Phytochemical Evaluation and Nutritional Analysis of Moringa oleifera Leaf Powder and its Capsule Formulation

Tejas S Ahire[1], Vrushali B Jagtap[2]
[1]*Students, Department of Pharm D, MGV's Pharmacy College, Panchavati, Nashik*
[2]*Assistant Professor, Department of Pharm D, MGV's Pharmacy College, Panchavati, Nashik*

***Abstract*—The "tree of life" or "miracle tree," Moringa oleifera, is regarded as an essential herbal plant because of its many health advantages, both medicinal and non-medical. The plant has historically been used to treat inflammation, cancer, heart disease, liver illness, wounds, and discomfort. It also intends to offer insight into the plant's economic and phytopharmaceutical uses. The Moringa oleifera tree yields incredibly nutrient-dense leaves. They can be eaten dried, cooked, or raw. It is feasible to turn dried Moringa leaves into leaf powder since they still contain nutrients. This leaf powder is easily manufactured and stored when leaves are plentiful. You can add moringa leaf powder to any recipe and it's a great nutritional supplement. Powdered moringa (Moringa oleifera) leaf has long been thought to provide health advantages. Functional components such as protein, vitamins, minerals, and phytonutrients like carotenoids, tocopherols, polyphenols, flavonoids, alkaloids, and tannins can all be found in abundance in moringa leaf powder. On the other hand, moringa is a plant found in many tropical nations worldwide. Geographical variations, cultivars, environmental factors, seasons, genotypes, and variants all affect its quality. In order to aid in future study, this review attempts to gather comprehensive overview of global studies, pharmacological activity, phytochemical, toxicological, and ethnomedical updates of Moringa oleifera. This page discusses the properties of moringa leaf powder extract as well as the bioactive components of moringa leaf powder. Additionally covered is the impact of fortifying food products with moringa leaf powder on their properties. Numerous pharmacological qualities, including those that are antioxidant, hepatoprotective, cardioprotective, anti-inflammatory, and anticancer, are present in moringa leaf powder.**

***Index Terms*—Moringa oleifera, traditional medicinal uses, pharmacological activity, bioactive compounds, fortification, leaf extract, capsule.**

I. INTRODUCTION

The variety and many uses of Moringa oleifera make it a miracle tree. It also includes nutrients and health-promoting secondary metabolites.[1] Moringa is a common component of traditional medicine in many underdeveloped nations. Tropical plants like moringa are abundant in bioactive substances. Pharmacological properties of moringa include antioxidant, antidiabetic, anti-inflammatory, and anticancer properties [2]. The presence of moringa's bioactive components is sufficiently correlated with its pharmacological characteristics. The anti-diabetic properties of moringa leaves are beneficial [3].

There are 13 species (M. oleifera, M. arborea, M. rivae, M. ruspoliana, M. drouhardii, M. hildebrandtii, M. concanensis, M. borziana, M. longituba, M. pygmaea, M. ovalifolia, M. peregrina, M. stenopetala) in all, varying in size from small herbs to enormous trees, that are found in tropical and subtropical regions. Moringa Oleifera (MO) is the species that is most commonly grown. MO is planted for its delicious leaves, flowers, and nourishing pods. It can be used as food, medicinal, cosmetic oil, or animal feed. Its height varies between 5 and 10 meters [4].

Numerous investigations have confirmed the positive impacts on people [5]. It is known that MO contains a large number of bioactive chemicals. The plant's leaves, which are abundant in vitamins, carotenoids, polyphenols, phenolic acids, flavonoids, alkaloids, glucosinolates, isothiocyanates, tannins, and saponins, are the most commonly utilized portions [6]. The pharmacological characteristics of MO leaves may be explained by the abundance of bioactive chemicals. These pharmacological characteristics have been

verified by several in vitro and in vivo investigations. Since MO leaves are high in antioxidants and other elements that people in developing nations sometimes lack, they are mostly employed for medical purposes as well as human nourishment. MO leaves have been used to cure a number of illnesses, including diabetes, hypertension, and typhoid fever in addition to malaria [7].

TAXONOMICAL CLASSIFICATION

The plant M. oleifera belongs to the [8]

Kingdom: Plantae
Sub kingdom: Tracheobionta
Super division: Spermatophyta
Division: Magnoliophyta
Class: Magnoliopsida
Sub class: Dilleniidae
Order: Capparales
Family: Moringaceae
Genus: Moringa
Species: oleifera

MATERIALS AND METHODS

Collection of leaves
↓
Washing
↓
Drying (50–60°C)
↓
Grinding
↓
Sieving
↓
Powder
↓
Capsule filling

II. PLANTING & GROWING MORINGA OLEIFERA

There are thirteen species of moringa known to exist. The most well-known is Moringa oleifera, a tree that grows quickly and is found in all tropical and subtropical regions. Temperatures between 25 and 35°C (77 and 95°F) are ideal for moringa growth. Although it can withstand some drought, it thrives in areas with annual rainfall of 250 to 1500 mm (10 to 60 in). It also loves elevations below 600 m (2000 ft). however, can endure in the tropics at elevations of 1200 meters (4000 feet); it cannot withstand extended flooding or inadequate drainage: Moringa can be grown by seeds or cuttings, and it prefers well-drained sandy-loam or loam with a pH of 5.0–9.0.[9]

In an intensive cultivation system, moringa is planted directly into a garden bed at close intervals or transferred there and then routinely clipped. In a tiny plot, this intense approach yields the most leaves possible. Research conducted in Nicaragua showed that 10 cm x 10 cm (4 in x 4 in) was the ideal spacing for intensive plots to yield the highest yield. This method's drawbacks include the inability to produce seeds and the extra upkeep needed for insect control, fertilizer, and irrigation. [10]

MAKING MORINGA LEAF POWDER

1. Leaf Harvest

Once the plants are established, moringa leaves can be collected whenever you want. In intense production plots, plants are clipped to a height of 15–50 cm (6–20 in) in order to collect leaves. Trimming intensive plots might occur up to nine times a year. In order to collect leaves from trees, chop the tree down to a height of 1-2 meters (3-6 feet); this is best done in the wet season to allow the tree to recuperate before the dry season. Other techniques for harvesting leaves from trees include pruning back half of each branch, plucking a few leaves from each branch, and trimming certain branches (keeping some branches for the next harvest or seed production). After being collected, leaves need to be separated from their stems. Any leaves that get discoloured or damaged during this process can be saved for compost or animal feed. [Branches and stems can also be composted or fed to animals.] Next, leaves are washed in either very clean water or diluted bleach solution (1:100) to get rid of bacteria and grime.

2. Drying Leaves

To avoid nutrient loss, leaves should be dried in a space shielded from light and kept free of dust and pests to avoid contamination. To keep leaves clean as they dry, you can cover them with mosquito netting or thin cloth if needed. To stop mould from growing, the drying process should be finished as soon as possible. If leaves start to mould or mildew, they should be thrown out or composted.

3. Grinding Leaves

A mortar and pestle, household grain grinders, hand-cranked or motor-driven burr mills, or even just scrubbing the dry leaves against a fine screen can all be used to turn them into powder. After the dried leaves have been ground into a powder, any leftover stems are taken out of the powder by sieving it.

STORING MORINGA LEAF POWDER

It is recommended to keep moringa leaf powder in airtight containers that are shielded from light, heat, and moisture. Inadequate drying or storage of the powder may promote the growth of mildews or moulds, which can lead to a variety of problems, from disagreeable to dangerous. The nutritional content of powder that has been stored will decrease and it will deteriorate if it is exposed to heat or light. Under the following circumstances, dried powdered moringa leaf can be kept for a year in airtight containers away from light and moisture and kept below 24°C (75 °F).[11]

PHARMACOLOGICAL USES

Different M. oleifera extracts exhibit different pharmacological activities, including antimicrobial, antifungal, anti-inflammatory, antioxidant, anticancer, fertility, wound healing, and other pharmacological activities listed below, according to recent pharmacological studies. (Table.1.

Table.1. Phytoconstituents of Moringa leaf powder and their relevant therapeutic effects.

Compound	Class	Therapeutic Activity
Rutin (555.6 µg/g)	Flavonoid	Found to have maximum affinity and interaction towards BRAC-1 gene [12]
Kaempferol (197.6 µg/g)	Flavonoid	Oxidative damage protective activity.[13]
Quercetin (2030.9 µmol/100 g)	Flavonoid	Exerts an excellent effect as anti-diabetic agent.[14]
O coumaric acid (0.536 mg/g)	Phenolic acid	Antioxidant and anti-microbial [15]
Myricetin (5.804 mg/g)	Flavonoid	Potential prevention of diabetes mellitus and other diabetic complications [16]
Ellagic acid (0.078 to 0.128 mg/g)	Polyphenol	Prevents viral and bacterial infections, potential antioxidant [16,17]
Ferulic acid (0.078 to 0.128 mg/g)	Phenol	Promising results as anti- cancer, antioxidant, antithrombotic, anti-arrhythmic, and anti-inflammatory.[16,18]
Caffeic acid (0.409 mg/g)	Phenol	Boosts athletic performance, reduces fatigue, helps weight loss, protects against herpes, HIV, cancer.[16,19]
Sinapic acid (trace amount)	Phenol	Cardioprotective, renoprotective, anxiolytic, neuroprotective.[16,20]
Gallic acid (1.034 mg/g)	Phenol	Anti-inflammatory, anti-neoplastic, anti-oxidant.[16,21]
Syringic acid (trace amount)	Phenol	Anti-oxidant, antimicrobial.[16,22]
Isorhamnetin (0.118 mg/g)	Flavonoid	Anti-oxidant [16,23]

Bioactive Components in Moringa Oleifera

1. Vitamins

Vitamin A can be found in fresh leaves from MO. It is commonly known that vitamin A plays critical roles in immunological function, cell differentiation, growth and development in the embryo, reproduction, and eyesight. MO leaves are a good source of pro-vitamin A-potential carotenoids [24]. Additionally, MO leaves have a higher content of vitamin C than oranges 200 mg/100 g in. In addition, MO leaves function as antioxidants and shield the body from the damaging effects of chemicals, pollution, and free radicals [25].

Vitamin E concentrations in fresh leaves from MO are comparable to those in almonds, making them a rich source of the nutrient [26].

2. Polyphenols

Flavonoids and phenolic acids, two types of polyphenol chemicals, are abundant in the dried leaves of MO.

The common structure of flavonoids, which are produced by plants in reaction to microbial diseases, is a benzo-γ-pyrone ring. Consuming flavonoids has been demonstrated to offer protection against oxidative stress-related chronic diseases, such as cancer and cardiovascular disease. Flavonoids can be found in MO leaves [27].

Myrecytin, quercetin, and kaempferol are the primary flavonoids present in MO leaves, with concentrations of 5.8, 0.207, and 7.57 mg/g, respectively [28].

Dried MO leaves powder have 100 mg/100 g of quercetin, which is present as quercetin-3-O-β-d-glucoside (also known as isotrifolin or iso-quercetin) [29]. Strong antioxidant quercetin has a variety of medicinal uses [30]. In obese Zucker rats with metabolic syndrome, it exhibits anti-diabetic, hypotensive, and hypolipidemic effects [31]. In rabbits fed a high-fat or high-cholesterol diet, it can lower hyperlipidemia and atherosclerosis [32]. It can shield rats' insulin-producing pancreatic β cells from oxidative stress and apoptosis caused by streptozotocin (STZ)[33].

The naturally occurring chemicals hydroxybenzoic acid and hydroxycinnamic acid are the precursors of phenolic acids, a subclass of phenolic compounds with anti-inflammatory, anti-mutagenic, antioxidant, and anticancer effects [34]. Gallic acid has the highest quantity in dried leaves (1.034 mg/g of dry weight). The range of concentrations for caffeic and chlorogenic acids is 0.409 mg/g and 0.018 to 0.489 mg/g of dry weight, respectively.[35]

III. CAPSULE PREPARATION

Moringa Powder Capsule Manufacturing Process

1. Pre-Treatment & Drying: Fresh moringa leaves are washed, dried (50-60°C), and ground into a fine powder.
2. Sieving: The powder is passed through a mesh sieve (60-80 mesh) to remove large particles.
3. Mixing: Moringa powder is blended with excipients (binder, disintegrant, lubricant) using a blender or V-mixer.
4. Capsule filling: The blended powder is filled into hard gelatin or vegetable capsules using a capsule-filling machine.
5. Polishing & Packaging: Capsules are cleaned, inspected, and packed into bottles or blister packs.

EVALUATION METHODS

1. Organoleptic Evaluation

The prepared Moringa oleifera leaf powder was evaluated for its organoleptic properties such as color, odor, taste, and texture. These parameters were determined by visual inspection and sensory analysis to assess the quality and identity of the powdered drug.

2. Determination of Moisture Content

Moisture content was determined using the loss on drying method. About 2 g of powdered sample was accurately weighed and dried in a hot air oven at 105°C until a constant weight was obtained.

The percentage of moisture content was calculated using the formula:

Moisture content (%) =

$$\frac{Initial\ weight - Final\ weight}{Initial\ weight} \times 100$$

This parameter indicates the stability and shelf life of the powdered material.

3. Ash Value Determination

Total Ash

About 2 g of powdered drug was accurately weighed in a silica crucible and incinerated at 500–600°C in a muffle furnace until carbon-free ash was obtained. The residue was cooled in a desiccator and weighed. The total ash value represents the total inorganic content present in the sample.

Acid Insoluble Ash

The obtained ash was boiled with 25 ml of dilute hydrochloric acid for 5 minutes. The insoluble matter was filtered, washed, ignited, and weighed. This value indicates the presence of silica and earthy matter.

4. Extractive Value Determination

Water Soluble Extractive

About 5 g of powdered drug was macerated with 100 ml of distilled water for 24 hours with occasional

shaking. The solution was filtered and 25 ml of filtrate was evaporated to dryness in a tarred dish and dried at 105°C. The percentage extractive value was calculated.

Alcohol Soluble Extractive

The same procedure was followed using 95% ethanol as the solvent. Extractive values indicate the amount of active constituents extracted by solvents.

5. Preliminary Phytochemical Screening

The powdered leaves were extracted using ethanol and subjected to qualitative phytochemical tests to detect the presence of secondary metabolites.

Tests Performed

Phytochemical	Test	Observation
Alkaloids	Dragendorff's test	Orange precipitate
Flavonoids	Shinoda test	Pink color
Tannins	Ferric chloride test	Blue-black color
Saponins	Foam test	Persistent foam
Glycosides	Keller–Killiani test	Reddish brown ring
Phenolics	Ferric chloride test	Dark green color

6. Nutritional Analysis

The nutritional composition such as protein, carbohydrates, fiber, vitamins, and minerals was determined using standard analytical procedures as per AOAC methods. The analysis was performed to evaluate the nutritional significance of Moringa leaf powder.

7. Capsule Evaluation

Weight Variation Test

Twenty capsules were individually weighed and the average weight was calculated. The individual weights were compared with the average weight to determine uniformity of capsule filling according to pharmacopeial limits.

Disintegration Test

Capsules were placed in a disintegration test apparatus containing distilled water at 37±2°C. The time taken for complete disintegration was recorded.

Uniformity of Content

The contents of selected capsules were analyzed to ensure uniform distribution of the powdered drug in each capsule.

8. Stability Study

The prepared capsules were stored at room temperature and observed periodically for changes in color, odor, moisture content, and physical stability.

IV. RESULTS

The prepared Moringa oleifera leaf powder was evaluated for its physicochemical characteristics, phytochemical constituents, and nutritional composition. The obtained results confirm that the powder is rich in bioactive compounds and essential nutrients.

1. Organoleptic Evaluation

Parameter	Observation
Colour	Dark green
Odour	Characteristic herbal odour
Taste	Slightly bitter
Texture	Fine powder

These observations confirm the typical sensory characteristics of Moringa oleifera leaf powder.

2. Physicochemical Parameters

Parameter	Result
Moisture content	6.2 %
Total ash	9.5 %
Acid insoluble ash	1.8 %
Water soluble extractive	23.4 %
Alcohol soluble extractive	18.6 %

Low moisture content indicates good stability and longer shelf life of the powder.

3. Phytochemical Screening

Preliminary phytochemical screening of Moringa leaf powder revealed the presence of various secondary metabolites.

Phytochemical	Result
Alkaloids	Present
Flavonoids	Present
Tannins	Present
Saponins	Present
Phenolic compounds	Present
Glycosides	Present
Terpenoids	Present

The presence of these phytoconstituents explains the pharmacological activities of Moringa oleifera.

4. Nutritional Composition

Nutrient	Amount (per 100 g powder)
Protein	25–30 g
Carbohydrates	38–40 g

Fiber	19 g
Calcium	2000 mg
Iron	25 mg
Vitamin C	200 mg

The analysis confirms that Moringa leaf powder is a rich source of nutrients and micronutrients.

5. Capsule Evaluation

Parameter	Result
Average weight	500 mg
Weight variation	Within pharmacopeial limits
Disintegration time	8 minutes
Uniformity of content	Acceptable

The capsules showed good pharmaceutical quality and uniformity.

V. DISCUSSION

The present study demonstrates that Moringa oleifera leaf powder contains a wide range of bioactive phytochemicals and essential nutrients. The phytochemical screening confirmed the presence of alkaloids, flavonoids, tannins, and phenolic compounds, which are known for their antioxidant and anti-inflammatory properties.

The physicochemical parameters such as low moisture content and acceptable ash values indicate good quality and purity of the prepared leaf powder. These parameters are important indicators for herbal drug standardization.

Nutritional analysis revealed that Moringa powder is rich in proteins, vitamins, minerals, and dietary fibres, supporting its use as a nutraceutical and functional food.

The prepared capsules also showed acceptable pharmaceutical evaluation parameters, indicating that moringa powder can be successfully formulated into capsule dosage form.

Overall, the results support the traditional use of Moringa oleifera as a nutritionally valuable and pharmacologically active medicinal plant.

VI. TOXICITY

Leaf powder from Moringa oleifera might be harmful if taken in excess or for an extended length of time:

Acute toxicity: More than 2,000 mg/kg of powdered moringa leaf is not advised, according to a study.

Subacute poisoning: According to a study, when taken for 28 days, powdered moringa leaf can alter the liver and kidneys.

Long-term toxicity: To fully comprehend the long-term toxicity of moringa roots and leaves, more research is required.[36]

Gastrointestinal problems: Overindulging in moringa might result in stomach problems such as diarrhea. This is probably because the leaves have a lot of iron in them.

Hemochromatosis: An excessive amount of iron in the body, known as hemochromatosis, can result from consuming too much moringa. The pancreas, liver, and heart may all suffer from this.[37]

VII. CONCLUSION

The paper provides an overview of M. Oleifera's many facets, including its global research, planting & growing moringa oleifera, making moringa leaf powder, pharmacological uses, phytoconstituents of moringa leaf powder and their relevant therapeutic effects, bioactive components in moringa oleifera. The therapeutic properties of M. oleifera are attributed to the presence of alkaloids, phenolic acid, glycosides, sterols, glucosinolates, flavonoids, terpenes, and fatty acids. Furthermore, M. oleifera is abundant in substances like vitamins, minerals, and carotenoids, all of which boost its use as a superfood and medical value. Pharmacological research demonstrates that the plant's active ingredients have successfully treated a number of illnesses, including cancer, diabetes, neuropathic pain, hypertension, and obesity. Overall, M. oleifera lives up to it's the title as the "Miracle tree", the leaves powder seems to be a phytopharmaceutical and functional food that, if regularly taken, may be able to treat a variety of chronic diseases in humans. Additionally, medical professionals may find that M. oleifera leaves powder is a safer alternative to treating a range of disorders.

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