals produced in the plant's secondary metabolism. These items are identified by their active ingredient, such as the phenolic chemicals found in essential oils(2).

Herbs have an important role in the treatment of a variety of diseases all over the world. The World Health Organization recently produced a structured action plan for improving food as medicine, which includes identifying traditional medicine and presenting a good strategy and plan. The development of awareness, particularly at the university level, is critical in order to increase adequate understanding of herbal treatments.(37)

In the form of extracts, public interest in functional foods and nutraceuticals has grown, notably in herbal remedies. Herbal remedies are extensively used to treat mild to severe depression, and almost 70% of medical doctors advocate them over any chemical drug for the treatment of numerous disorders. Phototherapy is considered to be relatively safe because it contains a large number of compounds with a specific structure that serve as an agent to improve or neutralise side effects. This supposition is based on limited scientific evidence(3).

Mulberry is a member of the Moraceae family and can be found in a wide range of climatic and environmental conditions, from tropical to temperate. Moraceae, generally known as the mulberry or fig family, is a flowering plant family that includes more than twenty-four species, each with one subspecies and at least a hundred variants. The name *Morus* comes from the Latin word 'mora,' which means 'delay,' most likely due to the sluggish growth of its buds. Mulberry is a fast-growing deciduous plant that grows in a wide range of climatic, topographical, and soil conditions and is found throughout the world, from temperate to subtropical zones. Mulberry as a whole plant has long been used as a functional food due to the presence of rich phytochemical elements(4,39).

Mulberries or their extracts have antimicrobial, anti-hyperglycemic, anti-hyperlipidemic, anti-inflammatory, and anti-cancer properties and are used to treat a variety of acute and chronic disorders. *Morus* species' fruits, leaves, twigs, and bark all have substantial anti-tyrosinase inhibitory activity, making them a good choice for use as a whitening ingredient in cosmetics(4).

The red mulberry, also known as the American mulberry, is native to the eastern United States, from Massachusetts to Kansas, and all the way down to the Gulf coast. The black mulberry is an Asian native that has been grown in Europe for its fruits since before the Roman era. Mulberry leaves have been used in sericulture for thousands of years, according to ancient Chinese literature. Fruits, leaves, roots, bark, and latex of the mulberry, *Morus alba* (L.), are used in some ayurveda therapeutic remedies to treat a variety of human ailments. Mulberry (*Morus alba*) is an extremely beneficial plant that contains a variety of bioactive substances, including flavonoid, phenolic, and dietary fibre experts. It can be deduced from the close proximity of bioactive sections and has a significant impact on diseases including diabetes, cardiovascular disease, and viral activity. Mulberry (*Morus alba*) investigates a broad range of important pharmacological properties, including antidiuretic, antibacterial, antimutagenic, developmental neutralising action, pro, anticancer, and anti-inflammatory properties(4).

The nutrient richness of the leaves of the mulberry, *Morus alba* (L), has propelled it to the forefront of sericulture activities. *Morus alba* (L.) is a mulberry native to eastern and central China. It took centuries for it to become neutralized in Europe. In early colonial times, the tree was brought to America for silkworm culture, but it quickly became neutralized and mixed with the local red mulberry. (40)The red mulberry, also known as the American mulberry, is native to the eastern United States, stretching from Massachusetts to Kansas and all the way down to the Gulf coast. The black mulberry is a native of western Asia that has been grown in Europe for its fruits since before the Roman era. It's a blooming, woody, perennial plant with a quick growth rate. It is classified as a member of the Moraceae family. Since time immemorial, the mulberry, *Morus alba* (L.), has attracted interest. This is because of its medicinal and economic benefits. Mulberry leaves have been reported to be used in sericulture(1,2).

Mulberries are high in iron, riboflavin, vitamin C, vitamin K, potassium, phosphorus, and calcium, all of which are essential elements for our bodies. They also have a lot of dietary fibre and a lot of organic substances, like phytonutrients, zeaxanthin, anthocyanins, lutein, and resveratrol, as well as other polyphenolic compounds like resveratrol. Apart from that, this plant is said to have numerous nutritional and therapeutic properties. The leaves are high in protein, and nutritional specialists in India have advised using dry leaf powder to make parathas, one of India's most popular foods. Mulberry leaves and fruits are utilised in the preparation of tea and ice creams in Korea and Japan, and are included in their functional meals. This plant has amazing results in decreasing blood glucose and cholesterol levels, making it suitable for use in traditional Chinese herbal and folk medicine. These characteristics are attributable to the presence of several bioactive compounds(3).

Because of their economic value, prospective strategies, and antioxidant effects, the phytochemicals found in these plants have received increased attention. Natural products account for about half of all medicines available. Around 80% of people in underdeveloped countries rely on traditional medicines, and the market for plant-derived medications is expected to be worth nearly \$35 billion by 2020. Because these bioactive-containing plants have become a fundamental part of basic health systems, the efficacy and safety of medicinal plants have been widely recognised(5).

Composition of Mulberry:

Vitamins:

Mulberry, which is high in vitamins B and C, can be employed by systems to promote healthy fat and starch oxidation and metabolic turnover for normal or accelerated activities. Similarly, the mulberry leaf contains rutin, which is responsible for the dynamic hair-like structure, GABA, which is responsible for heartbeat decrease, and DNJ, which is responsible for glucose reduction. Mulberry leaves also contain sitosterol, which is used to lower blood cholesterol levels. They discovered success in relation to previous experimental results with mice mulberry leaves as they grew older. Mulberry leaf powder is currently accessible in Korea in the form of pills or holders. Different strategies for using mulberry in humans are the next focus in the Korean market(6).

Mulberry leaves are high in Vitamin C, A, and B vitamins and can help you lose weight while improving your digestion. It is a non-lethal herb that is extremely safe to drink. It is beneficial for the elderly to drink on a daily basis and can help to combat infection. Young children, pregnant women, and bosom boosting moms should not consume large amounts of alcohol unless advised by a skilled professional(7).

Chemical Composition	<i>Morus alba</i>	<i>Morus nigra</i>	<i>Morus rubra</i>
Lipid (%)	1.10	0.95	0.85
Linoleic acid (%)	57.26	61.85	43.39
Palmitic acid (%)	22.42	12.06	24.79
Oleic acid (%)	10.49	14.75	-
Protein (%)	10.15–13.33	8.9–10.85	-
P (mg/100 g)	247	232	226
K (mg/100 g)	1668	922	834
Ca (mg/100 g)	152	132	132
Mg (mg/100 g)	106	106	115
Fe (mg/100 g)	4.2	4.2	4.5
Na (mg/100 g)	60	59	61
Mn (mg/100 g)	3.8	4.2	4.0
Zn (mg/100 g)	2.8	3.2	3.2
Cu (mg/100 g)	0.5	0.4	0.4
Se (mg/1000 g)	0.005	0.008	-
Vitamin C (mg/100 mL)	22.4	21.8	19.4

Bioactive Components:

Anthocyanins, alkaloids, and flavonoids are among the bioactive components found in Mulberry leaves and fruits. Mulberry leaves contain high levels of alkaloids, including 1deoxynojirimycin (DNJ), the most powerful glycosidase inhibitor that lowers blood sugar levels. Oxyresveratrol (trans-2,3,4,5-tetrahydroxystilbene) and Resveratrol (trans-3,4,5-trihydroxystilbene) are hydroxystilbenes found in Mulberry. This bioactive molecule protects the heart and brain. Oxyresveratrol inhibits tyrosinase, which reduces melanin biosynthesis, and is used as a cosmetic and medicinal treatment for hyperpigmentation. Flowers, fruits, and leaves are naturally coloured by anthocyanins, a category of phenolic chemicals. As anti-inflammatory and antioxidant chemicals, they are the most beneficial to your health.

Mulberry anthocyanin extract exhibits antimetastatic activity, inhibiting B16-F1 cell migration, and anthocyanin has a high inhibitory capacity on lipid oxidation. Flavonoids are abundant in the plant kingdom, with mulberry containing at least four flavonoids, including rutin. In humans, flavonoids have been shown to have antioxidant, anti-Pi, antithrombotic, antiallergic, antiviral, hepatoprotective, and carcinogenic properties. Plants are also high in nutritive substances such as crude fat, crude protein, total carbohydrates, and mineral elements, which are studied to determine the relationship between active components and antioxidant activity(8,36).

○ Alkaloid:

Aegelin, fragrine (C₁₃H₁₁O₃N), aelenine, marmeline, dictamine, aegelin N-2-[4-(3,3-dimethyleollyloxy) phenyl] ethyle cinnamide, N-2-[4-(3,3-dimethyleollyloxy) phenyl] ethyle cinnamide, N-2-ethoxy-(2-methoxyphenyle) ethyle cinnamide, O-methylehalfordinine, N-4-methyleoxys Marmesin, Marmelosin, Marmin, alloimperatorin, imperatorin, xanthotoxol, scoparone, methyl ether, scopoletin, umbelliferone, psoralen, and marmelide, as well as a-7 geranyleoxycoumarin and marmenole(9).

○ Phenolic compounds:

Epidemiological studies have established that phenolic compounds are a cancer-prevention agent, a contamination-protective component, and a movement of phenolics, with numerous report variants in phenolic compounds as a component of plant species. For the addition of phenolic content, remarkable differences were noticed in the leaves of three mulberry collections. These findings were noticeably superior to those of the well reported oil palm leaves and the Iranian restorative plant.

Mulberry extract is high in anthocyanin, a colourant ingredient found naturally in plants. By scavenging peroxy radicals in the trapping reaction, anthocyanins demonstrated antioxidant activity. Anthocyanin glycosides were not found in the GI tract after 8 hours of treatment. Anthocyanins were transported across the erythrocyte using a sodium-dependent glucose transporter. Bioactive components identified from *Morus alba*, such as Kuwanon-G and leachianone, have antibacterial properties.

Biological activities of *Morus alba* :



○ **Antioxidant activity:**

Antioxidants are chemical molecules that prevent oxidation, a chemical reaction that can result in free radicals and chain reactions that can harm organisms' cells. The antioxidative potential of the mulberry, *Morus alba*, is due to the presence of a diverse range of phytochemicals in various sections (L.). The fruits of the mulberry tree, *Morus alba* (L.), are considered a healthy food. This is due to the presence of flavonoids and polyphenols in the fruits of the mulberry, *Morus alba* (L.). Apigenin, luteolin, quercetin, morin, caffeic acid, gallic acid, rutin, umbelliferone, chlorogenic acid, and kaempferol are the most important flavonoids and polyphenols found in mulberry, *Morus alba* (L.). Maclurin, rutin, isoquercitrin, resveratrol, and morin are chemicals found in the twigs and root bark of the mulberry, *Morus alba* (L.). Essential fatty acids such as palmitic, oleic, and linoleic acids are found in the fruits of the mulberry, *Morus alba* (L.), and are necessary for cell membrane formation, appropriate nervous system development and function, eicosanoids production, and various inflammatory reactions(1,35).

Moran 20K is a chemical made from an aqueous methanolic extract of the root bark of the mulberry, *Morus alba* (L.). Moran 20K is a glycoprotein that has antioxidant and anti-diabetic properties. Different kinds of mulberry have also been shown to include 1-deoxynojirimycin (DNJ), resveratrol, oxyresveratrol, cyanidin3-O-beta-glucoside (Cy-3-glu), cyanidin-3-O-beta-rutinoside (Cy-3-rut), and rutin. Moracin, an acetone-soluble (and water-soluble) molecule derived from the fruits of the mulberry, *Morus alba* (L), is an appropriate molecule for preventing oxidative stress. Vitthalrao B. Khyade et al. evaluated the potential antioxidant activity of Moracin, a new mulberry chemical, using hydrogen peroxide generated stress in skin fibroblast cell line culture (AH927) (2018). The results of this experiment revealed that the Moracin protects against oxidative stress. On pre-incubation with the Moracin, cell viability was observed to be restored to that of the control(11,27).

○ **Antidiabetic Activity:**

Diabetes mellitus is a term that refers to a group of metabolic disorders. It is characterised by high levels of blood sugar (glucose). High blood sugar (glucose) levels are caused by problems with insulin secretion, action, or both. The condition diabetes mellitus was first diagnosed in the ancient world as a sickness associated with "sweet urine" and severe muscle loss. Increased blood glucose levels (also known as hyperglycemia) cause glucose to leak into the urine, hence the term sweet pee. Normal blood glucose levels are closely controlled by insulin, a hormone generated by the pancreas, in a healthy body(1,31).

Due to the presence of chemical compounds that lower high blood sugar levels, Chinese medicine has utilised mulberry leaves to treat diabetes for a long time (hyperglycemia). The blood sugar level rises sharply after eating high-sugar foods like potatoes or sweets, which induces the secretion of insulin to counteract the problem. However, if the need for more and more insulin occurs frequently, the pancreatic ability to produce enough insulin decreases, and body cells develop resistant to insulin because of its role in enabling glucose transfer across cell walls. As a result, type 2 diabetes is caused by this harmful insulin resistance. Obesity is the primary reason. Obesity increases a man's chances of developing diabetes. A Japanese research team discovered that the leaves of white Mulberry contain chemicals that block certain intestinal enzymes. Mulberries are a type of mulberry. Plants high in phytochemicals are important for ingesting fewer calorie-based diabetes medications. Mulberry includes alphasglucosidase inhibitors such as 1-deoxynojirimycin (DNJ) and several of its dependencies, which are used to treat mellitus diabetes(12,23,25).

○ **Anticancer Activity:**

Cancer, in its various forms, is considered to be one of the most common fatal diseases worldwide, with a high mortality rate. Many types of malignancies have recently been deemed to be among the diseases that cause the most deaths. There are many pharmaceuticals on the market to treat various types of cancer, but successful and safe drugs are rare. Natural bioactive chemicals, particularly phenolic compounds, are less poisonous and safer than synthetic and semi-synthetic substances(1).

Because of their antioxidant, anti-inflammatory, and chemopreventive qualities, anthocyanins are a category of phenolic chemicals that have been shown to reduce the risk of cardiovascular disease and cancer. The two anthocyanins found in mulberry, *Morus alba*, are cyanidin 3-rutinoside and cyanidin 3-glucoside (L.). They possess potent anticancer effects. They have been demonstrated to limit the invasion and migration of human lung cancer A549 cells by downregulating MMP-2 and urokinase plasminogen activator expression while increasing TIMP-2 and plasminogen activator inhibitor expression. In this scenario, there was also an inhibition of NF-kappa B and c-jun activation(4).

○ **Anti-inflammatory Activity:**

Mulberry leaves inhibited inflammatory processes by inhibiting nuclear factor (NF)- κ B signalling pathways, which are implicated in macrophage activation-induced inflammation. Proinflammatory cytokines such as inducible nitric oxide synthase (iNOS), cyclooxygenase-2 (COX-2), tumour necrosis factor-alpha (TNF- α), interleukin (IL)-1 β , and IL-6 were shown to be downregulated, contributing to the downregulation of NF- κ B transcription factors. In addition, mulberry leaves extract significantly inhibited endothelial cell adhesion of monocytes generated by TNF- α . Mulberry leaves have also been shown to have an anti-inflammatory effect with a dose-response association in previous research(13).

Because of the contents of morusin, kuwanon C, sanggenons B, C, D, E, and O, an extract of *Morus* root barks demonstrated inhibitory effects on inflammatory elements such as cyclooxygenase (COX) enzymes. Other investigations found that the contents had an inhibitory effect on the formation of nitric oxide (NO). Mulberry has an inhibitory effect on TNF-stimulated macrophage release(14).

- **Anti-atherosclerosis Activity:**

Mulberry leaf treatment slowed the progression of atherosclerotic events in numerous ways. Mulberry leaves extract reduced oxidative alteration of LDL particles and LDL translocation through artery wall in the process of foam cell production in in vitro tests. Lipid formation in foam cells was dramatically reduced, as evidenced by intracellular lipid analyses. In a dose-dependent way, mulberry leaves extract inhibited vascular smooth muscle cell (VSMC) proliferation and migration in cell lines and mice fed a high-cholesterol diet, according to the growth curve assay. Furthermore, mulberry leaf treatment restored normal levels of circulating endothelial dysfunction markers such as soluble vascular cell adhesion molecule-1 (sVCAM-1), fibrinogen, and nitric oxide. Mulberry leaves were found to be beneficial not just in the early stages of atherosclerosis, but also once atherosclerotic plaques had formed. The volume of plaque was greatly reduced(14).

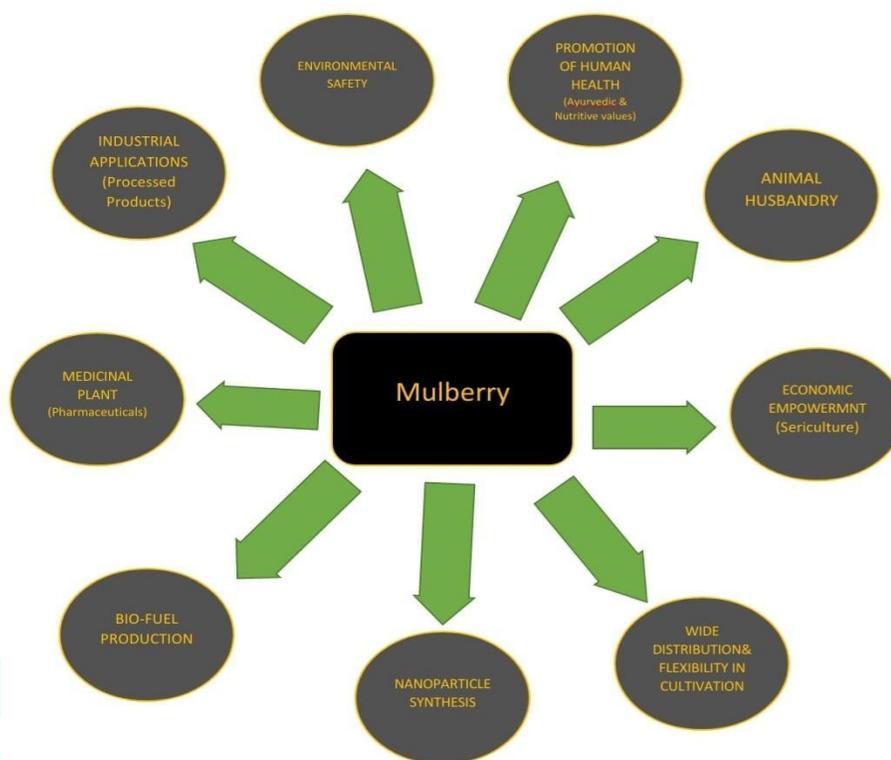
- **Antimicrobial Activity:**

Morus alba heat-stable proteins were examined for antibacterial activity against Escherichia coli, Staphylococcus aureus, Pseudomonas aeruginosa, and Bacillus subtilis, and were compared to the antibiotic chloramphenicol.(30) For all of the microorganisms examined by the mulberry varieties, the area of the zone of inhibition increased as the concentration of Heat Stable Proteins rose. The MIC for Escherichia coli was 25 l, but Morus alba was more effective against E. coli at 100 l. In another investigation, Morus alba leaf extracts were sequentially extracted with petroleum ether, chloroform, and methanol. The extracts were tested for antimicrobial activity against a variety of bacterial and fungal strains at various concentrations. Against the microorganisms, the zone of inhibition was determined. The antimicrobial activity of these extracts was compared to that of standard drugs. The results of the antimicrobial activity revealed that all of the extracts had detectable antimicrobial activity against the organisms studied in a dose-dependent manner(15,21,22).

- **Anti-Alzheimer's Activity:**

Alzheimer's disease causes a person's memory, reasoning, and, in some cases, feelings to deteriorate, as well as dementia. Evidence suggests that amyloid beta-peptide (1-42) plays a key role in the etiology of Alzheimer's disease, generating plaques and fibrils that disrupt the brain's neuron network. The findings show that mulberry extract could be used to treat Alzheimer's disease by inhibiting the development of amyloid beta-peptide (1-42) fibrils and reducing the neurotoxicity caused by amyloid beta-peptide(16).

Applications of Morus alba:



❖ Dietary Importance:

Mulberry fruit that has fully ripened has a delicious, mouthwatering taste with a pleasant aroma and flavour. It is valued for direct consumption as well as the creation of value-added products. Mulberry fruits are known for their high nutritional value, which makes them beneficial to human health. Mulberry fruits also include a variety of nutritional components that are important in human metabolism.(38) The fruit of *M.alba* is high in carbohydrate, fat, protein, vitamins, minerals, and fibres. Fresh *M.alba* fruit has a higher protein level than raspberries and strawberries, and is comparable to blackberries, but the anthocyanin content is higher than blackberry, blueberry, blackcurrant, and redcurrant. Essential and non-essential amino acids are found in *M.alba* fruit. The ratio of essential amino acids to total amino acids is 42%, which is nearly equivalent to certain protein-rich foods like fish and milk. As a result, it can be regarded a good source of protein(4,29).

❖ As Foodstuff:

Mulberry fruits are edible and well-known for their delectable flavour. They can be consumed straight or used to make wine, jam, or soft beverages. Mulberry fruits have several desirable characteristics, including a pleasant flavour, a moderate size, a pleasing colour, and strong nutritional and therapeutic qualities. Fresh mulberry fruits are high in amino acids, vitamins, and minerals including Zn, Mn, Fe, and Ca, which are essential for human health. Mulberry fruits are also high in pectin and fibrin, so they're a good source of both. Mulberry fruits were also investigated for use as a colouring and flavouring ingredient, among other things. Mulberry leaf has also been attempted in India in the preparation of various dishes such as tea, pakoda, dhokla, and cakes, with a high rate of acceptability due to its high nutritional content and taste(17).

❖ As Animal Feed:

The mulberry, which is high in protein, can be used as animal feed. During silkworm rearing, the tender leaves and whole shoot of the mulberry are commonly used to feed the young and late instars.(41) Mulberry leaf stalks and leftovers (such as twigs and shoots) regarded waste during this process, on the other hand, can be used as great feed for cows, sheep, and other livestock. Mulberry is also a hardy plant that may be grown in barren areas, along the roadside, and beside canals, among other places. As a result, it can serve a dual purpose: making animal husbandry a successful commercial enterprise for small and marginal farmers while also assisting in the appropriate management of finite land resources. Mulberry fodder with balanced nutrient contents of N, Ca, and P was an effective animal feed source(18,33).

❖ As Medicine:

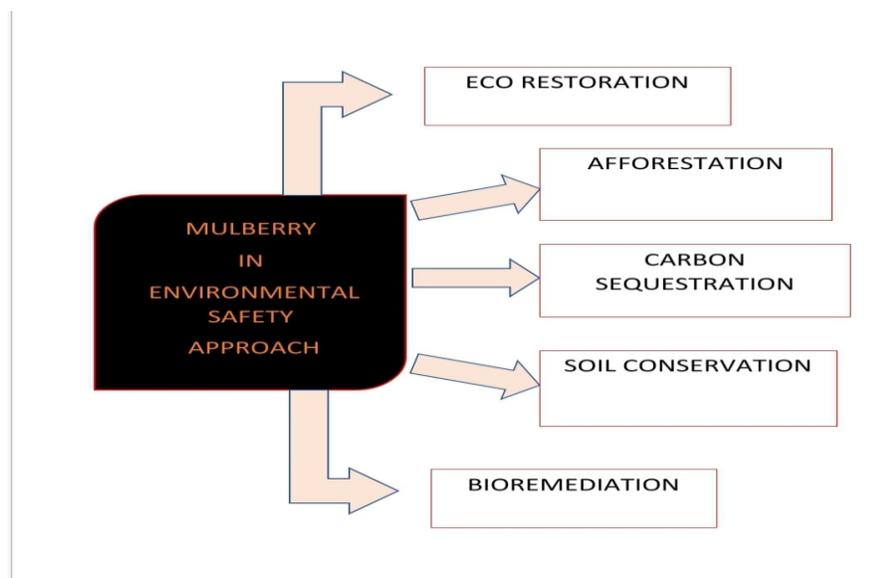
The importance of the mulberry plant in traditional medicine has long been recognised. Mulberry plant parts have been employed for thousands of years due to the presence of numerous essential bioactive chemicals such as polyphenol and antioxidative flavonoid compounds. Pharmacological substances are found in several regions of the mulberry plant, and their medical value is substantially greater. Several writers explored the therapeutic qualities of extracts extracted from mulberry leaves and fruits. Moranolin (DNJ), moran (glycopeptides), and hydrophobic flavonoids are found in the mulberry plant (flavones and flavonone)(19,32,42).

❖ For Cosmetics Application:

M. alba (leaves, fruits, root bark, and branches) is used in cosmetics in most Asian countries. In one study, an ethanolic extract of *M. alba* fruit was used to create an emulsion-based cream that was tested for eight weeks to see how it affected skin melanin, erythema, and moisture content. The cream's formulation dramatically reduced melanin content without causing skin discomfort. In other research, betulinic acid (C₃₀H₄₈O₃) was isolated from *M. alba* (hexane extract of stem and root bark), which has tyrosinase inhibitory activity and can be used as a whitening agent. The ethanolic extract of *M. nigra* has excellent tyrosinase inhibitory activity and can be used to make peel-off masks and acne treatments. Mulberries can aid in the decrease of age-related spots and blemishes, as well as the suppression of free radical-linked oxidative activity, giving the skin a healthier and shinier appearance(4,28).

❖ As Environmental Safety:

Rapid industrialization, combined with rising population, has had a negative impact on the environment. Global warming, natural disasters (such as floods and droughts), abrupt soil erosion, and a high rate of disease outbreak are all thought to have direct links to pollution. Mulberry has a number of distinct characteristics that have been linked to its ability to reduce pollutants in the environment. Mulberry plantations, for example, have shown promising outcomes in terms of improving air quality, boosting water retention capacity, removing heavy metals from polluted soils, and fostering beneficial soil microflora and fauna. This section demonstrates the value of the mulberry tree in terms of reducing the problems that have arisen as a result of pollution(20,24,26).



Conclusion:

Natural goods are being re-emphasized to address a number of health problems. Consumers are increasingly more attentive of their eating habits as the link between health and nutrition is well known. The creation of functional, nutraceuticals, and pharma foods, which now dominate the global nutrition market, emerged from the investigation of these links. The purpose of this review was to highlight the importance and applicability of *Morus* species in various fields, and it is obvious from the discussion that mulberry is a diverse medicinal plant with tremendous vitality. *Morus* species and their bioactive phytochemicals have been shown to have a wide range of biological activities, including antioxidants, anti-diabetic, hypolipidemic, anti-obesity, antihypertensive, and anti-atherosclerosis properties, among others. *Morus* extracts and components, particularly flavonoids such as chlorogenic acid, quercetin, rutin, and isoquercitrin, scavenge free radicals and have anti-oxidant potential. DNJ and fagomine, two alkaloids found in *M. alba*, have been shown to have anti-inflammatory properties.

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