

Antioxidant potential of tulsi leaves: a review

Raksha Banka¹, Manisha Maity^{2*}

^{1,2}Swami Vivekananda University, Telinipara, Barasat-Barrackpore Road, Kolkata, West Bengal-700121, India

*Corresponding author: Manisha Maity

Email id: manisham@svu.ac.in

Abstract:

Traditional medicines aid in several health issues leading to the use of green technology towards the treatment of numerous health complications. Medicines from plant sources are regarded as safe and easy sources for consumption. Tulsi leaves (*Ocimum sanctum*) are considered one of the most remarkable leaves in traditional medicine due to their potential properties and benefits. This review deals with one of the most important properties of Tulsi leaves, the antioxidant properties, which help in combating oxidative stress and preventing diseases that can be caused by an imbalance between free radicals and antioxidants, thus causing chronic diseases. Tulsi leaves are also well known for their bioactive compounds such as eugenol, rosmarinic acid and others, which exhibit strong antioxidant activities and thus enhance the body's defence mechanisms. Recent studies have shown that Tulsi leaves enhance enzymatic antioxidants such as glutathione peroxidase, catalase and others, thus helping in enhancing cellular adaptability. Tulsi leaf extract has been used in conventional treatments and has proven to have potential in modern medical practices. Therefore, this review focuses on the effectiveness of Tulsi leaves as a natural and cost-effective antioxidant source that can benefit oxidative stress-related health concerns. It also explains the molecular mechanisms and therapeutic applications in the nutraceutical and pharmaceutical industries.

Keywords: Traditional medicine, Tulsi leaves, antioxidant properties, cost-effective source, applications

Introduction

Traditional medicines have been an integral part of healthcare system since centuries, one of them being Tulsi (*Ocimum sanctum*), for their therapeutic benefits. In recent years, there has been more focus on plant-based medicines due to their potential health benefits and less side effects as compared to modern medicinal drugs (Bhattarai et al., 2024). Amongst them, Tulsi is very well known and holds a traditional place in Ayurvedic medicine because of its known properties such as antimicrobial properties, antioxidant properties as well as anti-inflammatory benefits (Cohen, 2014).

Antioxidants help in maintaining cellular health by reacting with free radicals and neutralizing them, thus reducing oxidative stress and damage. The molecules which are unstable and are produced as a by-product of cellular metabolism and with some external factors such as radiation or poor diet, are known as free radicals. If they get accumulated in the body in excess, they can lead to oxidative stress, which can ultimately damage proteins, lipids or DNA and other cellular components (Baliga et al., 2013). It can then lead to various chronic diseases such as cardiovascular disease, diabetes, cancer or even brain damage in extreme cases. The human body has its own antioxidant defence mechanisms but if free radicals are in excess, then they can increase oxidative damage which may get uncontrollable even with the body's defence mechanisms. Thus, antioxidants from diet are essential for the body (Sharma et al., 2022).

Tulsi is considered as a source of potent antioxidant properties, as it contains many bioactive components such as eugenol, rosmarinic acid, flavonoids and others, which can bind up with the body's free radicals and prevent it from oxidative stress and damage (Sankar et al., 2025). This review, therefore, aims to understand the antioxidant properties of Tulsi, its bioactive compounds and its potential applications in healthcare, nutraceutical and pharmaceutical industries.

Bioactive compounds in Tulsi and their antioxidant properties

Tulsi (*Ocimum sanctum*) contains various phytochemicals, which are the bioactive components, such as eugenol, rosmarinic acid, flavonoids, tannins, polyphenols and others. Eugenol is the most important and major available component of essential oil found in Tulsi. It is well-known for its antioxidant and anti-inflammatory properties. It helps in protecting the cell-membrane from oxidative damage by preventing lipid peroxidation. It also helps in reducing oxidative stress-induced damage in brain cells (Singh et al., 2025).

Rosmarinic acid is a powerful phytochemical. It has a strong free radical scavenging activity. It enhances the activity of few antioxidant enzymes such as glutathione peroxidase and also dismutase. It is well-known for its effect against neurodegenerative diseases and cardiovascular diseases (Saini et al., 2025).

Flavonoids are another well known antioxidant compounds that help in stabilizing free radicals, thus reducing oxidative cellular damage. They can be apigenin or luteolin. Not only this but they also contain anti-inflammatory properties as well as immune-modulating properties which can help in preventing many chronic diseases (Wicaksana et al., 2025).

Polyphenols and tannins can contribute as an antioxidant component as they can chelate metal ions, thus preventing the formation of free radicals and reducing cellular damage that can be caused by oxidative stress. They also help in maintaining the stability of cell membrane and integrity of DNA (Ezeorba et al., 2024).

The antioxidant activity of all these bioactive compounds work through multiple mechanisms, such as direct free radical scavenging, inhibiting lipid peroxidation and others. By neutralizing oxidative stress, Tulsi plays crucial role in preventing chronic diseases and maintaining overall health (Jamwal et al., 2025).

Antioxidant mechanisms of Tulsi

Tulsi exerts its antioxidant mechanisms through both enzymatic and non-enzymatic actions. It can help in protecting cells from oxidative stress and preventing chronic diseases (Chaudhary et al., 2020).

Enzymatic antioxidants enhanced by Tulsi:

a. Glutathione peroxidase: This enzyme helps to convert hydrogen peroxide to water, thus preventing oxidative damage to cellular components, Tulsi enhances the activity of glutathione peroxidase and improves detoxification as well as cellular protection (Shafiq et al., 2025).

b. Catalase: The function of catalase is to break down hydrogen peroxide into water and oxygen. It helps in protecting cells from oxidative damage. There are different bioactive compounds present in Tulsi that stimulate the activity of catalase, thus reducing oxidative stress at cellular level (Saini et al., 2025).

c. Superoxide dismutase: It is responsible for converting superoxide radicals into less harmful molecules such as hydrogen peroxide. Tulsi helps in boosting the levels of superoxide dismutase. It, therefore, prevents excessive free radical accumulation and reducing the risk of chronic diseases (Baliga et al., 2013).

Non-enzymatic antioxidants enhanced by Tulsi:

a. Direct free radical neutralization: The bioactive compounds in Tulsi, mainly eugenol and rosmarinic acid, directly scavenge free radicals, thus helps in preventing cellular and DNA damage (Ríos-Rodríguez et al., 2021).

b. Metal chelation and lipid peroxidation inhibition: Tulsi binds to metal ions and neutralizes them. It can thus generate free radicals through oxidative reactions. Some of the metals included here are copper and iron. Additionally, Tulsi prevent lipid peroxidation, which is a process in which free radicals attack cell membranes, leading to cell damage and ageing (Prangthip et al., 2023).

Therapeutic applications in health and disease prevention

Tulsi has been widely recognized for its health benefits due to its strong antioxidant properties. By reducing oxidative stress, it plays a vital role in preventing many chronic diseases.

Cardiovascular protection: Oxidative stress is considered as the main factor for cardiovascular issues. Tulsi can lower LDL oxidation (low density lipoprotein oxidation) which is the major cause of atherosclerosis. Phytochemicals like flavonoids and polyphenols in Tulsi prevents plaque formation in arteries, thus reducing the risk of heart attacks and stroke (Sharma et al., 2022).

Diabetes management: Oxidative stress plays a very important role in insulin resistance and diabetes complications. Tulsi helps in regulating blood glucose levels by improving insulin sensitivity and reducing oxidative stress in pancreatic cells. Flavonoids and polyphenols, the phytochemical components present in Tulsi, can enhance metabolism of glucose and prevent diabetes induced cellular damage, thus making it beneficial for diabetes (Jamwal et al., 2025).

Neuroprotective effects: Neurodegenerative diseases such as Parkinson's disease or Alzheimer's disease are associated with oxidative stress and neuroinflammation. Due to presence of eugenol and rosmarinic acid in Tulsi, they reduce neuroinflammation and free radical damage in brain cells. Tulsi enhances cognitive functions and protects neurons from oxidative stress, thus making it a vital and beneficial neuroprotective agent (Ajmal et al., 2025).

Applications in nutraceuticals and pharmaceuticals

Tulsi is widely used in nutraceutical and pharmaceutical industries due to its strong antioxidant and therapeutic benefits. It is added to supplements, herbal teas as well as functional foods to reduce oxidative stress and boost immunity (Yamani et al., 2016). Its bioactive compounds like eugenol and rosmarinic acid are studied for managing diabetes, cardiovascular diseases and neurodegenerative disorders. Tulsi's natural origin, safety and effectiveness make it a valuable ingredient in preventive and supportive therapies (Ajmal et al., 2025).

Conclusion

Tulsi (*Ocimum sanctum*) is a potent natural antioxidant having many health benefits, which includes cardiovascular protection, diabetes management, neuroprotection as well as immune enhancement. Its rich bioactive compounds such as eugenol, rosmarinic acid and flavonoids, help in combating oxidative stress and inflammation, thus reducing the risk of chronic diseases. Its growing use in nutraceutical and pharmaceutical industries shows its role in preventive healthcare. However, more human trials and research on bioavailability as well as pharmacological interactions will strengthen its medical credibility. Being a cost-effective, easily available and sustainable antioxidant source, Tulsi has immense potential in global healthcare. With continuation in scientific advancements and regular support, it can contribute to plant-based antioxidant therapies and disease prevention, thus ensuring better health outcomes for future generations.

Acknowledgement

The author thanks Swami Vivekananda University, Barrackpore, West Bengal, India, for the opportunity to present the article on the benefits of Tulsi as an antioxidant herb.

References

- Ajmal, M., Nijabat, A., Sajjad, I. *et al.* Evaluation of basil essential oils for antifungal and anti-aflatoxigenic activity against *Aspergillus flavus*. *Sci Rep* **15**, 6168 (2025). <https://doi.org/10.1038/s41598-025-87397-7>
- Baliga, M. S., Jimmy, R., Thilakchand, K. R., Sunitha, V., Bhat, N. R., Saldanha, E., Rao, S., Rao, P., Arora, R., & Palatty, P. L. (2013). *Ocimum sanctum* L (Holy Basil or Tulsi) and its phytochemicals in the prevention and treatment of cancer. *Nutrition and cancer*, *65 Suppl 1*, 26–35. <https://doi.org/10.1080/01635581.2013.785010>
- Bhattarai, K., Bhattarai, R., Pandey, R. D., Paudel, B., & Bhattarai, H. D. (2024). A Comprehensive Review of the Phytochemical Constituents and Bioactivities of *Ocimum tenuiflorum*. *TheScientificWorldJournal*, *2024*, 8895039. <https://doi.org/10.1155/2024/8895039>

Chaudhary, A., Sharma, S., Mittal, A., Gupta, S., & Dua, A. (2020). Phytochemical and antioxidant profiling of *Ocimum sanctum*. *Journal of food science and technology*, 57(10), 3852–3863. <https://doi.org/10.1007/s13197-020-04417-2>

Cohen M. M. (2014). Tulsi - *Ocimum sanctum*: A herb for all reasons. *Journal of Ayurveda and integrative medicine*, 5(4), 251–259. <https://doi.org/10.4103/0975-9476.146554>

Ezeorba, T. P. C., Chukwuma, I. F., Asomadu, R. O., Ezeorba, W. F. C., & Uchendu, N. O. (2024). Health and therapeutic potentials of *Ocimum* essential oils: a review on isolation, phytochemistry, biological activities, and future directions. *Journal of Essential Oil Research*, 36(3), 271–290. <https://doi.org/10.1080/10412905.2024.2338117>

Jamwal, S., Kumari, A., Veeragurunathan, V. *et al.* Enhancing growth, yield, essential oil content, and composition of holy basil (*Ocimum tenuiflorum* L.) using red algae-based bio-stimulant under acidic conditions of the Western Himalayas. *BMC Plant Biol* **25**, 84 (2025). <https://doi.org/10.1186/s12870-025-06064-1>

Prangthip, P., Panbangred, W. & Reamtong, O. Potential antihypertensive activity of novel peptides from green basil leaves. *BMC Complement Med Ther* **23**, 282 (2023). <https://doi.org/10.1186/s12906-023-04098-2>

Ríos-Rodríguez, D., Sahi, V.P. & Nick, P. Authentication of holy basil using markers relating to a toxicology-relevant compound. *Eur Food Res Technol* **247**, 2485–2497 (2021). <https://doi.org/10.1007/s00217-021-03812-z>

Saini, T., Sharma, S., Dash, K.K. *et al.* Role of bioactive phytochemicals in plant seeds and leaves for diabetes control and prevention: a comprehensive review. *Phytochem Rev* (2025). <https://doi.org/10.1007/s11101-025-10065-1>

Sankar, M., Suyamprakasam Sundaram, V., Sankar, M. *et al.* A review of the role of herbs in managing metabolic syndrome. *Discov Food* **5**, 90 (2025). <https://doi.org/10.1007/s44187-025-00349-y>

Shafiq, T., Jabeen, K., Iqbal, S., Umar, A., Elshikh, M. S., Aljowaie, R. M., Dufossé, L., Iqbal, R., & Ghosh, S.

(2025). Antifungal and antioxidant potential of *Ocimum* species against *Ascochyta rabiei* (Pass) Lab. *Revista Argentina de microbiologia*, S0325-7541(25)00030-6. Advance online publication. <https://doi.org/10.1016/j.ram.2025.02.003>

Sharma, A. D., Kaur, I., Angish, S., Thakur, A., Sania, S., & Singh, A. (2022). Comparative phytochemistry, antioxidant, antidiabetic, and anti-inflammatory activities of traditionally used *Ocimum basilicum* L. *Ocimum gratissimum* L., and *Ocimum tenuiflorum* L. *Biotechnologia*, 103(2), 131–142. <https://doi.org/10.5114/bta.2022.116206>

Singh, S.M., Tripathy, S. & Srivastav, P.P. Bioactive compound extraction from giloy leaves and steam using ultrasound: bioactivity, antimicrobial, and LC-MS/MS study. *Food Sci Biotechnol* **34**, 1835–1847 (2025). <https://doi.org/10.1007/s10068-024-01810-x>

Wicaksana, I. P. D. R., Siwananda, I. D. M. & Astuti, N. M. W. (2025). A Bibliometric Analysis of Research Trends in Antioxidant Activity of Anthocyanin Flavonoids in Basil Leaf (*Ocimum basilicum* L.) Extract. *Azerbaijan Pharmaceutical and Pharmacotherapy Journal*, 24(1), 28-39.

Yamani HA, Pang EC, Mantri N and Deighton MA (2016) Antimicrobial Activity of Tulsi (*Ocimum tenuiflorum*) Essential Oil and Their Major Constituents against Three Species of Bacteria. *Front. Microbiol.* 7:681. doi: 10.3389/fmicb.2016.00681