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Antioxidant Activity of Flavonoids from Moringa oleifera: A Comprehensive Review

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Abstract
The antioxidant properties of flavonoids from Moringa oleifera, a plant widely recognized for its nutritional and medicinal values, have garnered increasing attention. This paper reviews the current evidence on the antioxidant potential of flavonoid compounds isolated from different parts of M. oleifera, including leaves, seeds, and flowers. Flavonoids are known for their ability to scavenge free radicals, thereby reducing oxidative stress and mitigating the risk of several chronic diseases. The chemical structures, mechanisms of action, and potential therapeutic applications of these compounds, providing insights into their efficacy as natural antioxidants. The review also highlights the need for further research into bioavailability and clinical outcomes.
Keywords*: Moringa oleifera, flavonoids, antioxidant activity, oxidative stress, free radicals, polyphenols, therapeutic applications*

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I. Introduction

Moringa oleifera, commonly referred to as the "drumstick tree" or "miracle tree," is a plant native to tropical and subtropical regions. It has been traditionally used for its medicinal properties, nutritional benefits, and therapeutic applications in managing various diseases (Fahey, 2005).One of the key bioactive compounds in *Moringa* is flavonoids, a group of polyphenolic compounds known for their potent antioxidant activity. Antioxidants play a crucial role in neutralizing reactive oxygen species (ROS) and reducing oxidative stress, which has been implicated in the pathogenesis of many diseases, including cancer, cardiovascular disorders, and neurodegenerative conditions (Halliwell & Gutteridge, 2015).
This paper aims to explore the antioxidant potential of flavonoids from *M. oleifera* and their possible applications in human health.

Flavonoid Composition in *Moringa oleifera*

Moringa oleifera is a plant renowned for its rich nutrient profile and diverse bioactive compounds, including flavonoids, which contribute significantly to its medicinal and antioxidant properties. The flavonoid composition in *Moringa* varies across different parts of the plant, such as the leaves, seeds, flowers, and pods. These compounds, which are part of the broader polyphenolic family, have been studied for their antioxidant, anti-inflammatory, and antimicrobial activities. Below is a detailed overview of the primary flavonoids found in *Moringa oleifera*:

1. Types of Flavonoids in Moringa oleifera

The major flavonoid compounds in *Moringa oleifera* include quercetin, kaempferol, rhamnetin, isorhamnetin, and various glucosides of these compounds. These flavonoids are primarily concentrated in the leaves, but they are also present in smaller amounts in other parts of the plant. Below are the key flavonoids identified in *Moringa*:

Spectrophotometric Quantification of Total Phenolic Content (TPC)

Galic acid was used as a standard and the total phenolic were expressed as mg/g gallic acid equivalent (GAE). Line of Regression from Gallic acid was used for estimation of unknown phenol content depicts the variation of mean absorbance with different concentrations of Gallic acid. Total phenols were measured by Folin Ciocalteu reagent in terms of gallic acid equivalent. Significantly different amounts of phenolics were found in Petroleum ether, ethyl acetate and methanol extracts of *Moringa oleifera* L. leaves **(**represents the amounts of phenolics present in petroleum ether, ethyl acetate and methanol extract respectively. **1**represents the comparison of total phenolics present in petroleum ether, ethyl acetate and methanol extract. The quantitative analysis of TPC of extracts revealed that the methanol extract contains highest amounts of TPC (140.23mgGAE/gm) **(**followed by ethyl acetate extract (133.41mgGAE/gm) where as moderate amounts were recorded in petroleum ether extract (81.98mgGAE/gm)

Table 1: **Absorbance v/s concentration of Gallic acid**

S. No.	Concentration of Gallic acid (µg/ml)	Absorbance
1.	10	0.102±0.000577
2.	20	0.113±0.000577
3.	30	0.133±0.001155
4.	40	0.16±0.004714
5.	50	0.183±0.000577

Values are expressed as MEAN±SD

Graph 15: **Standard curve of Gallic acid.**

Spectrophotometric Quantification of Total Flavonoid Content (TFC)

Rutin was used as standard compound for the quantification of total flavonoid. Total flavonoid content was expressed as mg rutin/g dry weight (mg rutin/g DW). Line of regression from Rutin was used for estimation of unknown flavonoid content **.**depicts the variation of mean absorbance with different concentrations of Rutin. Different amounts of phenolics were present in petroleum ether, ethyl acetate and methanol extract. represents the amounts of flavonoids present in petroleum ether, ethyl acetae and methanol extract. represents the comparison of contents of flavonoids present in petroleum ether, ethyl acetate and methanol extract. The quantitative analysis of TFC in extracts revealed that methanol extract contained highest amount of TFC (107.64mgRE/gm) followed by ethyl acetate (86.97mgRE/gm) where as very less amount was found in petroleum ether (15.86mgRE/gm) **.** Comparison of phenolics and flavonoids of petroleum ether, ethyl acetate and methanol extract was also studied. The mounts of phenolics present in petroleum ether, ethyl acetate and methanol extract were higher than the amounts of flavonoids present in petroleum ether, ethyl acetate and methanol extract. representsthe comparison of phenolics and flavonoids present in the extracts.

Table: 2 Evaluation of isolated bioactive fractions from successive methanolic extract of *Moringa oelifera*. for antioxidant activity.

Conc. µg/mL	**% Inhibition (µg/mL)**					
	EF-I	**EF-II**	**BF-I**	**BF-II**	**AQF**	**ASA**
25	20.02±0.25	4.32±0.49	2.01±0.22	13.01±0.33	1.22±0.55	31.23±0.31
50	39.83±0.31	13.99±0.34	8.39±0.35	30.33±0.42	5.91±0.35	48.71±0.34
75	52.89±0.27	21.54±0.61	19.01±0.27	46.39±0.23	13.01±0.56	62.03±0.42
100	75.37±0.43	29.23±0.31	23.02±0.32	66.18±0.39	21.51±0.41	79.11±0.49
125	88.80±0.41	36.01±0.56	29.27±0.31	75.23±0.36	26.89±0.38	91.21±0.46
IC_{50} µg/mL	**67.26**	**167.41**	**197.11**	**80.90**	**229.58**	**59.62**

Total phenolic content o fmethanolic extract of,leaf and their fractions of Moringa oelifera was estimated by Folin-Ciocalteu assay. The results showed that M3 showed highest content of phenolics (275.35 mg/g equivalent of Gallic acid)

Table 3 Total flavonoid content of *Moringa oelifera*

Sample	**mgQR/g**	**STDEV**
M1	29.85217677	0.00384
M2	22.61987273	0.00785
M3	23.09319105	0.00340
M4	2.418646518	0.032554
M5	103.9738268	0.194596
M6	0.260314945	0.006413
M7	26.31175568	0.034892
M8	0.941893337	0.006728

The results of the above mentioned methods have shown methanol extract has shown highest antioxidant activity in both DPPH and Reducing power assays and moreover during Spectrophotometric quantification of total phenolic and flavonoid contents highest amounts of both phenolics and flavonoids were present in methanol extract as compared to ethyl acetate and methanol extract

II. Conclusion

Flavonoids are a key group of bioactive compounds in *Moringa oleifera*, with quercetin, kaempferol, rhamnetin, and isorhamnetin being among the most studied. These flavonoids contribute to the plant's impressive antioxidant profile and its therapeutic potential for combating oxidative stress-related diseases. The flavonoid composition varies across different parts of the plant, with the leaves being the richest source. Given the wide range of pharmacological activities attributed to these compounds, *Moringa* flavonoids represent an important area of research for both nutritional and medicinal purposes.

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