ISSN: 2456 - 530X
PubMed - National Library of Medicine - ID: 101737738

EIJO: Journal of Ayurveda, Herbal Medicine and Innovative Research (EIJO - AHMIR)
Einstein International Journal Organization (EIJO)
Available Online at: www.eijo.in
Volume – 10, Issue – 6, November - December - 2025, Page No. : 01 - 16

Antioxidant Profiles of Momordica Charantia, Ocimum Sanctum and Moringa Oleifera: Methods, Mechanisms and Therapeutic Implications

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Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Common medicinal plants with antioxidant properties include Moringa oleifera, Ocimum sanctum (holy basil), and Momordica charantia (bitter melon). There is a lack of a thorough comparative analysis of their phytochemical antioxidants, assay findings, and possible therapeutic utility. To identify knowledge gaps and suggest standardized comparative methodologies, the antioxidant composition and activity of M. charantia, O. sanctum, and M. oleifera will be critically reviewed and compared across extraction techniques, in-vitro/in-vivo assays, and human studies. systematic search of the literature for studies reporting phytochemical profiles, total phenolic/flavonoid contents, and antioxidant assays using electronic databases (PubMed, Scopus, Web of Science, and Google Scholar).Methodological heterogeneity and assay standardization were discussed, along with a qualitative and, if feasible, quantitative summary of the data. Strong antioxidant activity is demonstrated by each species, although the dominant compounds vary: M. oleifera has high levels of phenolics, flavonoids, and ascorbate; O. sanctum has eugenol, ursolic acid, and rosmarinic acid; and M. charantia has momordicosides, phenolics, and carotenoids. Assay results depend on both the assay and the extraction; protocol heterogeneity limits direct comparisons. Standardized extraction and assay procedures are necessary for accurate head-to-head comparison, even though all three plants show encouraging antioxidant potential. Standardized multi-assay panels, phytochemical fingerprinting (HPLC/LC-MS), and carefully planned in vivo/clinical studies should all be a part of future research.

Keywords: Momordica Charantia, Ocimum Sanctum, Moringa Oleifera, Antioxidant Activity, DPPH, Total Phenolic Content, Phytochemistry, Comparative Review

Introduction

Oxidative Stress and Health Relevance

When the body's natural antioxidant defense systems and the generation of reactive oxygen species (ROS) are out of balance, oxidative stress results. Overproduction of ROS can harm proteins, lipids, and DNA, which can lead to the development of chronic illnesses like diabetes, heart disease, cancer, neurodegenerative diseases, and aging-related disorders. Therefore, controlling oxidative stress is essential for preserving cellular homeostasis and stopping the progression of disease.[1]

Importance of Plant Antioxidants in Nutraceuticals and Therapeutics

Antioxidants derived from plants, including polyphenols, flavonoids, vitamins, and carotenoids, work by scavenging free radicals, chelating metal ions, and modifying endogenous antioxidant enzymes. When added to therapeutic formulations, functional foods, and nutraceuticals, these substances not only stop oxidative damage at the cellular level but also have positive health effects. Because of their natural source, safety record, and possible synergistic effects when compared to synthetic antioxidants, plant antioxidants have gained more attention.[2]

Plants Description

- **Momordica charantia (Bitter Melon):** Mordica charantia (bitter melons): Found throughout Asia, Africa, and the Caribbean, this plant has long been used to treat infections, diabetes, and gastrointestinal issues. Its medicinal qualities are enhanced by the abundance of bioactive substances like cucurbitane glycosides, saponins, and triterpenoids found in its fruit, seeds, and leaves.[3]

Bitter Melon (*Momordica charantia*)

Botanical Name	*Momordica charantia*
Family	Cucurbitaceae
Common Names	Bitter Melon, Bitter Gourd, Karela
Habit	Annual or perennial climbing vine
Distribution	Tropical and subtropical regions of Asia, Africa, and the Caribbean
Plant Height	2–5 meters (climbing tendrils)
Stem	Slender, green, angular, trailing or clinbing; bears tendrils
Leaves	Simple, alternate, deeply lobed (5–7 lobes), rough texture
Flowers	Unisexual, yellow, 2-3 cm in diameter; male and female flowers on same plant (monoecious)
Seeds	Flat, oblong, brownish-red with a white aril, bitter taste
Medicinal Uses	Antidiabetic, antioxidant, antiviral, anti-inflammatory

Figure 1: Plant profile of Bitter Melon

- **Ocimum sanctum (Holy Basil/Tulsi):** Holy basil, which is indigenous to India, is valued in Ayurvedic medicine for its antimicrobial, immunomodulatory, anti-inflammatory, and adaptogenic qualities. The phenolic compounds, rosmarinic acid, and eugenol found in leaves and essential oils are what give it its medicinal and antioxidant properties.[4]

Holy Basil (*Ocimum sanctum*)

Botanical Name	*Ocimum sanctum*	
Family	Lamiaceae	
Common Names	Holy Basil, Tulsi	
Habit	Short-lived perennial herb	
Distribution	Native to India, especially the eastern Himalayas	
Plant Height	0.3–1.5 meters	
Stem	Square, hairy stems	
Leaves	Simple, opposite, ovate leaves with serrate margins	
Flowers	Small, purple or white flowers arranged in a spike	
Seeds	Small, round, dark brown	
Medicinal Uses	antioxidant, anti-inflammatory, antimicrobial, adaptogenic	antioxidant, anti-inflammatory, anti-inflammatory

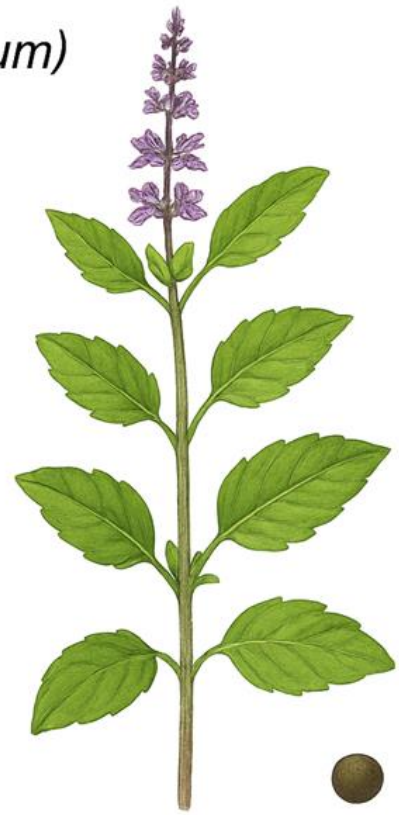
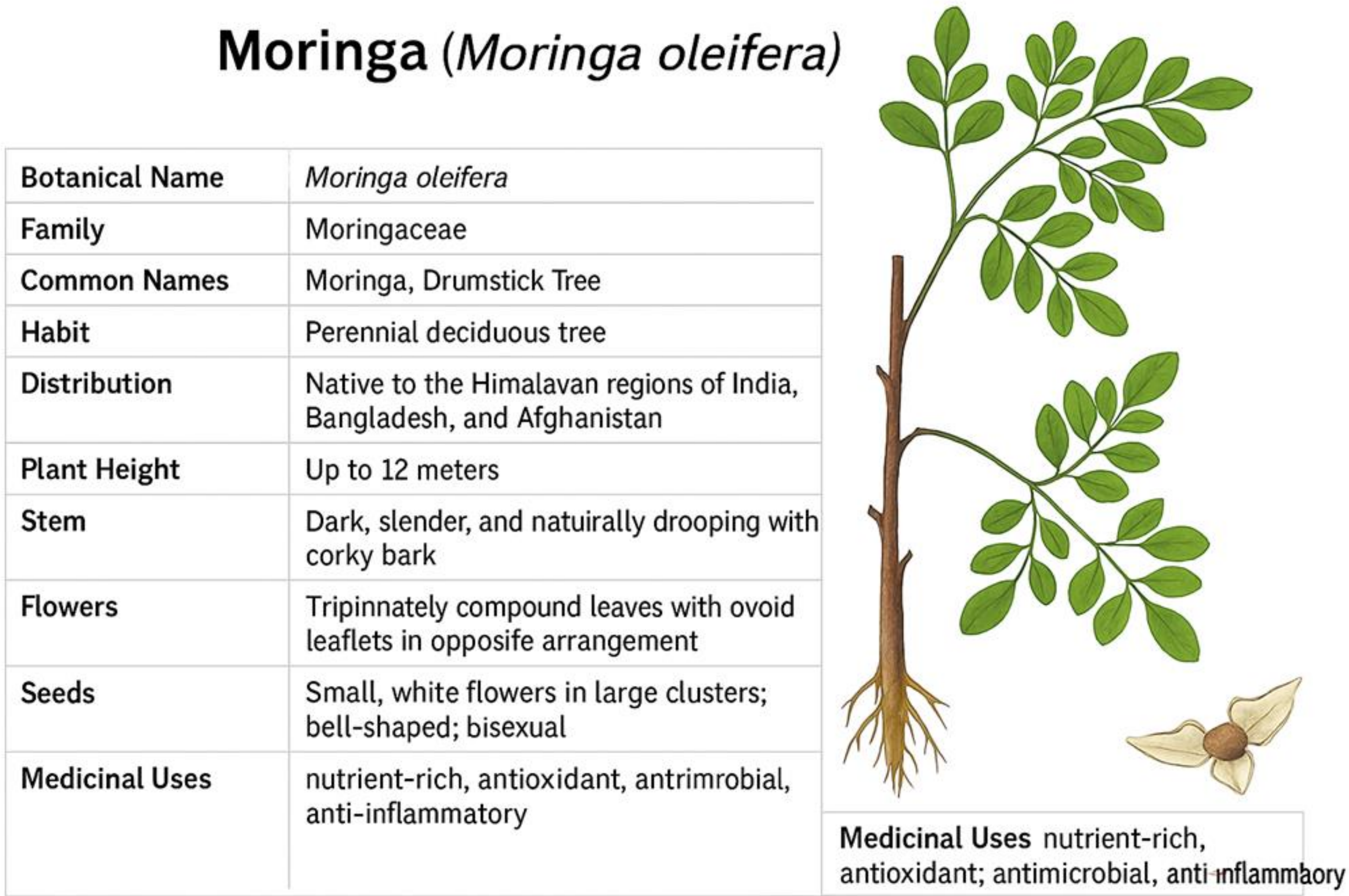


Figure 2: Plant Profile of Holy Basil

- **Moringa oleifera (Moringa):** Originating in South Asia, Moringa is now widely grown in tropical areas and is referred to as a "miracle tree" because of its therapeutic and nutritional benefits. Rich in polyphenols, vitamins, and minerals, leaves, seeds, and roots have long been used to treat wound healing, inflammation, and malnutrition.[5]



Botanical Name	*Moringa oleifera*
Family	Moringaceae
Common Names	Moringa, Drumstick Tree
Habit	Perennial deciduous tree
Distribution	Native to the Himalavan regions of India, Bangladesh, and Afghanistan
Plant Height	Up to 12 meters
Stem	Dark, slender, and natuirally drooping with corky bark
Flowers	Tripinnately compound leaves with ovoid leaflets in opposife arrangement
Seeds	Small, white flowers in large clusters; bell-shaped; bisexual
Medicinal Uses	nutrient-rich, antioxidant, antrimrobial, anti-inflammatory

Figure 3: Plant Profile of Moringa Oleifera

Rationale for Comparative Review and Objectives

There is little combined data comparing the antioxidant capacities of M. charantia, O. sanctum, and M. oleifera, despite in-depth research on individual plants. A comparative review offers a framework for comprehending their relative effectiveness, identifying the best plant parts and extraction techniques, and directing their use in therapeutic and nutraceutical applications. This review's goals are to highlight methodological variations, offer recommendations for future research directions, and systematically assess the in vitro, in vivo, and clinical data regarding these species' antioxidant activities.[6]

Methods Used to Measure Antioxidant Activity

Several chemical and biological tests with varying reaction mechanisms and radical types are used to evaluate antioxidant potential. While DPPH, ABTS, and FRAP measure free-radical scavenging or reducing power in vitro, the TPC and TFC assays quantify total reducing compounds. Because ORAC mimics the peroxyl radicals present in biological systems, it is thought to be more physiologically relevant. Lipid peroxidation in biological tissues is reflected by TBARS (MDA estimation), while reducing power assays offer supplementary data on electron-donating capacity. By taking into account uptake and metabolism within living cells, cellular antioxidant assays bring evaluation into the biological realm.A complex plant extract's total antioxidant capacity cannot be represented by a single assay because each one measures a distinct component of antioxidant behavior, such as electron transfer, hydrogen atom transfer, metal chelation, or radical quenching.[7]For thorough and trustworthy comparisons between Momordica charantia, Ocimum sanctum, and Moringa oleifera extracts, multi-assay panels are given in Table 1.

Table 1: Common Methods Used to Measure Antioxidant Activity and Their Analytical Characteristics[8,9,10]

Assay / Method	Principle / Reaction Basis	Expression of Results (Units)	Major Advantages	Limitations / Considerations
Total Phenolic Content (TPC) — Folin–Ciocalteu method	Reduction of phosphomolybdate–phosphotungstate complex (Folin reagent) by phenolic compounds → blue color measured at 760–765 nm.	mg Gallic Acid Equivalents (GAE)/g extract or sample.	Simple, rapid, inexpensive; good indicator of total reducing capacity.	Non-specific—reacts with other reducing agents (ascorbate, sugars); not a direct measure of antioxidant activity.
Total Flavonoid Content (TFC) — $AlCl_3$ colorimetric method	Formation of stable complex between $AlCl_3$ and flavonoid keto/hydroxyl groups → yellow color at 415 nm.	mg Quercetin or Catechin Equivalents (QE or CE)/g extract.	Estimates total flavonoid concentration; quick and reproducible.	Specific only for certain flavonoid structures; cannot distinguish subclasses.
DPPH Radical Scavenging Assay	Reduction of purple DPPH• (2,2-diphenyl-1-picrylhydrazyl) radical to yellow DPPH-H; absorbance decrease at 517 nm.	% inhibition or IC_{50} (µg/mL), or µmol Trolox Equivalents (TE)/g.	Widely used, simple, cost-effective; stable radical source.	Solvent sensitivity (works best in methanol/ethanol); limited for hydrophilic compounds; not biologically relevant radical.
ABTS Radical Cation Decolorization Assay	Reduction of blue-green $ABTS^{+}$• radical cation (λ = 734 nm) by antioxidants.	µmol Trolox Equivalents (TE)/g or mM TE/mL.	Applicable to both hydrophilic and lipophilic antioxidants; fast and reproducible.	Requires generation of $ABTS^{+}$•; sensitive to pH and solvent; less stable than DPPH.
Ferric Reducing Antioxidant Power	Reduction of Fe^{3+}–TPTZ complex to	µmol Fe^{2+} Equivalents/g or	Simple, fast, reproducible; no	Measures reducing power only; cannot detect thiols;

(FRAP)	blue Fe^{2+}–TPTZ by antioxidants; absorbance at 593 nm.	µmol Trolox Equivalents/g.	radical generation step.	pH-dependent; underestimates thiol antioxidants.
Oxygen Radical Absorbance Capacity (ORAC)	Measures ability of antioxidants to inhibit oxidation of fluorescent probe (fluorescein) by peroxyl radicals (AAPH generator).	µmol Trolox Equivalents (TE)/g sample.	Physiologically relevant (peroxyl radicals); suitable for both hydrophilic and lipophilic systems.	Requires fluorescence spectrophotometer; time-consuming; sensitive to conditions.
Reducing Power Assay	Antioxidants reduce Fe^{3+}/ferricyanide complex to Fe^{2+} → Prussian blue formation measured at 700 nm.	Absorbance increase or µmol Fe^{2+}/g extract.	Simple estimation of electron-donating capacity; correlates with TPC/TFC.	Non-specific; does not directly quantify radical scavenging potential.
Lipid Peroxidation (TBARS/MDA) Assay	Measures malondialdehyde (MDA) formed from lipid peroxidation reacting with thiobarbituric acid (TBA) → pink adduct at 532 nm.	nmol MDA/mg protein or µmol MDA/g tissue.	Widely used in vivo indicator of oxidative damage; useful for biological samples.	Lacks specificity—TBA reacts with other aldehydes; can overestimate MDA.
Cellular Antioxidant Activity (CAA) Assay	Measures intracellular oxidation of fluorescent probe (DCFH-DA) to DCF in cultured cells; antioxidants reduce fluorescence intensity.	Relative fluorescence units (RFU) or % inhibition vs control.	Reflects bioavailability, uptake, metabolism; biologically relevant.	Requires cell culture; complex and expensive; results vary with cell type and conditions.

Assay patterns & top performers. Top performers and assay patterns. M. oleifera is the most reliable in vitro antioxidant source of the three species in the literature sampled above because moringa leaf extracts consistently rank among the top performers in DPPH, ABTS, FRAP, and ORAC assays and exhibit high TPC across numerous independent studies. Momordica charantia exhibits moderate but significant antioxidant activity, frequently depending on the plant organ and extraction technique employed; Ocimum sanctum (holy basil) also performs well in a variety of tests, especially when phenolic-rich solvent fractions (butanol, ethyl acetate) or essential oils are examined.[11]

Role of solvent and extraction method. One of the main factors influencing assay results is solvent polarity. In comparison to aqueous or nonpolar solvents, methanol/ethanol and hydroethanolic systems consistently yield higher TPC/FRAP/ABTS values and lower DPPH IC_{30}s while extracting a wide range of phenolics and flavonoids. By increasing extraction efficiency, newer green solvents (DES) and assisted extraction (ultrasound, microwave, UAE) frequently raise measured TPC and assay responses. As a result, care should be taken when directly comparing studies that employed various extraction systems.[12]

Influence of plant part. Among the three species, leaves are the most abundant and reliable source of antioxidant activity (high levels of vitamin C, polyphenols, and chlorophyll). When compared on equivalent dry-weight bases, seeds and roots usually exhibit lower activity than leaves, though in some species they can be active (for example, concentrated seed oils or seed extracts with particular phenolics). For Momordica, fruit pulp typically exhibits less activity than leaves.[13]

Heterogeneity & reporting issues. Heterogeneity in (1) assay protocols (concentrations, incubation times, calibration standard used), (2) unit reporting (fresh vs. dry weight, µg/mL vs. µmol TE/g), (3) extraction parameters (solvent, ratio, time, temperature), and (4) plant material (chemotype, harvest time, leaf age, drying method) are major barriers to a quantitative head-to-head meta-analysis. Prior to data pooling, note assay-specific cautions (e.g., DPPH preference for lipophilic systems) and convert units to common bases (e.g., µmol TE/g dry weight).[14]

Table 2: Comparative summary of in-vitro assay results, effects of extraction solvent and plant part[15,16,17]

Assay	Typical findings (species comparison)	Effect of extraction solvent	Effect of plant part
DPPH (radical scavenging; IC_{50} or % inhibition)	Moringa leaves most often show strongest DPPH scavenging (lowest IC_{50} / highest % inhibition), followed by Ocimum leaves (variable depending on chemotype), with Momordica (fruit/leaf) showing moderate activity across studies.	Polar organic solvents (methanol, ethanol) and hydroethanolic mixtures typically extract more DPPH-active compounds than water; methanolic extracts often report lower IC_{50}. Deep-eutectic solvents and optimized hydroalcoholic methods can increase yields.	Leaves generally outperform seeds/roots; for Momordica, seeds and fruit sometimes show activity but leaf extracts are more consistent.
ABTS (radical cation; TE/g)	Moringa and Ocimum typically show high ABTS values;	ABTS is compatible with both hydrophilic and lipophilic	Leaves > stems/roots; essential-oil fractions of

	Momordica shows moderate ABTS depending on extraction. ABTS often gives higher numeric values than DPPH because it measures both hydrophilic and lipophilic antioxidants.	extracts; solvents that capture both classes (hydroethanolic, ethyl acetate fractions) give elevated ABTS scores.	Ocimum can have strong ABTS activity due to phenylpropanoids.
FRAP (reducing power; µmol Fe^{2+} eq./g)	FRAP correlates strongly with TPC; Moringa leaves often report the highest FRAP values, followed by Ocimum (but ethyl-acetate/butanol fractions may top crude extracts), and Momordica shows moderate reducing power.	Methanol/ethanol and hydroethanolic extracts commonly show higher FRAP; non-polar solvents give low FRAP. FRAP is pH-sensitive so assay conditions matter.	Leaf extracts (high chlorophyll/phenolic content) > roots/seeds for FRAP. Some seeds show high reducing power if oil/phenolic seed fractions concentrated.
ORAC (peroxyl radical quenching; µmol TE/g)	Fewer studies report ORAC; where measured, Moringa leaf extracts often show high ORAC, Ocimum variable by chemotype, Momordica moderate. ORAC often aligns with FRAP/TPC but captures H-atom transfer capacity.	ORAC responds to extraction that preserves peroxyl-active phenolics (aqueous + organic fractions both relevant). Requires careful sample prep to avoid fluorescence quenching.	Leaves generally higher ORAC; roots and seeds lower unless specifically concentrated for peroxyl-active compounds.
Total Phenolic Content (TPC; mg GAE/g)	Moringa leaves typically show the highest TPC (often reported in the range of several 10s–100s mg GAE/g depending on dry weight basis and method), Ocimum leaves and butanol/ethyl-acetate fractions show high TPC, Momordica variable but generally lower than moringa leaves in many comparative studies. TPC correlates moderately–strongly	Methanolic and hydroethanolic extractions give higher TPC than pure water or nonpolar solvents; extraction time/temperature and solvent ratio strongly influence TPC. DES and ultrasound/microwave assisted extractions can increase TPC.	Leaf tissues (high polyphenol & flavonoid density) >> seeds/roots/fruit pulp for TPC. Within species, young leaves often show higher TPC.

	with DPPH/FRAP in pooled datasets.		
Reducing power / other colorimetric assays	Trends match FRAP and TPC: Moringa > Ocimum (extract-dependent) > Momordica (variable).	Same solvent patterns: polar organic solvents > nonpolar.	Leaves > seeds/roots in most cases.
Lipid peroxidation inhibition (in vitro TBARS / linoleic acid models)	Moringa leaf extracts often show strong inhibition of lipid peroxidation; Ocimum essential oils and phenolic fractions also effective; Momordica shows moderate inhibition in many reports.	Lipophilic extracts (ether/ethyl acetate) can be more effective in lipid models; formulation (presence of lipids) influences efficacy.	Leaf and seed oil fractions can be effective; aqueous leaf extracts less so in lipid-based systems.

Table 3: Meta-table — representative studies (study species plant part, extraction, assay(s), result / reported units)[18,19,20,21]

Study (year)	Species	Plant part	Extraction	Assay(s)	Reported result (units)
Perumal et al. (2021). — Antioxidant profile of M. charantia fruit.	M. charantia	Fruit	Ethanolic extract	DPPH (IC_{50}), TPC	DPPH IC_{50} reported (µg/mL); TPC reported (mg GAE/g) — moderate scavenging vs plant standards.
Pham et al. (2019). — wild bitter melon activities.	M. charantia	Leaves / fruit	Methanol / chloroform	DPPH, FRAP	Methanolic extracts: low IC_{50} (strong activity); chloroform weaker.
Fidrianny et al. (2015). — three organs of bitter gourd.	M. charantia	Leaf, fruit, seed	Various (aqueous, methanol)	DPPH, FRAP	Leaves highest DPPH & FRAP among organs (IC_{50} & FRAP values reported).
Chaudhary et al. (2020). — Ocimum sanctum profiling.	O. sanctum	Leaves	Butanol, ethyl acetate fractions	TPC, DPPH, FRAP, ABTS	Butanol/EtOAc fractions: high TPC and strongDPPH/FRAP/ABTS activity (reported as mg GAE/g and µmol TE/g).
Trevisan et al. (2006). —	O. sanctum	Leaf (oil)	Hydrodistilled essential oil	Hypoxanthine/xanthine oxidase IC_{50}	Essential oil IC_{50} = 0.46 µL/mL (strong radical

essential oil antioxidant (Ocimum).					scavenging in that assay).
González-Romero et al. (2020). — Moringa in salad leaves comparison.	M. oleifera	Leaves	Methanol / ethanol / aqueous	DPPH, ABTS, FRAP, ORAC, TPC	Moringa leaves among highest TAC; TPC high (reported mg GAE/g), FRAP/ABTS/ORAC high (µmol TE/g).
Braham et al. (2022). — DES extraction of Moringa leaves.	M. oleifera	Leaves	Deep eutectic solvents (DES)	TPC, TFC, DPPH, ABTS, FRAP, ORAC	DES extracts showed improved extraction and high TE/g values (results in mmol TE/g or mg GAE/g depending on assay).
Olaoye et al. (2021). — location variation in Moringa leaves (Nigeria).	M. oleifera	Leaves	Methanol etc.	DPPH, Lipid peroxidation, TPC	Wide range across locations; some samples had very high DPPH inhibition and low IC_{50}; vitamin C standard often higher than samples.
Bhuker et al. (2023). — Moringa PKM-1 variety assays.	M. oleifera	Leaves, roots, seeds	Solvent extracts	DPPH, FRAP, ABTS	Leaves highest activity; roots/seeds lower; numeric assay values reported (see paper).
Anusmitha et al. (2022). — Ocimum ultrasound-assisted extracts.	Ocimum sp. (incl. sanctum)	Leaves	Ultrasound-assisted methanol/ethanol	DPPH, FRAP, TPC	Ultrasound/microwave-assisted methanol extracts = higher TPC & antioxidant activity vs conventional extraction.

In Vivo and Clinical Evidence on Antioxidant Activity of Momordica charantia, Ocimum sanctum, and Moringa oleifera

All three plants exhibit consistent antioxidant effects in animal studies, including increases in non-enzymatic reserves (GSH, TAC) and enzymatic antioxidants (SOD, CAT, GPx) and decreases in lipid peroxidation (MDA/TBARS). Because of its high phenolic and vitamin C content in leaf extracts, Moringa oleifera frequently reports the biggest and most consistent changes in TAC and enzymatic activity. [23]In models of chemically induced oxidative damage and inflammation, Ocimum sanctum exhibits strong protection, and essential oil components (ursolic acid and eugenol) help to modulate enzymes. Regardless of whether leaf, fruit, or seed extracts are used, Momordica charantia consistently reduces oxidative damage in diabetic and toxic models, though the magnitude of the effects varies.[24]

Methodological heterogeneity, such as distinct extraction solvents (aqueous, hydroalcoholic, and organic), plant parts, dosage schedules, animal strains, assay procedures, and reporting units, complicates comparisons. Comparative claims are weakened by the fact that many animal reports lack dose-response experimentation, blinding, or power calculations.[25]

Clinical evidence in humans is still in its early stages. Though these studies are usually short-term, small-sample, frequently uncontrolled or open-label, and use non-standardized extracts, small nutraceutical or supplement trials (available in a variety of forms: powders, capsules, and teas) have reported modest improvements in systemic antioxidant markers and reductions in oxidative/inflammatory biomarkers. The clinical effectiveness and relative ranking of the three species in humans are therefore still up for debate.[26,27]

Table 4: Comparative Summary of In Vivo and Clinical Evidence on Antioxidant Activity of Momordica charantia, Ocimum sanctum, and Moringa oleifera.[29,30,31,32]

Biomarker / Outcome	Momordica charantia (bitter melon) — animal evidence	Ocimum sanctum (holy basil) — animal evidence	Moringa oleifera — animal evidence	Typical models, dosing & endpoints reported	Limitations / Notes
Lipid peroxidation (MDA / TBARS)	Repeated oral/aqueous or ethanolic leaf/fruit extracts commonly decrease MDA in liver, kidney and serum vs controls.	Leaf or holy-basil oil extracts usually reduce MDA, especially in models of chemically-induced oxidative stress or diabetes.	Leaf and seed extracts frequently show marked reduction in MDA/TBARS, often greater than controls and correlated with dose.	Rodent models (rats/mice): induced oxidative stress (CCl_4, S.TZ, alloxan or streptozotocin diabetes), doses vary widely (e.g., 100–500 mg/kg crude extract typical); endpoints after days–weeks.	Reported effect sizes highly variable due to extraction method, plant part, dose and model. Units often inconsistent.
Superoxide dismutase (SOD) activity	Often increased SOD activity (tissue and serum), restoring levels toward baseline.	Consistently upregulates SOD in liver/brain/serum in several models.	Strong, often dose-dependent upregulation of SOD, sometimes reported as	Same in vivo models; enzyme activity measured by spectrophotometric assays; timepoints 7–28	Differences in assay kits and expression (units) complicate head-to-head comparison.

			largest enzymatic change.	days post-treatment.	
Catalase (CAT) activity	Frequently restores/increases CAT activity depleted by oxidative insult.	Increases CAT activity in multiple tissues; leaf essential oil and aqueous extracts effective.	Robust increases in CAT activity reported; correlated with decreased oxidative markers.	Tissue homogenates analyzed; results reported as U/mg protein or relative % change.	Baseline enzyme activities vary by species/strain; some studies lack proper controls.
Glutathione peroxidase (GPx) / GSH levels	Many studies report increased GPx activity and total GSH after treatment.	Reports show improved GPx activity and GSH content in organs.	Repeatedly reported enhancement of GPx and GSH, indicating improved redox buffering.	GPx often measured alongside SOD/CAT; total GSH via DTNB or HPLC.	Under-reporting of sample size & blinding; few dose-response curves.
Other antioxidant markers (e.g., TAC, Nrf2)	Some studies show increased total antioxidant capacity (TAC) and Nrf2 pathway activation.	Evidence for increased TAC and modulation of antioxidant gene expression (Nrf2, HO-1).	Several reports of Nrf2 upregulation and improved TAC; some studies show downstream anti-inflammatory effects.	Molecular readouts (Western blot/qPCR) in subset of studies; biomarkers vary.	Molecular evidence less consistent — many studies do biochemical only, few provide mechanistic confirmation.
Functional / physiological outcomes	Improved organ function (liver/kidney	Protection against chemically-induced organ damage, improved	Improved organ histology,	Histology, serum biochemistry, behavior tests;	Translational relevance depends on

	markers), reduced tissue damage, better glycemic control in diabetic models.	behavioral/neurological outcomes in some models.	reduced inflammation, better metabolic markers — often most pronounced among the three.	durations vary.	dosing relative to human equivalent doses (HED) which is often not calculated.
Human trials / nutraceutical interventions	Very limited human data; small nutraceutical trials or supplementation studies report trends toward reduced oxidative stress markers and improved metabolic parameters, but sample sizes small.	Few small clinical studies (supplementation/tea/extract) report modest improvements in antioxidant biomarkers and subjective outcomes; results mixed.	Several small-scale human studies and nutraceutical trials show improvements in antioxidant status, inflammatory markers, and metabolic indices — but heterogeneity is large.	Human trials are typically short (weeks), small N, varied formulations (powder, capsule, tea), and often lack placebo control.	Clinical evidence is sparse, heterogeneous in formulation/dose, and often underpowered. Firm clinical conclusions cannot yet be drawn.

Conclusion

Although they do so through different phytochemical pathways and antioxidant profiles, Momordica charantia (bitter melon), Ocimum sanctum (holy basil), and Moringa oleifera (moringa) all exhibit exceptional capacity to scavenge free radicals. Moringa oleifera leaves have the highest total phenolic and flavonoid content, according to in vitro tests like DPPH, ABTS, FRAP, and ORAC. These assays are also correlated with strong reducing power and ferric ion chelation activity. Ocimum sanctum exhibits strong ABTS and DPPH scavenging properties, mostly because of its high eugenol, rosmarinic acid, and flavonoid content, whereas Momordica charantia works well in metal chelation and lipid peroxidation inhibition tests because of its triterpenoids and cucurbitane glycosides...

Hydroethanolic and methanolic extracts generally exhibit higher antioxidant activity than aqueous extracts, underscoring the significance of solvent extraction efficiency in phenolic recovery. Variations in solvent polarity and plant parts also have a significant impact on assay results. Because they contain more bioactive secondary metabolites, leaf extracts typically perform better than fruit or seed extracts.

Overall, these results highlight the fact that the antioxidant capacity of plant systems cannot be fully captured by a single assay or extract. Therefore, to accurately assess antioxidant potential, a multi-assay and multi-extract approach is necessary. The integration of these botanicals into nutraceutical formulations and functional foods is supported by this comparative analysis, which highlights their potential for synergy in reducing disorders linked to oxidative stress.

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