

THERAPEUTIC POTENTIAL OF MORINGA OLEIFERA GERMINATED SEEDS IN POLYCYSTIC OVARY SYNDROME: A NARRATIVE REVIEW

Mariyum Batool^{*1}, Muhammad Aqib Saeed², Momena Malik³, Saba Yousaf⁴, Komal Saif⁵^{*1}Department of Human Nutrition and Dietetics, University of Management and Technology²Assistant Professor Department of AHS-Dietetics & Nutritional Sciences, University of Chenab^{3,4}Department of Human Nutrition and Dietetics, University of Management and Technology⁵Assistant Professor Department of AHS-Dietetics & Nutritional Sciences, University of Chenab^{*1}mrymbtul1@gmail.com ²aqib@ahs.uchenab.edu.pk ³momenamalik02@gmail.com⁴sabayousaf807@gmail.com ⁵komal@ahs.uchenab.edu.pkDOI: <https://doi.org/10.5281/zenodo.22007961>**Keywords**

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Copyright @Author**Corresponding Author: *****Mariyum Batool****Abstract**

Polycystic ovary syndrome (PCOS) is a common endocrine and metabolic disorder of obesity, insulin resistance, oxidative stress and chronic inflammation. Metformin is commonly used to manage it, but there are potential side effects to long-term use, so alternative therapies are necessary to ensure its safety and effectiveness. Moringa oleifera seeds are rich in nutrients and bioactive phytochemicals, while germination further enhances their nutritional quality and antioxidant potential. This narrative review summarizes the current evidence on the nutritional, phytochemical, and therapeutic potential of germinated Moringa oleifera seeds in obesity, insulin resistance, and PCOS. A literature search was conducted using PubMed, Scopus, Google Scholar, and ScienceDirect for studies published between 2010 and 2026. Owing to the limited availability of studies on germinated seeds, evidence from seed extracts, seed powders, and sprouts was also included. The available evidence suggests that Moringa oleifera seeds possess antioxidant, anti-inflammatory, antidiabetic, and anti-obesity properties that may help improve the metabolic disturbances associated with PCOS. However, current evidence is predominantly based on in vitro and animal studies. Further well-designed clinical trials are required to establish the efficacy, optimal dosage, and long-term safety of germinated Moringa oleifera seeds as an adjunctive therapy for PCOS.

INTRODUCTION

Polycystic ovarian syndrome (PCOS) is an endocrine and metabolic disorder that affects millions of women of reproductive age around the world. Epidemiological studies reported that the prevalence is between 4% and 21% and that about 11-13% of the female population of reproductive age suffers from this disease (Chen et al., 2026). Common clinical symptoms include increased hair growth, acne, elevated insulin levels, and

irregular menstrual cycles (Meier, 2018). Obesity and insulin resistance (IR) are metabolic problems that affect 60-80% of women with PCOS (Carmina et al., 2010). By raising the formation of free radicals and lowering the body's antioxidant capacity, oxidative stress in PCOS upsets the oxidative balance. This illness exacerbates chronic inflammation in ovarian tissue by activating inflammatory pathways like NF- κ B and JNK (Ainehchi et al., 2020).

Metformin is the first line of treatment for PCOS obesity, which improves GLUT-4, decreases peripheral insulin levels, increases peripheral glucose uptake, and inhibits hepatic glucose absorption. However, long-term metformin therapy causes diarrhea, indigestion, and other side effects. One of the alternative therapies being developed in the wider society is herbal therapy, which includes *Moringa oleifera* (Amelia et al., 2018)

Moringa Oleifera (Miracle tree) belongs to Moringaceae family grows widely in tropical and subtropical regions around the world with its origins traced in Pakistan, Bangladesh, Afghanistan, and India. Each part of the plant utilized for its nutritional value with leaves being especially abundant in beta carotene, essential minerals, potassium and calcium (Shwayil et al., 2026). *Moringa* seeds are a significant supply of important macronutrients carbohydrate, protein and fats (Liu et al., 2025). *M. Oleifera* seeds contain phytochemical ingredients including isothiocyanates and glucosinolates. Seeds are rich in phytochemicals such as resins, glycosides, tannins, flavonoids, alkaloids (Dzuvor et al., 2022).

Germination is a physiological process that begins when dormant seeds absorb water and concludes when the embryonic axis, usually the radicle, emerges through the surrounding tissues along with a number of intricate physiological and biochemical changes, such as respiration, protein biosynthesis, subcellular structural alterations, cell elongation, and mobilization of storage reserves, among other things (Bewley et al. 2012; Liu et al. 2022; Núñez-Gastélum et al. 2023; Rifna et al. 2019).

Adaptive reactions to biotic or abiotic stressors (such as temperature fluctuation, dehydration, and osmotic pressure) typically impact various physiological and biochemical processes of *moringa* seeds that are involved in the accumulation of nutrients and phytochemicals during germination. The sprouts and germinated seeds have several medical benefits, including anti-inflammatory, hepatoprotective, antidiabetic, anticancer, and antioxidant qualities, since these

bioactive compounds are produced. The germination process needs to be carefully managed with external factors of the germination process, like exogenous phytohormones, to make *moringa* sprouts with enhanced health promoting properties. (Liu et al., 2025).

Although there is growing evidence of the therapeutic effects of *Moringa oleifera*, research is still limited on the beneficial effect of germinated *Moringa oleifera* seeds on polycystic ovary syndrome (PCOS) management. Therefore, this narrative review summarizes the current evidence on the nutritional, phytochemical, and therapeutic potential of germinated *Moringa oleifera* seeds in obesity, insulin resistance, and PCOS.

Methodology:

A narrative review method was employed to round up the current scientific literature research. Relevant studies were retrieved using online electronic databases including PubMed, Google Scholar, Scopus and ScienceDirect. A literature search was done by using the combinations of keywords: *Moringa oleifera* seeds, germination, weight loss, obesity, PCOS, insulin resistance, phytochemicals. The studies were included if published in English from 2010 to 2026. Experimental studies, review papers and research articles covering nutritional composition, phytochemical composition, effect on germination and metabolic/hormonal effects of *moringa* seeds were considered to be eligible. Records of duplicated studies, non-peer reviewed sources, studies not dealing with seeds and studies dealing only with leaves were not included. The literature was critically analyzed and categorized under different sections like phytochemical profile, weight reduction effect, nutritional composition and possible effect on PCOS. Due to the limited availability of studies on germinated *Moringa oleifera* seeds, evidence from seed extracts, seed powders, and sprouts were also included to provide a comprehensive overview of their therapeutic potential.

Results:

The seed germination process starts with tegument rupturing and primary root development in seed.

The yellowish white and thick in structure is primary root while secondary roots are thinner and easily differentiated. After sowing germination process starts between 5 to 7 days. The first eophylls can be seen on 13th day while additional leaves develop on 15th day of germination process (Gastélum et al., 2023).

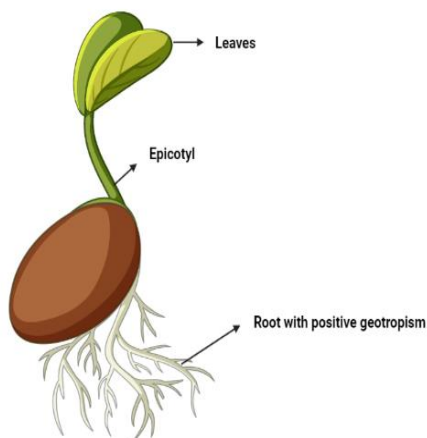


Figure 1: Tissue development during Germination (Gastélum et al., 2023)

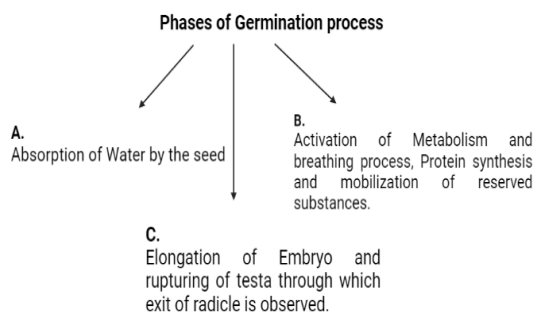


Figure 2: Phases of germination (Liu et al., 2025)

Through morphogenetic and metabolic mechanism, the embryo alters into a seed for germination. The germination process is regulated by both internal and external influences. Internal factors include the feasibility of embryo, different forms of dormancy, the reservoir tissue's quality and quantity while external factors are thickness of

testa, temperature, the availability of water and light (Russo et al., 2010). In greenhouse and laboratory the substrates are placed in containers and seeds are sowed in soil to germinate within 4-10 days duration.(Hassanein & Al-Soqeer, 2017) The irregularity is observed due to position of seed in pod in *M. Oleifera* seeds germination process. (Dao et al., 2017)

Moringa seeds have long been used in ethnomedicine for their multiple health advantages, which include hepatoprotection, anti-inflammatory, anticarcinogenic, and antidiabetic characteristics. The high quantities of phytochemicals such as glucomoringin, moringin, and phenolic compounds are primarily responsible for these bioactivities. Although there have been few in vivo investigations on moringa seeds, sprouts, and extracts, multiple studies have consistently proved moringa seeds' medical effects (Al-Malki and El Rabey 2015; Hamza 2010; Zunica et al. 2021). To that purpose, we summarize the key health advantages of moringa seeds, sprouts, and extracts seen in vivo, with a focus on the potential mechanisms of action. The major findings, experimental models, and sample types summarized in Table 1.

Moringa seed powder's antioxidant components, such as glucomoringin and moringin, flavonoids (like quercetin and kaempferol), and phenols (like chlorogenic acid), which have the ability to scavenge free radicals, are probably responsible for its antidiabetic action. Moreover, moringa seed extracts could be useful for diabetes management due to their ability to maintain lipid homeostasis and reduce serum cholesterol and triglyceride levels while also decreasing oxidative stress (Aljazzaf et al., 2023). Additionally, via modifying the expression of inflammatory (like iNOS) and antioxidant (like NQO1) genes as well as the gut microbiota, moringa seed extracts enhanced glucose and insulin tolerance as well as general metabolic health in obese mice fed a very high-fat diet (Jaja-Chimedza et al. 2018).

Table 1: Experimental evidence on therapeutic effect of *Moringa Oleifera* seeds

Sample type	Models	Major results	References
Weight Management and Obesity			
80% aqueous ethanol extracts of moringa seeds	VHFD-fed obese C57BL/6J male mice	Reduced body weight, decreased adiposity, and improved glucose tolerance Maintained metabolic health by modulating inflammatory (e.g., iNOS) and antioxidant gene expression (e.g., NQO1) and gut microbiota	Jaja-Chimedza et al., (2018)
Diabetes and insulin resistance			
Moringa seed powder	STZ-induced diabetes in adult male albino rats	Reduced lipid peroxidation, IL-6, immunoglobulins (e.g., IgA and IgG), levels of glycosylated hemoglobin (HbA1c) Increased antioxidant enzyme activity (e.g., catalase, superoxide dismutase, and reduced glutathione) Reduced levels of glucosuria, creatinine, urea nitrogen, albumin, sodium, and potassium	Al-Malki and El Rabey (2015)
Methanol extracts of moringa seeds	Alloxan-induced diabetes in adult male Swiss albino mice	Lower fasting blood glucose Reduced (AST, ALT, and ALP) levels in serum the activities of liver enzymes Maintained lipid homeostasis and decreased serum cholesterol and triglyceride levels Decreased the oxidative stress biomarkers (e.g., MDA, NO, and PC)	Aljazzaf et al., (2023)
Aqueous moringa seeds extracts	HFD-fed Sprague Dawley male rats with STZ-induced diabetic nephropathy	Enhanced GSK-3 β activity for renal protection Modulated Nrf2/HO-1 signaling pathway to reduce oxidative injury in kidneys	Wen et al., (2022)
Anti-inflammatory and antioxidant effect			
Pure extracts of moringa seed oil	EAC-inoculated Swiss albino female mice	Reduced pro-inflammatory cytokines IL-2, IL-6, and TNF- α Enhanced activities of GSH and superoxide SOD while reducing MDA levels	Aldayel et al., (2023)
MPG extracted from moringa seeds	CCl ₄ -induced hepatotoxicity in ICR mice	Ameliorated oxidative stress Regulated MCP-1 and inflammatory cytokines like TNF- α , IL-1 β , and IL-10 Inhibited hepatic apoptosis	Sun et al., (2019)

80% ethanol extracts of moringa seeds	DSS-induced ulcerative colitis C57BL/6J in male mice	Downregulation of pro-inflammatory mediators (e.g., IL-1, IL-6, TNF- α , and iNOS) while upregulated the GSTP1, an Nrf2-mediated phase II detoxifying enzyme	Kim et al., (2017)
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Discussions

In vitro and in vivo studies have revealed that moringa seeds, moringa sprouts and extracts exhibit potent antioxidant activity. Free radical scavenging tests have shown their in vitro antioxidant capabilities (Zhnag, et al. 2024). Moreover, moringa seed extracts also show promising anti-inflammatory activity in animal and cell models. For instance, cellular research has shown that moringa seed extracts have anti-inflammatory properties by lowering NO production through the iNOS pathway (Jaja-Chimedza et al. 2017).

Moringa seed powder's antioxidant substances, such as glucomoringin and moringin, flavonoids (like quercetin and kaempferol), and phenols (like chlorogenic acid), which have the ability to scavenge free radicals, are probably responsible for its antidiabetic effects. Besides regulating oxidative stress, moringa seed extracts can also help manage diabetes by maintaining lipid homeostasis and reducing levels of serum cholesterol and triglycerides (Aljazzaf et al., 2023).

Conclusion

Germinated Moringa oleifera seeds are an interesting functional food due to their higher content of bioactive phytochemicals and nutrition. Based on the available evidence, there are positive effects on oxidative stress, inflammation, obesity and insulin resistance, all of which are highly related to PCOS. Much of the information available is based on in vitro and animal studies however, more human clinical trials that are meticulously planned and executed are required before they can be recommended as an adjunct therapy in women with PCOS, to establish efficacy, optimal dose, and safety.

Abbreviations

PCOS	Polycystic Ovary Syndrome
M. Oleifera	Maringa oleifera
IR	Insulin resistance
NF- κ B	Nuclear Factor Kappa B
GLUT-4	Glucose Transporter Type 4
IL-1 β	Interleukin-1 beta
IL-2	Interleukin-2
IL-6	Interleukin-6
TNF- α	Tumor Necrosis Factor-alpha
iNOS	Inducible Nitric Oxide Synthase
NQO1	NAD(P)H Quinone Dehydrogenase 1
STZ	Streptozotocin
AST	Aspartate Aminotransferase
ALT	Alanine Aminotransferase
ALP	Alkaline Phosphatase
MDA	Malondialdehyde
NO	Nitric Oxide
PC	Protein Carbonyls
GSK-3 β	Glycogen Synthase Kinase-3 Beta
Nrf2	Nuclear Factor Erythroid 2
HO-1	Heme Oxygenase-1
HFD	High-Fat Diet
VHFD	Very High-Fat Diet
DSS	Dextran Sulfate Sodium
GSTP1	Glutathione S-Transferase Pi 1
GSH	Reduced Glutathione
SOD	Superoxide Dismutase
MPG	Moringa Polysaccharide Glycoconjugate
EAC	Ehrlich Ascites Carcinoma
MCP-1	Monocyte Chemoattractant Protein-1
CCl ₄	Carbon Tetrachloride
ICR	Institute of Cancer Research

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