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Review Article

Malvaceae bioactives in mitigating oxidative stress: a comprehensive review

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Abstract: The Malvaceae family is known for its rich diversity of phytochemicals, which contribute significantly to its antioxidant potential. The review compiles and analyzes the antioxidant compounds reported across some of the selected Malvaceae species, highlighting the prominence of phenolic constituents, particularly flavonoids and phenolic acids. Compounds such as quercetin, kaempferol, luteolin, caffeic acid and chlorogenic acid consistently exhibit high antioxidant activity due to their structural characteristics, including hydroxylation and conjugation. In contrast, non-polar metabolites such as triterpenoids and phytosterols typically exhibit moderate to low activity, though there are notable exceptions like tocopherols. This analysis also reveals that factors such as compound polarity, degree of glycosylation and structural modifications significantly influence antioxidant efficiency. Overall, this study emphasizes on Malvaceae as a valuable source of natural antioxidants and provides insights for targeted phytochemical exploration and application in nutraceutical and pharmacological fields.

Keywords: Antioxidants, nutraceutical potential, pharmacological applications, phenolic compounds, secondary metabolites

Introduction

Oxidative stress occurs when there is an imbalance between the production of reactive oxygen species (ROS) and the antioxidant defense system, resulting in cellular and molecular damage (Qin et al., 2026). Excessive ROS generation is linked to the development of several chronic diseases, including cardiovascular diseases, diabetes, cancer and neurodegenerative disorders (Leyane et al., 2022). In recent years, plant-derived bioactive compounds have gained considerable attention as natural antioxidants capable of mitigating oxidative damage (Tüğen and Buruleanu, 2025). It is specifically due to various reasons, one of which is their highersafety profile compared to synthetic counterparts. Additionally, these compounds exhibit various multifaceted molecular mechanisms that have direct scavenging actions, metal ion chelating activity, activation of specific signalling pathways and lipid degradation activity in a non-polar environment.The family Malvaceae, comprising over 240 genera, is widely distributed across tropical and subtropical regions, representing a significant reservoir of pharmacologically active phytochemicals (Sharifi-Rad et al., 2020). Species such as *Hibiscus sabdariffa* are particularly rich in polyphenols, flavonoids and anthocyanins, which exhibit strong antioxidant and therapeutic properties and are therefore used as herbal beverages that are also rich in dietary supplements (Wang et al., 2014). Despite extensive studies on individual species, a comprehensive understanding of the bioactive compounds in Malvaceae and their role in mitigating oxidative stress remains fragmented.This review aims to analyze the phytochemical diversity of Malvaceae and discuss their potential in combating oxidative stress, with an emphasis on their therapeutic implications.

Methodology

The present study is based on an extensive survey of published literature related to the family Malvaceae. We consulted scientific databases, including Google Scholar, Scopus, PubMed and Web of Science, to retrieve peer-reviewed research articles, review papers, ethnobotanical surveys and pharmacological studies. A variety of keywords such as “Malvaceae”, “antioxidant activity”, “oxidative stress”, “bioactive compounds”, “Hibiscus family”, “radical scavenging”, “metal chelating” and “pharmacology” were used to identify relevant publications. Additionally, we examined regional floras, books and reports that document traditional knowledge and distribution patterns. Only studies containing verifiable scientific or ethnomedicinal data were included in the analysis. The information gathered was critically analyzed and systematically organized into thematic sections to ensure clarity and coherence (Kumar, 2025; Sahu et al., 2026).

Neuroprotective activity

The antioxidant potential of Malvaceae species is largely governed by their phenolic compounds, especially flavonoids and phenolic acids (Table 1). Species such as *Hibiscus sabdariffa*, *Grewia tiliifolia* and *Malva* spp. exhibit strong antioxidant activity due to the presence of compounds like quercetin, luteolin and caffeic acid, which are polar and well-structured for effective radical scavenging. In contrast, species like *Bombax ceiba* and *Firmiana colorata*, which are dominated by non-polar triterpenoids and phytosterols, show only moderate to low activity because they lack sufficient phenolic groups. Additionally, structural variations among compounds influence their activity: tiliroside demonstrates high activity, particularly due to the effects of acylation, while lespedin shows low activity as a result of excessive glycosylation. Although most non-polar compounds exhibit lower antioxidant activity, there are exceptions like tocopherols, which demonstrate strong antioxidant potential in lipid environments.

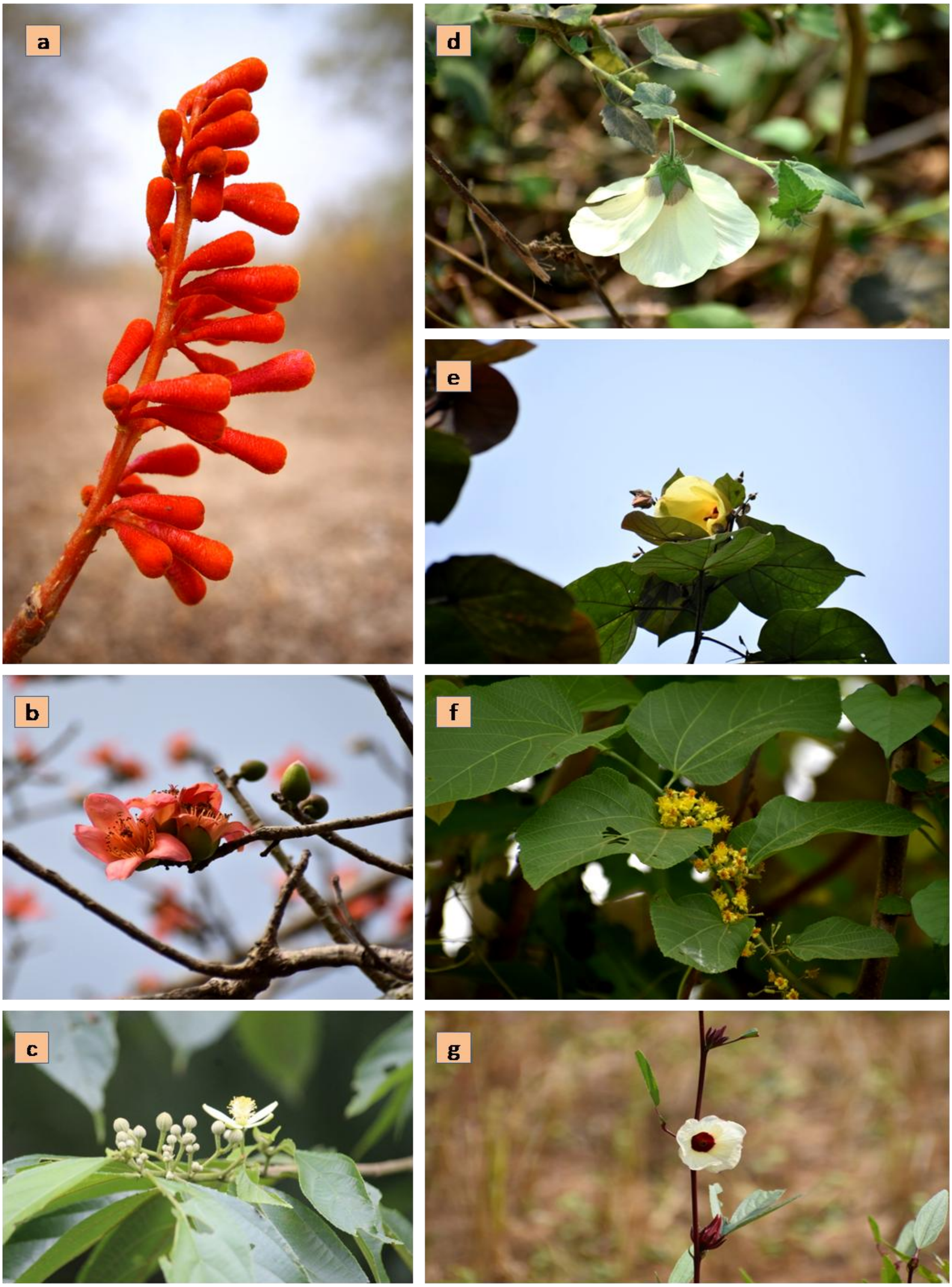

Plate 1: Members of family Malvaceae; (a) *Firmianacolorata* (b) *Bombax ceiba* (c) *Grewia hirsuta* (d) *Hibiscus vitifolius* (e) *Hibiscus tiliaceus* (f) *Grewia tilifolia* and (g) *Hibiscus sabdariffa*

Table 1: Neuroprotective bioactive potential of selected Malvaceae species

Source plant	Antioxidant compound(s)	Chemical class	Solubility	Antioxidant activity	Source(s)
Bombax ceiba L. (Plate 1b)	Lupeol	Pentacyclic triterpenoid	Non-polar	Moderate	Akhtar and Mustafa, (2017)
	P-sitosterol	Phytosterol	Non-polar	Moderate	
	Shamimicin	Flavonoid glycoside	Polar	High	
Firmiana colorata (Roxb.) R.Br. (Plate 1a)	9-Hexadecenoic acid, hexadecyl ester, (Z)-	Fatty acid ester	Non-polar	Low-moderate	Lala, (2023)
	cis-9-Hexadecenoic acid, heptyl ester		Non-polar	Low-moderate	
	Phytol	Diterpene alcohol	Non-polar	Moderate	
	Squalene	Triterpene hydrocarbon	Non-polar	Moderate	
	VitaminE (Tocopherol)	Lipophilic antioxidant	Non-polar	High	
	Stigmasterol	Phytosterol	Non-polar	Low–Moderate	
Grewia hirsuta Vahl (Plate 1c)	4′-Methoxy kaempferol	Flavonol (Flavonoid)	Polar	High	Chikkamath et al., (2019)
	Vanillic acid	Phenolic acid (benzoic acid derivative)	Polar	Moderate	
	Syringic acid		Polar	Moderate	
	Gentisic acid		Polar	High	
	Protocatechuic acid		Polar	High	
	p-Hydroxybenzoic acid		Polar	Moderate	
	Ferulic acid (cis/trans)	Phenolic acid (cinnamic acid derivative)	Slightly polar	High	
	p-Coumaric acid			Moderate	

	(cis/trans)				
	Linoleic acid	Polyunsaturated fatty acid	Non-polar	Moderate	
	Oleic acid	Monounsaturated fatty acid	Non-polar	Low–Moderate	
	Gingerol	Phenolic ketone	Moderately polar	High	
	Tannins (group)	Polyphenols	Polar	High	
Grewia tiliifolia Vahl (Plate 1f)	Betulin	Pentacyclic triterpenoid	Non-polar	Moderate	Rahim et al., (2026)
	Lupeol		Non-polar	Moderate	
	Friedelin	Triterpenoid ketone	Non-polar	Low–Moderate	
	β-Sitosterol	Phytosterol	Non-polar	Low–Moderate	
	Stigmasterol		Non-polar	Low–Moderate	
	β-Sitosterol-D-glucoside (Daucosterol)	Sterol glycoside	Amphiphilic	Moderate	
	Vitexin	Flavonoid glycoside	Polar	High	
	Isovitexin		Polar	High	
	Vitexin-4-O-glucoside		Polar	High	
	Kaempferol	Flavonol	Polar	High	
	Quercetin		Polar	High	
	Rutin	Flavonoid glycoside	Polar	High	
	Catechin	Flavan-3-ol	Polar	High	
	Epicatechin		Polar	High	

	Gallic acid	Phenolic acid	Polar	High	
	Caffeic acid	Phenolic acid (cinnamic derivative)	Polar	High	
	Chlorogenic acid	Phenolic ester	Polar	High	
	p-Coumaric acid	Phenolic acid	Slightly polar	Moderate–High	
	Ellagic acid	Polyphenolic compound	Slightly polar	High	
	3-Methyl ellagic acid	Polyphenol derivative	Slightly polar	High	
	Umbelliferone	Coumarin	Moderately polar	Moderate–High	
	Gulonic acid γ-lactone	Sugar acid derivative	Polar	Moderate	
	DDMP (2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one)	Maillard-derived antioxidant	Polar	High	
	Hydroxymethylfurfural (HMF)	Furan derivative	Polar	Moderate	
	Squalene	Triterpene hydrocarbon	Non-polar	Moderate	
Herissantia crispa (L.) Brizicky	Tiliroside	Flavonoid glycoside	Polar	High	de Oliveira et al. (2012)
	Lespedin		Polar	Low	
Hibiscus sabdariffa L. (Plate 1g)	Chlorogenic acid	Phenolic acid (ester)	Polar	High	Obouayeba et al.(2014)
	Protocatechuic acid	Phenolic acid	Polar	High	
	Gossypetrin	Flavonoid glycoside	Polar	High	

	Sabdaretin	Flavonoid	Polar	High	
	Gossypetin	Flavonol	Polar	High	
	Luteolin	Flavone	Polar	High	
	Gossytrin	Flavonoid glycoside	Polar	High	
	Hibiscetin	Flavonol	Polar	High	
	Rutin	Flavonoid glycoside	Polar	High	
	Hibiscetrin		Polar	High	
	Myricetin	Flavonol	Polar	High	
	Eugenol	Phenolic compound	Slightly polar	Moderate–High	
	Nicotiflorin (Kaempferol-3-O-rutinoside)	Flavonoid glycoside	Polar	High	
	Quercitrin		Polar	High	
	Quercetin	Flavonol	Polar	High	
	Kaempferol		Polar	High	
	Astragalin (Kaempferol-3-O-glucoside)	Flavonoid glycoside	Polar	High	
	Cyranoside		Polar	High	
Hibiscus tiliaceus L. (Plate 1e)	Rutin		Polar	High	Borive Amani et al. (2025)
	Kaempferol 3-*O*-rutinoside		Polar	HIgh	
	Quercetin	Flavonol	Polar	High	Dhanarasu et al. (2017)
	Quercetin 3-O-arabinopyranoside	Flavonoid glycoside	Polar	High	
	Gossypin (Gossypin-8-O-glucoside)		Polar	High	

Malva neglecta Wallr.	Quercetin 3-glucoside		Polar	High	Memdueva et al., (2025)
	Rutin		Polar	High	
	Kaempferol 3-glucoside		Polar	Moderate–High	
	Kaempferol 3-rutinoside		Polar	Moderate	
	Tiliroside		Polar	High	
	p-Coumaroyl hexose	Phenolic derivative	Polar	Moderate	
	Hydroxybenzoic acid derivatives	Phenolic acids	Polar	Moderate	
	Caffeic acid		Polar	High	
Malva sylvestris L.	Flavonoid triglycosides	Flavonoid glycosides	Polar	Moderate	Rhimi et al., (2025)
	Malvone (2-methyl-3-methoxy-5,6-dihydroxy-1,4-naphthoquinone)	Naphthoquinone	Moderately polar	High	Batiha et al.(2023); Rhimi et al.(2025)
	Quercetin	Flavonol	Polar	High	
	Luteolin	Flavone	Polar	High	
	Apigenin	Flavone	Moderately polar	Moderate	
	Kaempferol	Flavonol	Moderately polar	Moderate–High	
	β-carotene	Carotenoid	Non-polar	Moderate	
	Tocopherols (Vitamin E)	Lipophilic methylated phenol	Non-polar	High	
Sida	Total phenolics	Polyphenols	Polar	Moderate	de

rhombifolia L.					Oliveira et al. (2012)
Sida spp. (*S. acuta*, *S. cordifolia*, etc.)	Polyphenolic isolates (LOX inhibitors)		Polar	High	
Sidastrum micranthum (A.St.-Hil.) Fryxell	Tiliroside	Flavonoid glycoside	Polar	High	
Wissadula periplocifolia (L.) Thwaites	Tiliroside (Kaempferol 3-O-(6''-E-p-coumaroyl)-glucoside)		Polar	High	
	Lespedin (Kaempferol 3,7-di-O-rhamnoside)		Polar	Low	

Research gaps

While extensive identification of phytochemicals has been documented, there is a scarcity of comparative, standardized studies linking specific compounds to their *in vivo* antioxidant efficacy. Furthermore, the synergistic interactions among metabolites and the impact of extraction methods remain inadequately explored.

Future aspects

Future research should prioritize bioactivity-guided isolation, *in vivo* validation and mechanistic studies of essential antioxidant compounds. Investigating synergistic effects, advanced extraction techniques and their formulation into functional foods or therapeutics can enhance their practical applications.

Conclusion

The antioxidant potential of Malvaceae is largely influenced by its diverse and complex phenolic compounds, particularly flavonoids and phenolic acids, which play a central role. Although non-polar compounds provide some benefits, polar extracts that are rich in phenolic compounds consistently exhibit superior antioxidant activity. These characteristics position Malvaceae as a promising source of natural antioxidants, with significant potential for health and pharmaceutical applications.

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