

Exploring the Commercial Versatility of *Moringa oleifera*: A Valuable Resource for Diverse Industries

Maqsood Maryam* and Asia Manzoor

Faculty of Life Sciences, SBKW University, Pakistan

Corresponding Author

Maqsood Maryam, Faculty of Life Sciences, SBKW University, Pakistan.

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Abstract

The versatile plant *Moringa oleifera* L., including those in food and medicine. The plant is incredibly nutrient-rich and contains phytochemicals with potential therapeutic benefits in all of its leaves, pods, seeds, flowers, fruits, and roots, all of which can be consumed. It also contains antioxidants like carotenoids, flavonoids, vitamin E, and phenolic compounds in addition to protein, iron, calcium, vitamins A and C, and vitamins A and C. It also has a lot of commercial advantages. They can be used in addition to conventional crops to boost feed efficiency and animal performance or in substitution of them to produce outcomes that are more economically viable. Additionally, moringa can be used as a crop enhancer, which is a low-cost, environmentally friendly method of increasing crop yields. There are several commercial and biological uses for moringa and its derivatives, including seed production, biopesticides, animal and poultry feed, medicines, and green fertilization. Due to its antioxidant, antifungal, antibacterial, and insecticidal properties, moringa also aids in the management of plant diseases. Toxins and antinutritional elements are present in various plant components, limiting their usefulness as a food source. To prevent any potential issues, the plant should be ingested in low or medium quantities in the production of animals and poultry. To enhance soil qualities and plant growth, however, moringa should be used. Therefore, it is crucial to carry out more research on moringa to highlight its contributions to the production of both plants and animals in agriculture.

Keywords: *Moringa Oleifera*, Agriculture, Animal Husbandry, Industries, Commercial Use

1. Introduction

Many herbs and plants offer secure sources of bioactive compounds and multifunctional curing agents. According to WHO (World Health Organization), 80 percent of the world's population, especially in developing nations, uses herbal medicine for illness prevention and treatment [1]. Additionally, about 25% of synthetic drugs come from therapeutic plants [2].

For many years, the need for food has been a major issue in developing countries as a means of preventing hunger and malnutrition. Malnutrition, caused by a lack of essential nutrients in food, is still a major issue in many Asian and African nations [3]. The use of *Moringa oleifera* is one approach to solving this issue.

Moringa (Moringa oleifera Lam.), also known as the horseradish tree, mulangay, mlonge, and drumstick tree, is a popular therapeutic herb in tropical and subtropical regions. It is a little tree from the sub-Himalayan regions of North West India that is a member of the Moringaceae family and is now widespread around the world [4]. Because of its propensity to treat a wide range of illnesses and chronic conditions, *Moringa oleifera* is well renowned for its health advantages and has taken on the

moniker "the miracle tree." In these areas, it is customarily consumed as a daily vegetable. Due to its several uses, the plant has undergone substantial research for its bioactive chemicals in various portions, making it an essential phytomedicine in medicine.

In many civilizations around the world, the moringa plant has been utilized for generations as a medicine. Its use in the treatment of a variety of conditions, including cholera, bronchitis, asthma, and blood impurities, has been documented. It also has several medicinal qualities, including antipyretic, anti-epileptic, diuretic, and anti-diabetic actions [5]. The plant is used in many healthcare products, including body and hair moisturizers, conditioners, and skin ointments, demonstrating its cosmetic value [6]. Moringa is one of the most nutrient-dense plants known to man.

Moringa is a versatile plant with diverse applications. Its numerous parts, including roots, leaves, flowers, green pods, and seeds, are utilized in the manufacture of nutraceuticals, functional and therapeutic food products, water filtration methods, and biodiesel [7]. Due to the high concentration of monounsaturated fatty acids in moringa seed oil, it is a viable

feedstock for the generation of biodiesel [8]. Additionally, because of their antimicrobial and coagulant qualities, proteins extracted from Moringa seeds are used for domestic and industrial water purification [9].

2. Nutritional Profile

Scientific research has verified the outstanding nutritional profile of the moringa plant. Numerous vital nutrients, such as vitamins, minerals, amino acids, and phytochemicals, can be found in moringa. For instance, it is a good source of the B-complex vitamins thiamin, riboflavin, and niacin, as well as vitamins A, C, and E. Minerals including calcium, iron, magnesium, and zinc are also abundant in it [10]. The high concentration of antioxidants found in moringa, including flavonoids, polyphenols, and ascorbic acid, can help shield the body against oxidative stress and other types of cellular deterioration [11]. Overall, the nutritional makeup of moringa makes it an important component of a nutritious diet.

It is unusual for a single plant to contain a lot of crucial nutrients. The Moringa plant, on the other hand, has a higher concentration of numerous nutrients than those found separately in other fruits and vegetables, according to studies done at the Asian Vegetable Studies and Development Centre (AVRDC). It was discovered that the leaves of four different varieties of Moringa were exceptionally nutrient and antioxidant-loaded. The nutritional value varied according to the method of preparation, the age of the leaves, and the time of harvest. Unlike most vegetables, which lose nutrients when cooked, moringa leaves retain their nutritional value even after being cooked or stored as a dry powder for months without refrigeration [12]. It was shown that, compared to raw leaves, boiling the leaves produced three times as much bioavailable iron [13]. Moringa also has unique compounds with unusual sugar-modified glucosinolates that have chemopreventive effects and trigger apoptosis.

100 grams of dry moringa leaf contains	
10 times	The vitamin A in carrots
7 times	The vitamin C in oranges
17 times	The calcium in milk
15 times	the potassium in bananas
25 times	The iron in spinach
9 times	The protein in yogurt

Table 1: Comparison of the Nutrient Content of 100 Grams of Dry Moringa Leaf with other Commonly Consumed Foods [14].

3. Industrial and Commercial Uses

Moringa oleifera has many industrial and commercial applications. The global market for moringa products is valued at \$5.5 billion and is expected to grow at an exponential rate [15]. Its seeds are a source of high-quality oil that can be used in cooking, cosmetics, and lubricants. The plant's leaves, which are rich in nutrients, can be dried and ground into a powder that can be used as a dietary supplement or added to food products.

Additionally, moringa has been used in traditional medicine for centuries and is now being studied for its potential as a natural remedy for various health conditions. The plant's many uses make it an attractive crop for farmers and entrepreneurs, and its sustainable cultivation and harvesting methods further add to its appeal as a valuable commodity. Here are some of the most significant. Overall, the versatility of *Moringa oleifera* makes it a valuable resource for many different industries and applications.

Use	Properties	References
Food	The nutrient-rich, mild, slightly sweet flavor	(Aquila Jabeen et al., 2022)
Culinary Arts	Enhances the flavor of soups, stews, and dishes	(Coelho et al., 2022)
Agriculture	Improve crop growth and productivity. Aqueous extracts are used as natural pesticides, and leaves are used as fertilizer.	(Mashamaite et al., 2022)
Horticulture	Tolerates drought and grows well in poor soil. A best companion plant's leaves and other parts are used as natural growth enhancers.	(Thapa et al., 2019)
Animal Husbandry	Its high protein content improves growth rates. Fast-growing tree and can be the best animal fodder, best as a range plant.	(Mizory & Altaee, 2023)
Water Purification	Seeds can be used to purify water, used as biosorbents, and as coagulants.	(Varkey, 2020)
Traditional Medicine	Huge traditional uses as Anti-inflammatory, anti-diabetic, antioxidant, and many others	(Abdel-Daim et al., 2020)
Contemporary Medicine	potential to treat various diseases and ailments and bioactive compounds can be extracted easily	(Meireles et al., 2020)
Biofuel	High oil content in seeds can be used for biodiesel production.	(Granella et al., 2021)
Cosmetics	Moisturizing, anti-aging, and anti-inflammatory properties	(Jeziarska & Sykuła, 2023)
Textiles	Strong, durable fibers for textile production	(Musarra et al., 2019)

Table 1: Uses and Properties of Moringa in Various Industries and Disciplines

4. Commercial and Industrial Scope

Numerous commercial and industrial uses for *Moringa oleifera* present numerous chances for local communities to benefit from its adaptability. This plant has a wide range of potential uses and is very valuable to many different sectors and business ventures. The catalog of potential applications for *Moringa oleifera* is extensive, encompassing a multitude of significant uses. The following is a non-exhaustive list of some of these uses, focusing on discussing in greater detail those that are particularly noteworthy.

4.1 Growing Demand for Organic Dietary Alternatives

As the demand for organic dietary alternatives continues to increase on a global scale, there has been a corresponding surge in the consumption of nutritional and medicinal plants, including *Moringa oleifera*. Thus, it has become imperative to utilize this plant for commercial and industrial production to promote a healthy and sustainable lifestyle, particularly in low-income countries that cannot afford expensive luxury items. By advocating the use of *Moringa oleifera* as a nutritional and medicinal resource, it is possible to establish a culture of good health and well-being for individuals of all socioeconomic backgrounds. This will also help to decrease reliance on artificially and chemically processed products that have a detrimental impact on both the environment and human health.

This shift towards the utilization of moringa and its products has caused industries to recognize global trends and adapt accordingly. The value of the global market for moringa ingredients was predicted to be about 6.9 billion USD in 2020. By 2028, it is expected to have grown by 9.5% from 2021 to 2028, or 14,270.6 million USD, at a compound annual growth rate. This growth is a result of both the increasing demand for dietary supplements and their use in the food, pharmaceutical, and cosmetics industries [16]. As people incorporate moringa into their daily diets and routines, they discover its various uses and applications in diverse industries. In light of the growing environmental and health crises worldwide, there is a shift towards safer, more cost-effective, and sustainable alternatives, making plants like Moringa and their products a viable solution for the future.

4.2 The Manufacturing Business of *Moringa Oleifera* Products

The manufacturing business of *moringa oleifera* products can be an effective solution to the growing demand for organic dietary alternatives and the need for sustainable and eco-friendly products. As more people become aware of the benefits of *Moringa oleifera*, the demand for its products will increase, creating a lucrative market for manufacturers. The future of the world is moving towards a more sustainable, eco-friendly, and healthy lifestyle, and the *moringa oleifera* plant aligns with these goals. Thus, investing in the manufacturing business of *moringa oleifera* products can be a wise decision, as it offers the potential for high growth and profitability. Manufacturing businesses can explore various product lines such as moringa tea, capsules, powders, and skincare products, among others. The production process can be designed to be environmentally sustainable, ensuring minimal waste and a low carbon footprint. By adopting eco-friendly packaging, companies can reduce their impact on the environment while meeting consumer demands. By collaborating with researchers, manufacturers can explore the full

potential of the *moringa oleifera* plant and its applications in various industries.

4.3 Commercial Production of Moringa Oil

The oil content of *Moringa oleifera* plant seeds ranges from 30 to 42%, and the press cake created as a byproduct of oil extraction contains a significant amount of proteins [17]. *Moringa oleifera* is a potentially lucrative crop for commercial applications due to its high oil content and protein-rich press-cake. The oil's strong nutritional value and nutty flavor enable it to be extracted and utilized as a healthy substitute for conventional frying oils. Moringa oil can be a promising business venture with numerous benefits, including its use in cosmetics, food, and medicinal products. As the demand for natural and organic products increases, moringa oil can serve as a viable alternative to chemical-based oils. To utilize the commercial potential of moringa oil, manufacturers can focus on producing high-quality, organic moringa oil that meets the demands of the market. They can also explore different application hair care products, as well as in the pharmaceutical industries of moringa oil, such as in the production of skincare andy. This can have a positive impact on the community by providing employment opportunities and promoting sustainable agriculture. By partnering with local farmers, manufacturers can ensure a reliable supply of moringa seeds and support the local economy. The production and use of moringa oil can result in a sustainable and successful business with proper planning, quality control, and community involvement because it has a bright future, especially with the rising demand.

4.4 Use of Moringa in Biofuels

Moringa oleifera has a high potential for use in biofuels due to its oil content, which can be extracted and converted into biodiesel. This presents a unique opportunity for large-scale commercial or industrial production of biofuels, which can benefit rural communities by providing a sustainable and affordable source of energy. Additionally, the by-products of *Moringa oleifera* processing can be used for other purposes, such as animal feed or organic fertilizers, creating a circular economy that further supports the community. To fully utilize the potential of *Moringa oleifera* for biofuel production, it is essential to invest in research and development of efficient extraction and conversion technologies, with community engagement and participation. Thus, it can provide local knowledge and ensure the equitable distribution of benefits. By promoting the large-scale commercial or industrial production of *Moringa oleifera* for biofuels, a sustainable and self-sufficient future for rural communities can be created while also reducing dependence on fossil fuels and mitigating the impacts of climate change. It is considered a sustainable and environmentally friendly alternative to traditional fossil fuels. Moringa biodiesel has several advantages, including its renewability, biodegradability, and reduced emissions of harmful pollutants. In addition, Moringa biodiesel can be produced using simple and low-cost methods, making it accessible to small-scale farmers and rural communities. However, more research is needed to optimize the production process and increase the efficiency of moringa biodiesel as a fuel source.

4.5. Water Purification Industry

The use of *Moringa oleifera* in the water purification industry presents an excellent opportunity to address the challenges of

accessing clean drinking water, especially in rural communities. The plant's seeds contain natural coagulants that can remove impurities and suspended particles from water, making it safe for human consumption, irrigation, and animal drinking. It has been discovered that *Moringa oleifera* seeds may effectively purify water from a variety of sources. In a study, water from four distinct sources, including two shallow wells and two bodies of surface water, was treated using *M. oleifera* seed powder. The outcomes revealed a reduction in turbidity up to 99% and a hardness level of 60–70% in the treated water [18]. These results show the potential of *M. oleifera* seeds as a low-cost and efficient water treatment method in areas with limited access to potable water. The seeds are a promising natural coagulant for use in water treatment and purification procedures because of their capacity to reduce turbidity and hardness in water [19]. The large-scale commercial production of Moringa-based water purification products can create sustainable solutions for communities, particularly in developing countries, that are facing water scarcity and contamination issues. Moreover, the use of moringa in water purification can significantly reduce the costs associated with traditional water treatment methods and improve the quality of life for individuals in the community. To promote the use of *Moringa oleifera* in the water purification industry, governments, and private sector organizations can collaborate to establish training programs and infrastructure for small-scale production and distribution of Moringa-based water purification products in rural areas. Additionally, large-scale commercial production can be facilitated by leveraging innovative technologies such as nanofiltration to ensure the effective and efficient purification of water at an industrial scale. Ultimately, the use of *Moringa oleifera* in the water purification industry can have a significant impact on improving public health, agricultural productivity, and livestock welfare, while also promoting economic development and environmental sustainability.

4.6 *Moringa oleifera* as a coagulant

Moringa oleifera seeds are commonly used as a natural coagulant for water treatment purposes. The negatively charged water particles are attracted to the positively charged proteins in the seed extract, forming larger particles that are simple to filter or sediment by sedimentation [20]. This process can effectively remove suspended solids, bacteria, and other impurities from water, making it safe for drinking and other uses. This application helps in other industries, such as the treatment of industrial wastewater and the production of bioplastics. It is a sustainable and eco-friendly alternative to traditional coagulants, which often have negative environmental impacts. It can help provide safe and clean water for communities, reduce environmental pollution, and promote sustainable development.

4.7. *Moringa oleifera* used as a biosorbent

Moringa oleifera is effective as a biosorbent, which means it can be used to remove pollutants from water and wastewater. The seeds of the plant contain natural cationic polyelectrolytes which can coagulate suspended particles in water, making them easier to remove. One of the most common uses of *Moringa oleifera* as a biosorbent is in the treatment of turbid water. Studies have shown that the plant can remove up to 99% of the suspended particles in water, including bacteria, algae, and organic matter [21]. It can also be used to remove heavy metals such as

lead, cadmium, and chromium from industrial wastewater [22]. The roots of the plant can absorb pollutants from the soil, such as heavy metals and organic compounds, which can then be eliminated by gathering and discarding the contaminated plant material [23]. The use of *Moringa oleifera* as a biosorbent has the potential to be a cost-effective and environmentally friendly method for removing pollutants from water and soil.

4.8 Processing and Preservation Methods

The best way to use processing and preservation methods for *Moringa oleifera* is to concentrate on preserving its bioactive components and lengthening its shelf life to maximize the benefits of this highly nutritious plant, increase its use, and make it accessible. This can be achieved through various techniques such as drying, freeze-drying, and extracting. Drying moringa leaves is a highly effective method of preserving them because it lowers moisture content and inhibits both enzymatic and non-enzymatic deterioration. To maintain the biological activity of the leaves and their original, high phytonutrient content, it is crucial to select an environmentally friendly drying technique. Moringa leaves have been dried using a variety of techniques, including air drying, sun drying, and drying at 50°C in a multifunctional dryer. Using a multifunctional dryer to dry moringa leaves is the most efficient way, per a study by Foline et al., since it preserves the majority of the phytonutrients present in the leaves, whereas air drying is the only technique that preserves higher quantities of such compounds. In a study by Saini et al., fresh moringa leaves were dried using a variety of techniques, including cabinet tray drying, oven drying, sun drying, microwave drying, and lyophilization. The maximum concentration of total carotenoids (60.1%), particularly trans- β -carotene (90.1%) and 13-cis-lutein (93.2%), as well as DPPH activity, was retained with cabinet tray-drying as effectively as lyophilization. However, lyophilization provided the best preservation for ascorbic acid (97.8%) and trans-lutein (51.3%). Additionally, to preserve nutrients and antioxidant activity in moringa leaves at the household level, they suggested oven drying rather than sun drying. By doing so, *Moringa oleifera* products can be made more readily available and accessible to consumers while retaining their nutritional and medicinal properties.

Moreover, the processing and preservation of *Moringa oleifera* products can be a promising industry for rural communities. By providing training and resources for these communities to engage in processing and preservation methods, they can create value-added products and generate income. Additionally, the availability of *Moringa oleifera* products can improve the nutritional status and health of individuals living in these communities. Therefore, it is crucial to invest in the development of processing and preservation methods for *Moringa oleifera* to benefit both the industry and rural communities.

4.9. *Moringa* for the Textile Industry

Due to its potential as a natural coagulant and flocculant in water treatment, moringa has been attracting attention in the textile sector. Studies on the coagulating and flocculating abilities of moringa seeds have revealed that they are efficient at clearing the water of impurities and pollutants, making them suitable for use in the manufacture of textiles [24]. Additionally, studies have demonstrated that moringa seed powder can be used as a natural

textile dye, providing an eco-friendly and long-lasting substitute for synthetic dyes. Moringa seed powder can produce colors ranging from yellow to dark brown, depending on the amount of dye used and the type of fabric that is being dyed. Additionally, communities that grow the plant may benefit economically from using moringa seed powder as a natural dye because they can sell it as a value-added item. Overall, moringa has a lot of promise as an organic and environmentally friendly textile industry solution.

4.10. Moringa for the Makeup Industry

Due to the high concentration of antioxidants, vitamins, and minerals found in moringa, it has become increasingly popular in the cosmetics business. Because it absorbs quickly by the skin and doesn't leave a greasy aftertaste, the oil obtained from Moringa seeds is frequently used as a moisturizer in skin care products [25]. Due to its capacity to dissolve pollutants and makeup without removing the skin's natural oils, it is also used as a natural makeup remover. Because it can provide natural color and texture, moringa leaf powder is also used as an ingredient in cosmetics like foundations, powders, and eyeshadows. Due to its high vitamin A and C concentrations, it is also a well-liked ingredient in anti-aging and skin-brightening cosmetics. Overall, moringa provides a healthy and sustainable substitute for the synthetic ingredients that are frequently used in the cosmetics industry. To avoid overexploitation of the plant and harm to local populations, it is crucial to ensure that moringa products are produced ethically and sustainably.

4.11. Moringa for Agriculture and Animal Husbandry

Moringa has numerous applications in the fields of agriculture and animal husbandry. The seeds and the leaves can be used as natural pesticides and fertilizers to increase crop yields while lowering the need for chemical inputs. The plant makes an excellent addition to livestock's diet because it is a good source of protein and other nutrients. It can be used to control pests and diseases in crops due to its insecticidal and fungicidal properties. It can be added to the soil to improve soil fertility and enhance plant growth. Moringa's ability to fix nitrogen from the air and incorporate it into the soil also makes it a useful crop in crop rotation systems. This can improve the health and productivity of livestock, particularly in areas where access to quality feed is limited. Moringa can also be used as a natural remedy for common animal ailments such as digestive issues and respiratory infections. Here are some of the most significant ones discussed in detail:

5. Moringa for Agriculture

The use of this plant domestically and commercially can save money, time, effort, and resources in agricultural nations like Pakistan, which have limited economic resources. The fact that it is so environmentally friendly can also help improve local climate and environmental conditions for farmers. *Moringa oleifera* can be used as a natural and sustainable solution for soil and water treatment in agriculture. The plant can remove impurities such as heavy metals, bacteria, and turbidity from water, making it safe for irrigation and consumption by livestock. Additionally, moringa can be used as a natural fertilizer, providing essential nutrients to the soil that promote healthy crop growth and increased yield [26]. The use of Moringa in agriculture can reduce

the need for chemical fertilizers and pesticides, thus decreasing the negative impact of agriculture on the environment. For a variety of crops, including wheat, citrus, and tomatoes, moringa leaf extract has been used to promote plant development[27]. A practical option that can be included in pest management plans is the use of moringa as a natural biopesticide. Applying Moringa Leaf Extract (MLE) has been shown to significantly improve pest and disease resistance, leading to a 20% to 35% increase in overall crop yield. Moreover, the use of moringa can contribute to climate change mitigation, as it is a carbon-sequestering plant[28]. By promoting the use of Moringa in agriculture, farmers can benefit from increased crop yield, improved soil health, and reduced costs associated with the use of chemical inputs. This can also contribute to the socio-economic development of rural communities by providing a sustainable source of income through the production and sale of moringa-based products.

5.1. Effect of *Moringa Oleifera* on Plant Growth Characteristics and Yield

Moringa oleifera extracts can improve seed germination rates and promote early seedling growth in a variety of crops, including maize, sorghum, and okra. The extracts are known to increase the amount of chlorophyll, activity, and overall biomass of the plant, which results in higher yields for crops and ornamental gardening, such as marigolds and petunias. The plant's insecticidal properties can help protect ornamental plants and crops from pests and diseases, and its use is completely safe for the environment. The moringa plant, which can grow in many types of soil and flourish in drought situations, can be used as green manure to improve agricultural soil. This entails sowing 1 million moringa seeds per hectare in plowed soil, 2 cm thick and spaced 10 cm apart. After the seeds, seedlings are planted, which are then plowed into the ground to a depth of 15 cm. The soil's fertility will significantly increase as a result of being ready for the intended crop[29]. It is well acclaimed for its capacity to improve seed germination, foster vigorous plant growth, and induce deeper root development. It is also thought to increase output and produce quality, as well as the lifespan of fruit, making it a desirable substance for agricultural use [30].

5.2. Applications of *Moringa Oleifera* in Water Treatment and Purification for Agricultural Use

Moringa oleifera is a useful tool for water treatment and purification in agricultural settings. The plant's seeds contain cationic polyelectrolytes that can be used to clarify water by attracting negatively charged particles such as dirt and bacteria, making them easier to filter out. The seeds act as a flocculant that magnetizes and aggregates particles detained in water suspension, which then precipitates out of the water flakes, leaving clearing water. *M. oleifera* seeds also have the potential to remove a wide range of gram-positive and gram-negative bacteria, algae, organic pollutants, and pesticides from tainted water and may produce less sludge than chemical coagulants [31]. Due to its active soluble protein component, which serves as a cationic polyelectrolyte, dried and crushed moringa seeds can be utilized as a natural coagulant for water filtration [32]. This process can be particularly useful in areas where water sources are contaminated or where access to clean water is limited.

Moringa seed aqueous extract has been shown in numerous

studies to considerably reduce turbidity and color by more than 90% as well as bacteria, including *Escherichia coli*, by over 95% in African nations like Nigeria, Rwanda, Malawi, Egypt, and Sudan [33]. Moringa seed extract has also been shown to be beneficial in lowering the levels of *Staphylococcus aureus* and fecal coliforms in river and well water [32].

5.3 Uses of Moringa in Plant Disease Management

In numerous ways, moringa can aid in the control of plant diseases. Both soil amendments and seed treatments are used to help manage illnesses that are transmitted through seeds. It might be necessary to apply a foliar application or soak the soil surrounding the plant to control foliar diseases. It functions as a biopesticide and can help with disease prevention, pest repulsion, and pest management. Work as a companion Due to its allelopathic effects, planting it alongside other crops can help prevent the spread of illnesses and stunt the growth of unwanted plants. Moringa may be able to protect against foodborne infections such as *Salmonella typhi*, *Salmonella paratyphi*, *Escherichia coli*, *Shigella dysenteriae*, *Citrobacter* spp., and *Pseudomonas aeruginosa*, according to several laboratory investigations [34].

5.4. Use of Moringa as a Natural Fertilizer

Moringa leaves and seeds are a valuable source of natural fertilizer for agriculture. The leaves and seeds are rich in essential nutrients such as nitrogen, phosphorus, and potassium, which are vital for plant growth and development. It has been shown to improve soil fertility, increase crop yields, and enhance the quality of produce. As a natural fertilizer in agriculture, it can promote sustainable farming practices, reduce the use of chemical fertilizers, and improve soil health and crop yields.

5.5. Effect of *Moringa Oleifera* on the Physicochemical Attributes of Plants

Its use has been shown to improve soil fertility, increase water-holding capacity, and enhance nutrient uptake in plants. The plant is rich in essential minerals and nutrients, such as calcium, magnesium, and potassium, which are important for plant growth and development. The high levels of nitrogen and phosphorus in moringa leaves make it an ideal natural fertilizer for crops. The application of Moringa leaf extract to plants has also been found to enhance chlorophyll content and photosynthesis, leading to increased plant growth and yield.

6. Moringa for Animal Husbandry

Moringa leaves, seeds and oil cake can be used as animal feed supplements due to their high protein, fiber, and mineral content. Studies have shown that incorporating Moringa leaves or powder into the diet of livestock can improve their growth, milk production, and overall health. Moringa leaves have been shown to have antiparasitic properties, which can reduce the incidence of gastrointestinal parasites in livestock. Moringa can also be used as a natural remedy for various animal ailments, such as respiratory infections, skin disorders, and inflammation. Moringa leaf extracts have been found to have antimicrobial and anti-inflammatory properties, making them effective against several bacterial and fungal infections in livestock. In terms of commercial production, moringa can be cultivated as a feed crop for livestock in areas where traditional animal feed sources are scarce or expensive. Additionally, the by-products of Moringa

oil production, such as seed cake and press cake, can be used as animal feed supplements due to their high protein and nutrient content.

Moringa can generate enough green feed annually in 4 to 5 cuttings to feed 18 to 20 animals using a mixed feeding system, or more than 100 to 120 tonnes/hectare [35]. Moringa can also be grown by taking stem cuttings or transplanting young trees [36]. Under field conditions, 1 kg of moringa seed typically produces 2500 seedlings [37]. In the suggested amounts of 4-5 kg/animal/day, fresh leaves can be cut and added to animal feed [38]. Due to the possibility that these leaves also contain antinutritional components, the suggested dosage should not be exceeded. Increasing seed yield and fodder production could be aided by raising awareness of the adoption of good agricultural practices (GAPs) for moringa cultivation.

6.1. Uses of Moringa in the Poultry Industry

There are several potential uses of *Moringa oleifera* in poultry farming. Including *Moringa oleifera* leaves in poultry, diets can improve the overall health and growth of the birds, as well as increase egg production. Moringa leaves make an excellent feed for livestock and poultry due to their high protein content, favorable mineral profile, and abundance in vitamins A, B, and C. They also contain between 30% and 40% of edible oil (ben oil), which is a large proportion [34]. The plant's natural antimicrobial properties may also help to prevent and treat common poultry diseases caused by bacteria, viruses, and parasites. Studies have shown that *Moringa oleifera* has an anticoccidial effect on poultry, meaning it can help prevent and treat coccidiosis, a parasitic disease that affects the intestinal tract of birds. Additionally, *Moringa oleifera* has been found to have antiviral and antibacterial effects, which can be useful in preventing and treating viral and bacterial diseases in poultry. Incorporating *Moringa oleifera* into poultry farming practices may lead to healthier birds, improved productivity, and reduced use of antibiotics and other medications.

6.2. Uses of Moringa in the Livestock Industry

The leaves and stems of the moringa plant are very nutritious and can be used as cattle fodder, making it a potential use in the livestock business. They are a great addition to conventional meals like hay and silage since they are high in protein, vitamins, and minerals. It is the best choice for foraging trees for livestock and is well-suited to range areas, where it may provide cattle with a valuable source of feed. Animals can benefit from the leaves and pods, which are edible and can enhance their nutrition and well-being. According to research, adding moringa to animal feed can enhance animal performance, including weight gain, milk production, and reproductive efficiency. Its high nutritional value can help solve dietary deficits in animal diets. With its antibacterial qualities to stop or treat infections in animals, it serves as a natural therapy for common livestock illnesses. Overall, the addition of moringa to the livestock business has the potential to be beneficial, both as a feed source and as a natural treatment for ailments affecting animal health.

6.3. Uses of Moringa in Dairy Farming

It contains necessary amino acids, vitamins, and minerals and can be used in fish farming in a variety of ways, including as

fish feed. It can be dried, pounded into a powder, and combined with other components for feed to create a wholesome and affordable diet. Seeds contain a natural coagulant that can bind to impurities and sediment and help cleanse water in fish ponds and water filtration. Seeds can facilitate the removal of silt and pollutants from water. In fish ponds, moringa leaves, seeds, and bark can be utilized as organic fertilizers. They offer vital minerals like potassium, phosphorus, and nitrogen that can aid in boosting fish development and productivity. Its antibacterial and antifungal properties can aid in the prevention of fish illnesses. The fish's health can be enhanced, and the danger of infections can be decreased, by adding moringa leaves to the water in the fish pond. It adds value to fish farming enterprises by offering a natural and secure resource alternative [39-53].

7. Conclusion

Moringa oleifera L. is a highly versatile plant with a wide range of applications in different industries. Its various parts, such as leaves, seeds, flowers, fruits, and roots, are rich in phytochemical compounds, making it a valuable resource for medicinal and nutritional purposes. Its leaves can be used as a supplement to improve livestock performance or as a replacement for conventional crops to achieve economic sustainability. The use of moringa as a crop enhancer is an eco-friendly approach to improving crop yields. Additionally, moringa has several nutritional and biological applications, including use in green fertilization, animal and poultry feeds, medicines, biopesticides, and seed production. However, certain parts of the plant contain toxins and other anti-nutritional factors that limit their use as food sources for humans or animals. Therefore, care must be taken to ensure that the plant is used appropriately and in the right concentrations. In conclusion, further research on moringa is necessary to expand its potential applications and highlight its role in agricultural production.

8. Challenges

Due to its nutritional density and medicinal potential, *Moringa oleifera* has a variety of uses in food, medicine, and industry. Despite its many advantages, there are still problems with its application. Due to issues with overuse toxicity and antinutritional components, as well as limitations on its commercial manufacturing and distribution, it cannot be used as a food source. To fully explore its potential and optimize its utilization in diverse industries, more study is also required.

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