

A Comparative Review on the Biological and Therapeutic Activities of *Moringa oleifera* and *Zingiber officinale*-Based Nanoparticles

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ABSTRACT

Moringa oleifera and *Zingiber officinale* (ginger) are renowned medicinal plants exhibiting remarkable anti-inflammatory and antioxidant properties. Recent advancements in nanotechnology have enhanced their bioavailability and therapeutic efficacy through nanoparticle formulations. *Moringa* and ginger-based nanoparticles possess potent phytochemicals such as flavonoids, phenolics, and alkaloids that scavenge free radicals, reduce oxidative stress, and inhibit inflammatory mediators. These nanoparticles improve cellular uptake and stability, offering promising potential in managing inflammation-related disorders and oxidative damage. Thus, the integration of *moringa* and ginger into nanoparticle systems represents a novel and effective approach for developing natural, safe, and efficient therapeutic agents

Keywords: Drumstrict Tree, *Zingiber officinale* ; Antidiabetic activity; Antioxidant activity Antiinflammatory activity ; Phytochemicals; Flavonoids; Phenolic compounds; Nonotechnology

INTRODUCTION

Moringa Olifera

Moringa oleifera (*M. oleifera*), the “miracle tree”, thrives globally in almost all tropical and subtropical regions, but it is believed to be native to Afghanistan, Bangladesh, India, and Pakistan [1]. The *Moringa* family comprises 13 species (*M. oleifera*, *M. arborea*, *M. rivaie*, *M. ruspoliana*, *M. drouhardii*, *M. hildebrandtii*, *M. concanensis*, *M. borziana*, *M. longituba*, *M. pygmaea*, *M. ovalifolia*, *M. peregrina*, *M. stenopetala*), of which *M. oleifera* has become well known for its use in nutrition, biogas production, fertilizer, etc., [2,3]. *Moringa* has the unique property of tolerating drought [3]. Studies have shown that *M. oleifera* is among the cheapest and most reliable alternatives for good nutrition [4]. Nearly all parts of the tree are used for their essential nutrients. *M. oleifera* leaves have a high content of beta-carotene, minerals, calcium, and potassium [5]. Dried leaves have an oleic acid content of about 70%,

which makes them suitable for making moisturizers [6]. The powdered leaves are used to make many beverages, of which “Zija” is the most popular in India [7]. The bark of the tree is considered very useful in the treatment of different disorders such as ulcers [8], toothache [9], and hypertension [10]. Roots, however, are found to have a role in the treatment of toothache [9], helminthiasis [11], and paralysis [12]. The flowers are used to treat ulcers, enlarged spleen, and to produce aphrodisiac substances [2]. The tree is believed to have incredible properties in treating malnutrition in infants and lactating mothers [3]. The present review aims to sum up the updated insight regarding the pharmacological activities, worldwide research analysis, toxicological, phytochemical, and ethnomedicinal properties of *M. oleifera*. [4].

Ginger:

Ginger (*Zingiber officinale* Roscoe), a well-known herbaceous plant, has been widely used as a flavoring

Relevant conflicts of interest/financial disclosures: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

agent and herbal medicine for centuries. Furthermore, the consumption of the ginger rhizome is a typical traditional remedy to relieve common health problems, including pain, nausea, and vomiting [13]. Specifically, the major classes of ginger compounds are gingerol, shogaols, zingiberene, and zingerone, as well as other less common compounds, including terpenes, vitamins, and minerals [14]. Among them, gingerols are considered as the primary components, reported to possess several bioactivities [15]. As a result, many related biological activities have been explored such as those of antioxidant, antimicrobial, and anti-neuroinflammation, just to name a few [16]. Moreover, in recent years, the role of ginger has been extended to anticancer, chemotherapy-induced nausea and vomiting (CINV), and fatigue, as well as improvements in the quality of life in daily human work [17,18]. In order to prevent various disorders, the immune system identifies and eliminates pathogens while inducing inflammation, cell or tissue damage, cell death, and wound healing. Immune-mediated diseases, metabolic disorders, and inflammatory diseases can occur if homeostasis is not maintained, as well as susceptibility to infectious diseases such as COVID-19 [19,20].

Nanoparticles process :

Defination & Instroduction :

Nanotechnology evolved as the achievement of science in the 21st century. The synthesis, management, and

application of those materials with a size smaller than 100 nm fall under the interdisciplinary umbrella of this field. Nanoparticles have significant applications in different sectors such as the environment, agriculture, food, biotechnology, biomedical, medicines, etc. like; for treatment of waste water.[21], environment monitoring (22), as a functional food additives (23), and as antimicrobial agents (24). Cutting-edge properties of NPs such as; nature, biocompatibility, anti-inflammatory and antibacterial activity, effective drug delivery, bioactivity, bioavailability, tumor targeting, and bio-absorption have led to a growth in the biotechnological, and applied microbiological applications of NPs. Nanoparticles size ranges from 1 to 100nm which are made up of metal, metal oxides, organic matter, carbon. [25] Nanoparticles differ from various dimensions, to shapes and sizes apart from their material. [26] . It has been reported that over 65% of new active pharmaceutical ingredients (APIs) are either poorly soluble in water or insoluble. Due to their low aqueous solubility properties and high permeability, they are categorized as class II of the Biopharmaceutics Classification System (BCS), where the dissolution step is the rate limiting factor in drug absorption. The pharmaceutical industries are now facing a challenge to improve the dissolution characteristic of poorly watersoluble drugs which is the key factor in enhancing drug bioavailability. For instance, they help to increase the stability of drugs/proteins and possess useful controlled release properties



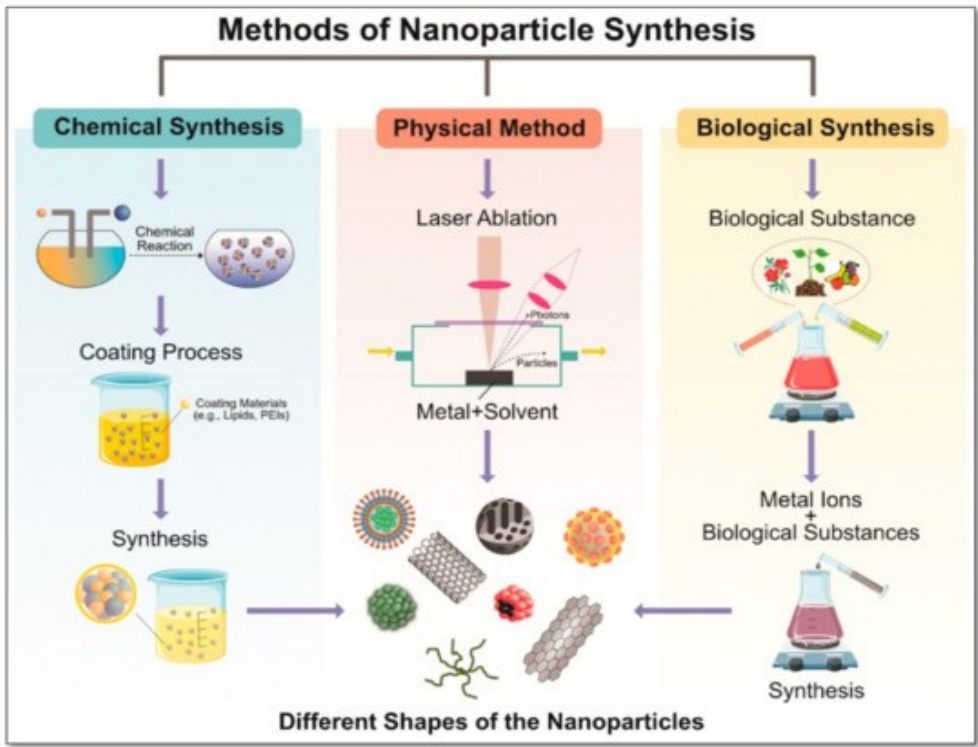


Figure: Synthesis Of Nanoparticles [27].

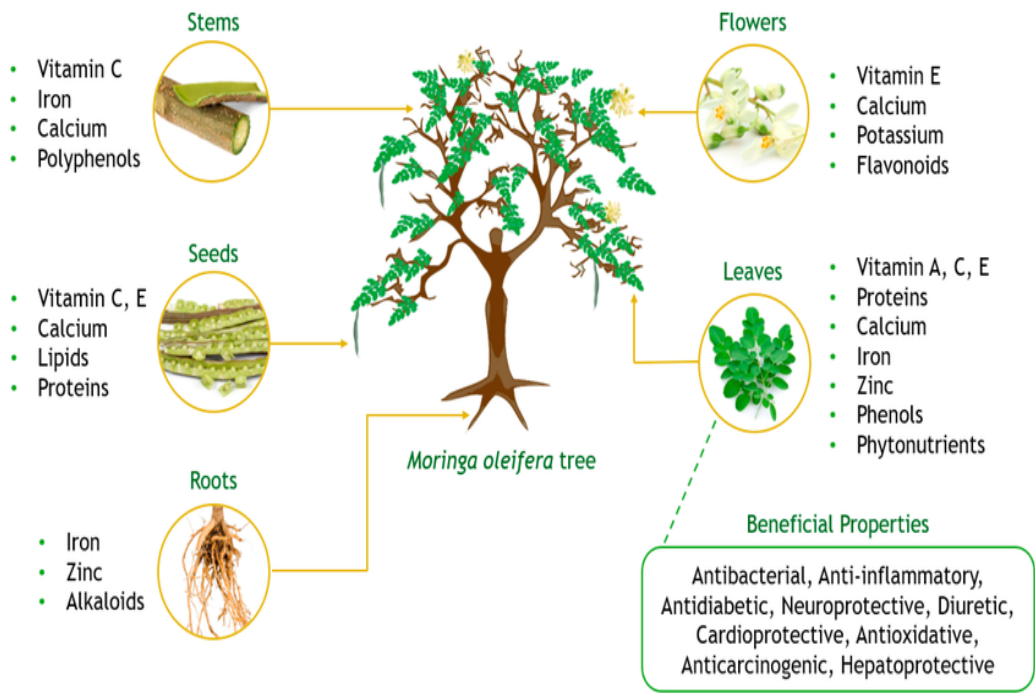


Figure . Moringa olifera [in google scolar]

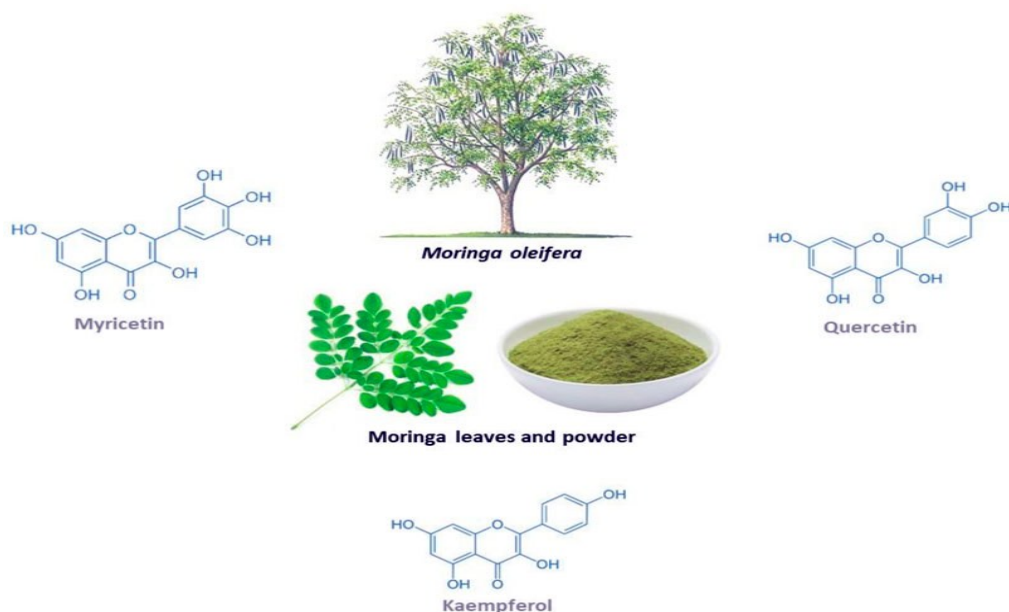


Diagram of ginger & their constituents, parts

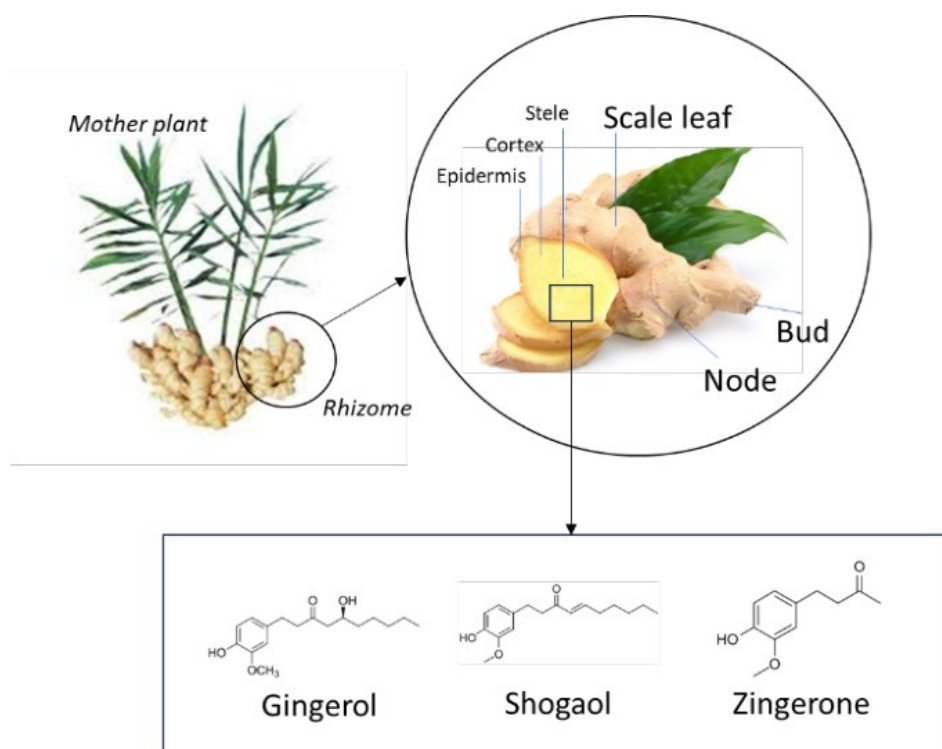


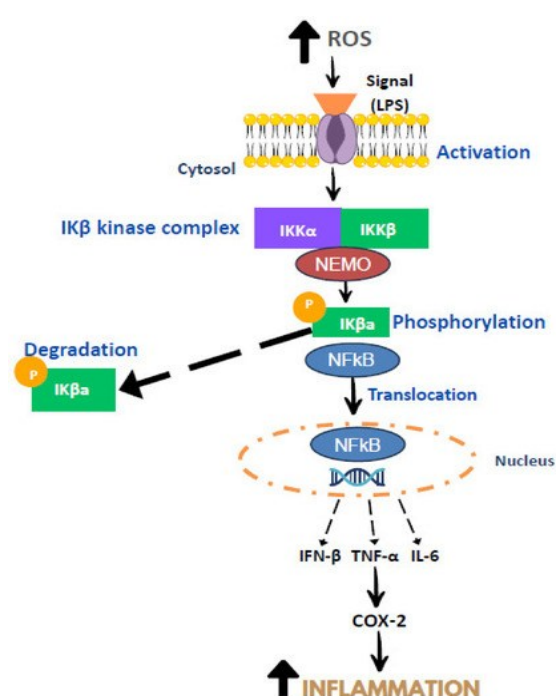
Diagram Of Ginger Tree: [Google Scholar]



Biological Properties of Moringa Olifera:

The Anti-Inflammatory Properties of *Moringa oleifera* and Ginger

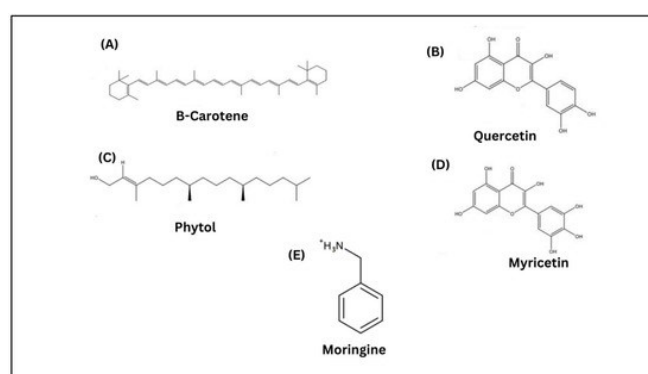
In a previous study, several active compounds, particularly phenols, alkaloids, flavonoids, tannins, β -sitosterone, vanillin, β -sitosterol, moringine, moringinine and hydroxymellein, have been found to promote the anti-inflammatory property of MO [28]. β -Sitosterol, for example, can downregulate inflammatory cytokines, such as IL-6, interleukin 8 (IL-8) and TNF- α , together with induction of haem oxygenase-1 (HO-1), an anti-inflammatory protein [28]. In addition, the inhibition of NLRP3 inflammasomes and the production of active forms of pro-IL-1 β and caspase-1 were demonstrated. In another study, quercetin reduced inflammation by inhibiting the action of NF- κ B and subsequent NF- κ B-dependent downstream events of inflammation [29].



Mechanism of moringa olifera and ginger as a Antinflammatory Activity

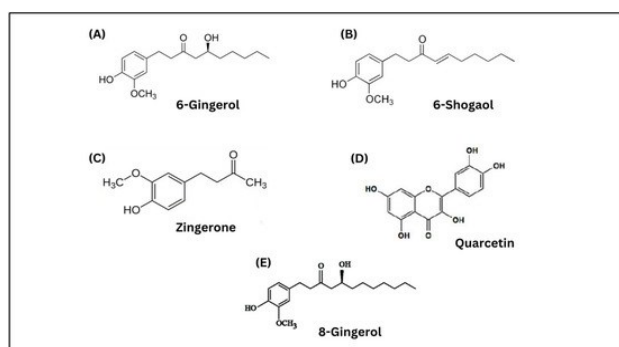
Moringa oleifera and *Zingiber Offinale* Roscoe

Moringa (*Moringa oleifera* Lam) (MO) comes from the Moringaceae family, and the Moringa genus is among the Indian traditional herbs used widely for health benefits. This plant is also known as “the magic tree” among the local people, which is related to its ability to treat various types of diseases [30]. MO is also recognised as Mulangay, Horseradish tree, Benzolive, Mlonge, Drumstick tree, Saijihan, Sajna, Kelor, and Marango [31]. MO seed, root, leaves, and flowers are useful for medicinal purposes. MO is widely distributed in North West India, Africa, the Caribbean, South East Asia, and South America [30]. A previous study found that the MO plant has been used extensively in treating skin infections, diabetes, anaemia, hypertension, and other types of diseases. MO is rich in bioactive components, particularly beta-carotene, quercetin, phytol, myricetin, and moringine [32].



Zingiber officinale Roscoe (ginger) is another medicinal herb studied as an anti-inflammatory agent in the pathogenesis of some degenerative diseases caused by inflammation processes [33]. Ginger, from

the Zingiberaceae family and the *Zingiber* genus, is used as a spice or flavour in cooking. It is also used as a medicinal herb for treating numerous diseases, including hypertension, diabetes, migraine, nausea, cardiovascular disease and Alzheimer's disease [34,35,36,37]. Ginger originated in tropical and subtropical Asia, China, Far East Asia, India, and Africa [38]. Ginger is composed of various types of bioactive components, including 6-gingerol, 6-shogaol, 8-gingerol, zingerone, and quercetin (Figure 3), which exhibit not only an anti-inflammatory effect but also antibacterial, anticancer, antidiabetic, gastro-protective, antioxidant, and neuroprotective effects [39,40,41].



2. Antioxidant Properties :

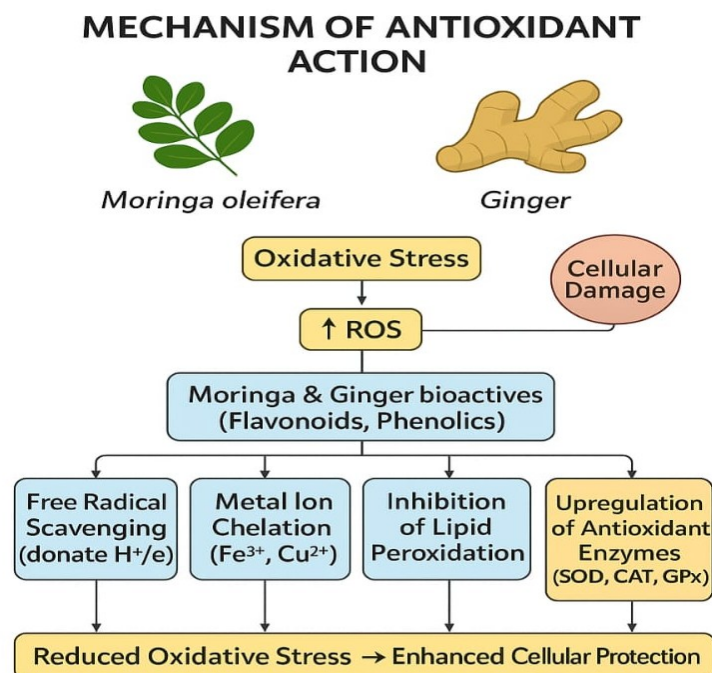
1. *Moringa Olifera* :

MO is a rich source of antioxidant (42). It has been reported that aqueous extracts of leaf, fruit and seed of MO act as an antioxidant (43). During a study reporting antioxidant property of freeze dried

Moringa leaves from different extraction procedures, it was found that methanol and ethanol extracts of Indian origin MO have the highest antioxidant activity with 65.1 and 66.8%, respectively (44, 45). It was also reported that the major bioactive compounds of phenolics, such as quercetin and kaempferol are responsible for antioxidant activity (45,46). During another study, quercetin and kaempferol have shown good antioxidant activity on hepatocyte growth factor (HGF) induced Met phosphorylation with IC₅₀ value for 12 and ~6 μ M/L, respectively (47). Another recent study comparing palm oil with MO seeds for their antioxidant potential found out that MO seed are superiors for radical scavenging (48).

2. *Zingiber Offinale Roscoe*.

Ginger roots extracts contain polyphenol compounds (6-gingerol and its derivatives), which have a high antioxidant Activity. Antioxidant compounds are widely used compounds to counter the free radicals mediate oxidative stress in the cell. Antioxidant activity is due to the presence of flavones, isoflavones, flavonoids, anthocyanin, coumarin, lignans, catechins and isocatechins. The total phenolic content in the alcoholic extract of the dried rhizome of ginger was 870.1 mg/g extract. Extract exhibited 90.1% of DPPH radical scavenging activity with the IC₅₀ concentration of 0.64 μ g/ml [49]. Antioxidant property of ginger is an extremely significant activity which can be used as a preventive agent against a number of diseases.



3. Anti Diabetic Properties

1. Moringa Olifera:

Several medicinal plants have been evaluated for their potential as therapeutic agent for diabetes. MO is also an important component in this category. MO leaves significantly decrease blood glucose concentration in Wistar rats and Goto-Kakizaki (GK) rats, modeled type 2 diabetes (50). Another study indicated that the extract from Moringa leaf is effective in lowering blood sugar levels within 3 h after ingestion (51). As a mechanistic model for antidiabetic activity of MO, it has been indicated that dark chocolate polyphenols (52) and other polyphenols (53, 54) are responsible for hypoglycemic activity. Moringa leaves are potent source of polyphenols, including quercetin-3-glycoside, rutin, kaempferol glycosides, and other polyphenols (55). Thus, potential antidiabetic activity of MO can be commercialized through the development of suitable technology with achieving anti-diabetic activity up to conventional drugs.

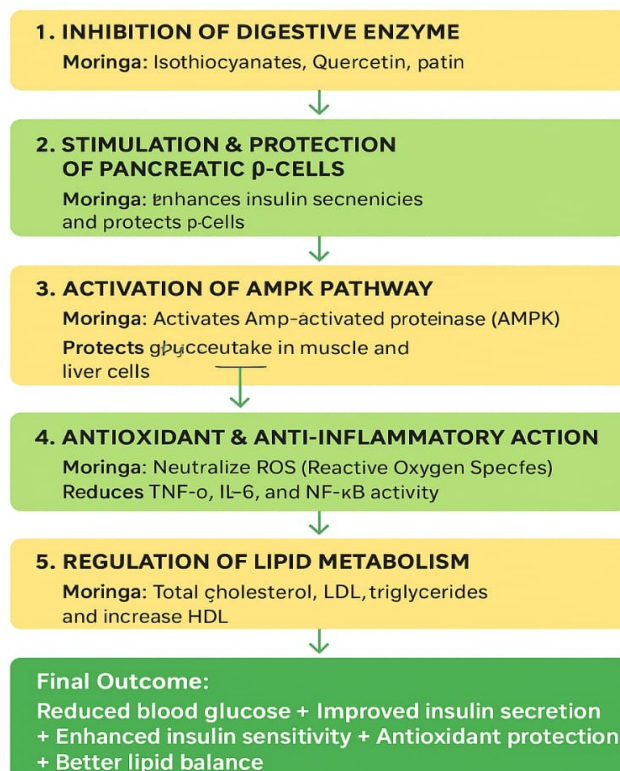
2. Zingiber Offinale Roscoe.

Previously, several human illnesses have been treated by using ginger rhizome extract. Functional and nutraceutical ingredients present in ginger rhizome

have hypocholesterolemic and hypoglycemic effects especially antioxidants, fat-soluble vitamins, phytosterols and some pyrazanol containing moieties [56,57]. The gingerol shows antioxidant [58], and anti-inflammatory behavior [59]. 1 g of ginger powder on an average contained 2.56 mg, 0.47 mg, 0.36 mg and 1.27 mg of 6-gingerol, 8-gingerol, 10-gingerol and 6-shogaols, respectively [60]. Pretreatment of ginger inhibits the induced hyperglycemia, hyperinsulinemia and hyperlipidemia [61]. It contains zingiberol, the principal aroma contributing component as well as gingerol, shogaols, paradols, zingiberene, gingediol, diarylheptanoids, vitamins and phytosterols [62]. The antioxidant activity of ginger extract is dependent on the concentration of 6-gingerol in the extract. In a study, it was investigated that the concentration of 6-gingerol is highly related to the antihyperlipidemic effects of ginger extract in fructose-induced hypolipidemic rats [63]. Diabetes is a disorder of carbohydrate metabolism that leads to low blood insulin level [64,65]. Ginger and its constituents significantly controlled diabetes through decreasing blood glucose level [86] and inhibition of oxidative stress and anti-inflammatory process.



COMBINED MECHANISM OF ANTIDIABETIC ACTION OF MORINGA OLEIFERA AND GINGER (ZINGIBER OFFICINALE)



CONCLUSION

The combined therapeutic potential of *Moringa oleifera* and *Ginger (Zingiber officinale)* demonstrates significant promise in the management and prevention of diabetes mellitus and its associated complications. Both plants possess rich bioactive compounds—such as flavonoids, phenolics, isothiocyanates, and gingerols—that exhibit strong antioxidant, anti-inflammatory, and antidiabetic activities. Their synergistic effects include inhibition of carbohydrate-metabolizing enzymes, enhancement of insulin secretion and sensitivity, protection of pancreatic β-cells from oxidative stress, and improvement of lipid metabolism. By modulating key pathways like AMPK activation and suppressing inflammatory mediators, these natural agents help regulate glucose homeostasis and prevent cellular damage caused by hyperglycemia.

Overall, *Moringa oleifera* and *Ginger* represent safe, affordable, and effective complementary options for diabetes management. However, further clinical and mechanistic studies are essential to establish optimal

dosages, formulations, and long-term efficacy in human populations.

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HOW TO CITE: Srushti Avhad, Vrushi Navale, Vaishnavi Gunjal, Diksha Ahire, Pratiksha Mhaske, A Comparative Review on the Biological and Therapeutic Activities of *Moringa oleifera* and *Zingiber officinale*-Based Nanoparticles, *J. Pharm. Sci.*, 2025, 1 (12), 376-387. <https://doi.org/10.5281/zenodo.17839322>

