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Significance of Species of Mulberry Leaves with Reference to their Medicinal Value

Rutuja Vitthal Shelake[1] and Sanjay K. Bais[2]
Fabtech College of Pharmacy, Sangola, Solapur, Maharashtra[1,2]
rutujashelake96@gmail.com

Abstract: *Mulberry leaves (Morus spp.) have gained considerable attention nutrition, traditional medicine, pharmaceuticals, and sustainable agriculture. the cultivation and propagation of mulberry plants, the major species used. cultivated in tropical, subtropical, and temperate regions, particularly for sericulture and silkworm nutrition. Their propagation through seeds, stem cuttings, and grafting supports the development of cultivars with desirable agronomic and phytochemical characteristics. Several species, including Morus alba, Morus nigra, and Morus rubra. Mulberry leaves contain polysaccharides, vitamins, and minerals. Among these constituents, 1-deoxynojirimycin (DNJ), rutin, quercetin derivatives, and chlorogenic acid have attracted interest because of their potential metabolic and antioxidant effects. Reported pharmacological activities include antioxidant, anti-inflammatory, antidiabetic, antimicrobial, and lipid-regulating effects. Despite encouraging findings from laboratory and animal studies, variations in plant species, cultivation conditions, extraction methods, and compound concentrations complicate comparisons between studies. mulberry leaves represent a promising botanical resource, although stronger clinical evidence is required to establish their safety, efficacy, and appropriate therapeutic applications.*

Keywords:Morus alba, mulberry leaves, bioactive constituents, pharmacological activities, phytochemicals, nutraceuticals, cultivation, therapeutic potential.

I. INTRODUCTION

Cardiometabolic health is influenced by several interconnected abnormalities, including impaired glucose regulation or insulin resistance. thereby contributing to increased disease-related complications and mortality .(1)

The development and progression of oxidative stress, endothelial dysfunction, and persistent vascular inflammation. These affect vascular health and may occur alongside metabolic abnormalities or develop independently (Savoia et al., 2011). The simultaneous presence of multiple cardiometabolic abnormalities may further increase an individual's overall cardiovascular and metabolic risk.(2)

Lifestyle modification remains an important component of prevention and treatment. Appropriate nutritional management, regular physical activity, and avoidance of smoking can contribute to improved metabolic and cardiovascular health. These used together with conventional pharmacological therapies when clinically required. Combining lifestyle interventions with suitable medical treatment may provide greater benefits in controlling cardiometabolic abnormalities.(1,2,3)

II. AIM

to the provide a comprehensive overview of mulberry leaves (Morus spp.), focusing on their cultivation, propagation, phytochemical composition, pharmacological properties, and potential applications in healthcare, nutrition, and pharmaceutical research. (7,8,9)

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III. OBJECTIVES OF MULBERRY LEAVES

The specific objectives are:

1. To review the cultivation, propagation, and major species of mulberry plants.
2. To identify and describe the important bioactive constituents present in mulberry leaves.
3. To investigate the reported anti-inflammatory, and antimicrobial effects.
4. To explore the potential applications of mulberry leaves in nutrition, traditional medicine, nutraceuticals, and pharmaceutical development.
5. To identify existing research gaps and safety, efficacy, and therapeutic potential of mulberry leaf preparations.(10)

IV. CULTIVATION AND PROPAGATION OF MULBERRY LEAVES

Mulberry plants (Morus spp.) are widely cultivated because of their economic importance in sericulture and their potential value. The quality and chemical composition of mulberry leaves can vary according to genetic characteristics, soil conditions, climate, irrigation, and agricultural management practices.

Although the plant can tolerate a range of environmental conditions, appropriate moisture availability and balanced nutrient management support vigorous growth and leaf production. Regular pruning and timely harvesting encourage the development of new shoots and help maintain a continuous supply of leaves. The selection of suitable cultivars according to local climatic conditions is also important for improving productivity and plant health.(13)

Propagation Method

Mulberry plants can be propagated through sexual and vegetative methods. Seed propagation is mainly useful for breeding and genetic improvement because seedlings may exhibit considerable variation in their characteristics. For commercial cultivation, vegetative propagation is often preferred because it helps preserve the desirable traits of selected plants.Stem cutting is a commonly used method in which healthy, mature branches are selected and planted in a suitable rooting medium. Adequate moisture, suitable temperature, and appropriate growing conditions promote root formation and the establishment of young plants. Grafting and budding may also be employed to combine desirable characteristics of selected cultivars, depending on the species and cultivation objectives. In addition, tissue culture techniques offer opportunities for rapid multiplication of selected plant material under controlled conditions(14).

Mulberry Leaves: Various Species and Their Characteristics

mulberry leaves contain minerals, vitamins, dietary fibre, polyphenols, flavonoids, and other biologically active compounds. These components have encouraged researchers to investigate mulberry leaves for their possible nutritional, antioxidant, anti-inflammatory, antidiabetic, and other health-related properties. Therefore, understanding the major mulberry species is important when evaluating their nutritional and medicinal potential.(15)

1. Morus alba

Morus alba L., commonly called white mulberry, is widely cultivated mulberry species. The species is especially important in sericulture because its leaves provide suitable nutrition for the silkworm.Depending on the variety and stage of growth, the leaves may be entire, lobed, or deeply divided. Their nutritional quality can vary according to cultivar, soil conditions, climate, irrigation, harvesting stage, and cultivation practices.Morus alba leaves contain proteins, minerals, fibre, vitamins, and several secondary metabolites. Morus alba leaves may influence carbohydrate digestion and glucose regulation. However, the results of laboratory and animal studies should not automatically be interpreted as evidence of clinical effectiveness in humans.(15)

2. Morus nigra

Morus nigra L. is commonly known as black mulberry. It is traditionally associated with regions of western Asia .The leaves of Morus nigra are generally thicker and more rough-textured than those of some other mulberry species. They may have a broad shape with serrated margins and can show variation depending on age and growing conditions.Black mulberry leaves contain a range of nutritional and phytochemical constituents.These substances are of interest because

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of their potential antioxidant properties. Studies of Morus nigra have investigated antioxidant, antimicrobial, anti-inflammatory, and metabolic activities. (16)

3. Morus rubra

Morus rubra L., commonly known as red mulberry, is a species native to North America. It is found naturally in several regions and can grow under a range of environmental conditions.The leaves of red mulberry are relatively variable in appearance. mulberry leaves is generally green during the growing season and undergo changes before falling during the colder months.The chemical profile can differ depending on geographical location, plant maturity, environmental conditions, and extraction methods. Such variation is important when comparing the biological activity of leaves collected from different sources.

4. Morus macroura

Morus macroura is another mulberry species found primarily in parts of Asia. It is sometimes referred to as Himalayan mulberry and is associated with mountainous and subtropical regions. Leaf morphology can vary considerably depending on environmental conditions and plant development. As with other mulberry species, the leaves contain nutrients and plant secondary metabolites.studies of different Morus plants suggest that it may also contain phenolic compounds, flavonoids, minerals, and other biologically relevant constituents.The cultivation and utilization of Morus macroura may have regional importance, particularly in areas where mulberry is used for sericulture or traditional plant-based applications.(17)

5. Morus indica

Morus indica is a mulberry species associated particularly with the Indian subcontinent and has historically been important in Indian sericulture. The species and related cultivated forms are valued for their leaf production and suitability for silkworm cultivation. In agricultural systems, leaf yield and quality are important characteristics because they directly influence silkworm growth and silk production.Like other mulberry species, Morus indica leaves contain proteins, carbohydrates, minerals, fibre, and various phytochemicals. (18)

V. BIOACTIVE CONSTITUENTS OF MULBERRY LEAVES :

Mulberry leaves are an important source of naturally occurring bioactive compounds with potential antioxidant, anti-inflammatory, antidiabetic, antimicrobial, and metabolic health benefits.they contain diverse phytochemicals, including flavonoids, phenolic acids, alkaloids, aminosugars , polysaccharides, aminoacids, vitamins, and minerals. . The following material is organized as an original scientific-style draft that you can develop for a manuscript. It uses freshly composed explanations rather than copied passages. However, **original wording alone does not establish scientific originality**: claims, quantitative data, and findings from previous studies must still be supported with appropriate references.(19)

Detailed description of individual bioactive constituents

1. Flavonoids

These compounds possess a characteristic carbon framework consisting of two aromatic rings connected through a heterocyclic ring. Variations in hydroxylation, methylation, glycosylation, and other structural modifications produce compounds with different solubilities, stability characteristics, and biological properties.Reported examples include quercetin derivatives, kaempferol derivatives, rutin, and astragalin. Specialized flavonoid-related compounds, including moracinflavans and other mulberry-associated structures, have also received research attention. marker for chromatographic characterization, provided the method has been validated for the specific leaf material.(22)

2. Phenolic acids

Phenolic acids are another important category of mulberry leaf constituents. They are commonly divided into hydroxybenzoic acids and hydroxycinnamic acids according to their chemical structures. The number and position of hydroxyl and methoxy groups influence their chemical reactivity, polarity, and interactions with other molecules.Reported phenolic acids in mulberry leaves include chlorogenic, caffeic, gallic, protocatechuic, vanillic,

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syringic, p-coumaric, ferulic, and p-hydroxybenzoic acids. Their relative concentrations differ among cultivars and extraction procedure

Chlorogenic acid

Chlorogenic acid is a caffeoylquinic acid derivative widely investigated in plant foods. It may contribute to the radical-scavenging activity of mulberry leaf extracts. Its structure supports antioxidant reactions, and it may occur in free form or as part of larger conjugated molecules. The balance between free and bound forms can affect the amount detected during analysis.(25)

3. Iminosugar alkaloids

Mulberry leaves are particularly notable for containing amino sugars, a group of nitrogen-containing compounds whose structures resemble those of ordinary sugars. **1-Deoxynojirimycin (DNJ)** is the best-known example. By slowing the enzymatic release of absorbable sugars, DNJ may reduce the rate at which glucose enters the circulation after a carbohydrate-containing meal. The degree of effect depends on the administered amount, formulation, meal composition, and other physiological factors.(26)

4. Benzofurans and related phenolic compounds

Benzofurans are aromatic compounds containing a fused benzene and furan ring system. Mulberry plants produce a range of specialized aromatic metabolites, some of which are associated with the genus. Moracin-related compounds and other structurally distinct phenolic metabolites have been described in mulberry phytochemical studies. Findings for a benzofuran isolated from root bark, for example, cannot automatically be presented as evidence that the same compound occurs at a meaningful concentration in mulberry leaves. This distinction is particularly important when preparing a leaf-specific review article.(25)

5. Coumarins and stilbenoids

Coumarins and constitute additional groups of aromatic plant metabolites. Coumarins contain a benzopyrone-related structural framework, whereas contain a characteristic arrangement of two aromatic rings linked by a short carbon chain.

Biological significance. These classes may provide additional chemical diversity to mulberry extracts and offer candidates for targeted phytochemical screening. Their contribution to the overall activity of a leaf extract remains dependent on actual abundance, extractability, and biological potency.(25)

6. Terpenoids and volatile constituents

Terpenoids are a diverse class of natural products constructed from isoprene-derived building blocks. Volatile constituents are generally examined using techniques such as gas chromatography–mass spectrometry (GC–MS), whereas less volatile and more polar compounds often require liquid chromatography-based methods. (23)

7. Polysaccharides and dietary fibre

Mulberry leaves contain carbohydrates that serve structural, storage, and nutritional functions. These include cell-wall polysaccharides and dietary fibre, whose composition and physicochemical characteristics depend on processing method. The term mulberry leaf polysaccharides should therefore be used carefully. It does not necessarily refer to a single chemically defined compound.

8. Proteins, amino acids, vitamins, minerals, and organic acids

Proteins and amino acids contribute to nutritional quality, while vitamins and minerals support normal physiological functions. Organic acids can influence acidity, taste, and other physicochemical properties of leaf-based preparations. These constituents should be distinguished from specialized secondary metabolites: nutritional value and phytochemical bioactivity .(23)

VI. BIOLOGICAL PROPERTIES OF MULBERRY LEAVES

1. Antihyperglycaemic Effect

Mulberry leaves have shown promising blood-glucose-lowering activity in experimental studies. A single dose can reduce postprandial blood glucose (PPG) following carbohydrate consumption, particularly by lowering the maximum

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glucose level and the incremental area under the curve (iAUC). At the same time, enzymes involved in glycolysis, including glucokinase, phosphofructokinase and pyruvate kinase, may be increased. Since DNJ has limited intestinal absorption, other constituents, particularly phenolic compounds, may contribute to these systemic effects.(28)

2. Antihyperlipidaemic Effect

Mulberry leaves have demonstrated lipid-lowering effects in experimental animals.Mulberry leaves may also reduce the accumulation of lipids in the liver by decreasing both the number and size of lipid droplets in hepatic cells. They may also reduce lipid synthesis by influencing enzymes and regulatory proteins such as fatty acid synthase (FAS), glycerol-3-phosphate acyltransferase (GPAT), SREBP-1c and LXR.(27)

3. Anti-obesity Effect

Reductions in visceral fat and total body-fat accumulation have also been observed. Microscopic studies indicated fewer adipocytes and smaller lipid droplets following treatment. One proposed mechanism is inhibition of adipocyte formation. Mulberry leaf extracts may decrease the expression of transcription factors such as SREBP-1 and PPAR-γ, which are involved in adipocyte differentiation. They can also reduce the activity or expression of lipogenic enzymes, including FAS and acetyl-CoA carboxylase (ACC). Phenolic compounds are considered possible contributors to these anti-obesity effects.(27,28)

4. Antihypertensive Effect

mulberry leaves help regulate elevated blood pressure. The antihypertensive activity may involve inhibition of angiotensin-converting enzyme (ACE). calcium entry into vascular smooth-muscle cells, thereby reducing vascular contraction. In addition, γ-aminobutyric acid (GABA) present in mulberry leaves has been suggested as another possible contributor to the blood-pressure-lowering effect.(27,28)

5. Antioxidative Effect

Mulberry leaves contain several compounds capable of protecting cells against oxidative stress. The extracts can also participate in electron-transfer reactions and reduce ferric ions (Fe^{3+}) to ferrous ions (Fe^{2+}). mulberry leaves may enhance glutathione reductase, glutathione peroxidase, glutathione-S-transferase and superoxide dismutase. Chlorogenic acid has also demonstrated considerable antioxidant potential.(27)

6.Anti-inflammatory Effect

Mulberry leaves may suppress inflammatory reactions by influencing the nuclear factor-kappa signalling pathway. Mulberry leaf reduce TNF-α-induced adhesion of monocytes to endothelial cells. These findings suggest a dose-dependent anti-inflammatory potential.(27)

7. Anti-atherosclerotic Effect

Mulberry leaves may help prevent or slow the development of atherosclerosis through several mechanisms. Experimental evidence indicates that mulberry extracts can reduce oxidative modification of LDL and limit its movement across the arterial wall. This may decrease lipid accumulation within foam cells. Animal studies further suggest that prolonged treatment can reduce the size of established atherosclerotic plaques.(29)

VII. APPLICATIONS OF MULBERRY LEAVES

Mulberry leaves (Morus spp.) are nutritionally and pharmacologically important plant materials containing proteins, minerals, vitamins, flavonoids, phenolic acids, alkaloids and other phytochemicals. Their long-standing use as silkworm feed, food material, herbal tea and traditional medicine has encouraged their investigation for modern nutritional and health-related applications.(32)

1. Glucose Management

Among the different biological activities reported for mulberry leaves, their potential role in glucose regulation has received considerable scientific attention. The leaves contain 1-deoxynojirimycin (DNJ), an iminosugar that can interfere with intestinal α-glucosidase and other carbohydrate-digesting enzymes. By slowing the breakdown of dietary carbohydrates, DNJ may help moderate the increase in blood glucose after meals. Therefore, mulberry leaf extracts are being investigated as potential dietary or nutraceutical ingredients for supporting glucose metabolism.(32)

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2. Sericulture

The most established application of mulberry leaves is their use as feed for the silkworm, Bombyx mori. The nutritional composition of the leaves supports larval development and contributes to silk production. (32)

3. Food and Nutritional Applications

In certain regions, young mulberry leaves are consumed as vegetables or incorporated into traditional food preparations. Their protein, mineral, vitamin, fibre and phytochemical content provides nutritional value. Leaf powder and other processed forms have also attracted interest as ingredients for functional foods and other value-added nutritional products.(32)

4. Herbal Tea and Beverages

Mulberry leaves can be dried and processed into herbal tea and other plant-based beverages. The presence of phenolic compounds, flavonoids and other bioactive constituents has contributed to interest in these preparations as functional beverages..(32)

5. Traditional Medicinal Use

Mulberry leaves have been used traditionally in herbal preparations, particularly in Asian medicinal practices. Their traditional applications have contributed to scientific investigations into their possible effects on glucose metabolism, lipid metabolism, inflammation and oxidative stress. Modern research is therefore examining whether these traditional uses can be supported by pharmacological and clinical evidence.(32)

6. Functional Foods and Nutraceuticals

The combination of nutritional components and biologically active phytochemicals makes mulberry leaves potential ingredients for functional foods and nutraceutical products. Leaf powders and standardized extracts are being investigated for incorporation into products intended to support metabolic and general health. Nevertheless, appropriate standardization, safety assessment and clinical validation are necessary before specific health claims can be established.[1]

7. Postprandial Glucose Control

Mulberry leaf preparations have attracted particular interest for their possible influence on postprandial glucose levels. DNJ is considered an important contributor because of its inhibitory effect on intestinal carbohydrate-digesting enzymes. Experimental investigations and some clinical studies have reported beneficial effects on post-meal glucose responses, although the strength of evidence varies according to the preparation, dose and study design.(32)]

8. Lipid-Metabolism Applications

Research has also examined the influence of mulberry leaves on lipid metabolism. Experimental findings indicate that mulberry leaf constituents may affect cholesterol and triglyceride metabolism and may interfere with pathways associated with lipid synthesis and accumulation. These observations support further investigation of mulberry leaves as components of functional foods or nutraceuticals designed to support healthy lipid metabolism.(32)

9. Weight-Management Applications

Preclinical investigations have reported that mulberry leaf extracts may influence body-weight gain, fat deposition and adipose-tissue development. Such observations have generated interest in their possible incorporation into functional foods and nutraceutical formulations intended for weight-management support. However, evidence from human studies remains insufficient to establish a definite weight-loss effect.(32)

10. Antioxidant Applications

Mulberry leaves contain phenolic acids and flavonoids with measurable antioxidant properties. Extracts have demonstrated free-radical-scavenging and related antioxidant activities in experimental assays. Consequently, mulberry-derived ingredients are being investigated as natural antioxidant sources for food, nutraceutical and pharmaceutical research.(32)

11. Anti-inflammatory Applications

Several studies have reported that mulberry leaf constituents can modulate inflammatory pathways and mediators. This has increased interest in their potential use as sources of natural compounds for anti-inflammatory formulations.

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However, most of the available evidence is derived from laboratory and animal experiments, and additional human studies are necessary to establish clinical relevance.(32)

VIII. MULBERRY LEAVES AS A POTENTIAL BIOMATERIAL

Mulberry leaves, mainly obtained from plants belonging to the genus Morus, are traditionally recognized as the primary food source for silkworms. Beyond their agricultural importance, these leaves have attracted scientific interest because they contain a variety of natural compounds with functional and biological properties. Their availability, renewable nature, and chemical composition make mulberry leaves an interesting raw material for the development of natural and sustainable biomaterials.(36)

Mulberry leaves contain carbohydrates, proteins, dietary fibers, minerals, polyphenols, flavonoids, vitamins, and other phytochemicals. The proportion of these constituents can vary according to plant species, geographical conditions, maturity of the leaves, and processing methods. Some of these compounds possess antioxidant and antimicrobial characteristics, which may provide additional functionality when leaf-derived materials are incorporated into biomaterial systems.(36)

The fibrous and polymer-rich components of mulberry leaves can be explored for the preparation of natural films, composites, and other biodegradable materials. Plant-derived fiber are attractive because they are renewable and can potentially reduce dependence on petroleum-based materials. After suitable processing, mulberry leaf biomass may be converted into useful components for composite or polymeric systems.(39)

Mulberry leaves may also have potential in pharmaceutical biomaterial research. Extracts or purified fractions can be incorporated into polymeric matrices, films, gels, or hydrogel-type systems. Such formulations could be investigated for controlled release of active compounds or for providing antioxidant functionality. (39)

The biological properties of mulberry leaves make them an interesting candidate for research related to wound-care materials. Polyphenols and flavonoids present in the leaves may provide antioxidant activity, while some leaf constituents have demonstrated antimicrobial effects in experimental studies. When incorporated into an appropriate biocompatible matrix, these compounds could potentially contribute to functional wound-dressing systems. However, their suitability for clinical wound care requires systematic evaluation of toxicity, biocompatibility, stability, and healing performance.

Sustainable Biomaterial Source An important advantage of mulberry leaves is their renewable plant origin. Leaves are produced repeatedly during plant growth and can provide a readily available biomass resource. Utilizing suitable leaf residues for material development may also support the concept of waste reduction and value addition. (38)

IX. DISCUSSION

mulberry leaves are increasingly being investigated as a functional plant material with potential nutritional and pharmacological significance. Their presence of polyphenols, flavonoids, alkaloids, polysaccharides, vitamins, minerals, and other secondary metabolites. The chemical composition of mulberry leaves varies considerably depending on the Morus species, geographical location, stage of leaf maturity, cultivation conditions, and processing method. Important nutrients reported in mulberry leaves include proteins, dietary , minerals, and several vitamins. flavonoids that contribute to their antioxidant potential. These components may act individually or synergistically and could contribute to the overall functional properties of the leaves. A characteristic constituent, 1-deoxynojirimycin (DNJ), can inhibit intestinal carbohydrate-digesting enzymes, particularly α-glucosidase. By slowing carbohydrate breakdown and glucose absorption, DNJ-containing mulberry preparations may help moderate the rise in postprandial blood glucose. This property has made mulberry leaves an important subject of research in the development of plant-based approaches for glycaemic management. However, the magnitude of the effect depends on the DNJ concentration, preparation method, dose, and individual biological factors. the antioxidant properties of mulberry leaves have generated interest in areas such as cardiovascular, hepatic, and neurological research. Nevertheless, antioxidant activity observed in laboratory assays should not automatically be interpreted as a confirmed therapeutic effect in humans.

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Mulberry leaves have also demonstrated anti-inflammatory and lipid-modulating potential in preclinical investigations. Certain leaf constituents may influence inflammatory pathways and lipid metabolism, suggesting possible applications in research related to metabolic health.(40,41)

X. FUTURE PROSPECTS

Mulberry leaves (Morus spp.) development in the food, nutraceutical, pharmaceutical, and biomaterial sectors because of their nutritional composition and diverse phytochemical profile. Their naturally occurring proteins, dietary , minerals, polyphenols, flavonoids, and other bioactive constituents provide opportunities for developing value-added products from an underutilized plant resource.(42).In the food and nutraceutical field, mulberry leaves could be incorporated into functional foods, herbal beverages, powdered formulations, dietary products, and other health-oriented preparations.Future product development should focus on standardized preparations with controlled levels of active constituents rather than relying only on crude leaf powder. The pharmaceutical potential of mulberry leaves also warrants further investigation. Phenolic compounds, flavonoids, and other phytochemicals may contribute to antioxidant, anti-inflammatory, glucose-modulating, and lipid-regulating activities observed in experimental studies. (42,43).However, systematic clinical investigations are required to determine effective doses, safety, bioavailability, possible drug interactions, and long-term effects. Standardization of extraction procedures and chemical markers will be particularly important for developing reproducible mulberry-leaf formulations. Their polysaccharide components could be explored for biodegradable films, composite materials, hydrogel systems, and other functional formulations. Utilizing leaf biomass in this manner could provide an additional route for value addition while supporting environmentally sustainable material development. Selective breeding help develop mulberry varieties with improved leaf yield, higher concentrations of desirable phytochemicals, better nutritional characteristics, and increased resistance to drought, pests, and other environmental stresses. Genomic approaches could also assist in identifying genes associated with the production of important bioactive compounds such as DNJ and phenolic constituents. Another promising area is the use of mulberry leaves and their pigments or phytochemicals as natural functional ingredients. Research should particularly address the stability of bioactive compounds during processing and storage. Overall, the future of mulberry leaves depends on converting promising laboratory findings into standardized, safe, reproducible, and clinically supported applications. Greater collaboration between plant scientists, pharmaceutical researchers, food technologists, and biomedical researchers could accelerate this process. With appropriate scientific validation and quality control, mulberry leaves may develop from a traditional plant resource into a valuable source of functional ingredients and innovative sustainable products.(44)

XI. CONCLUSION

Mulberry leaves (Morus spp.) represent a valuable plant resource with considerable nutritional, phytochemical, and therapeutic potential. Although they are traditionally recognized as an essential feed for silkworms, increasing research has highlighted their importance as a source of proteins, dietary fiber, minerals, polyphenols, flavonoids, and other biologically active constituents. These compounds may contribute to the diverse functional properties associated with mulberry leaves. (45).This characteristic has made mulberry leaves an important subject of research in the area of glucose management. In addition, phenolic and flavonoid compounds may contribute to antioxidant and anti-inflammatory effects by influencing oxidative and inflammatory processes. Experimental investigations have also explored the possible hepatoprotective, cardioprotective, antimicrobial, lipid-modulating, and neuroprotective activities of mulberry leaves. However, many of these findings are based on laboratory or animal studies.he diverse composition of mulberry leaves use in functional foods, nutraceutical formulations, pharmaceutical research, cosmetics, and sustainable biomaterial development. Leaf powders, extracts, and isolated phytochemicals may provide useful ingredients for developing value-added products, provided that appropriate quality, stability, toxicity, and dosage standards are established. Future research should concentrate on identifying the most important bioactive constituents, understanding their mechanisms of action, improving extraction and standardization methods, and evaluating

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bioavailability and safety. available plant resource into standardized and scientifically validated value-added products. (46)

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