International Journal of Scientific Engineering and Research (IJSER)
ISSN (Online): 2347-3878
SJIF (2024): 6.623

Tulsi (Ocimum sanctum Linn.) as a Potential Anti-Cancer Drug: A Comprehensive Review

Dr. Manoj Kumar Sharma

Professor & Principal
Mangalayatan Ayurved Medical College & Research Centre, Aligarh, U.P., India
Email: drmanoj78[at]yahoo.co.in

Abstract: ***Cancer remains a major global health challenge due to increasing therapeutic resistance, toxicity of chemotherapeutic agents, and limited efficacy in advanced stages. Tulsi (Ocimum sanctum Linn.), an important Rasayana herb of Ayurveda, contains a rich spectrum of bioactive compounds such as eugenol, ursolic acid, rosmarinic acid, and apigenin, all of which demonstrate significant anti-cancer potential. This review synthesizes classical Ayurvedic knowledge with contemporary scientific evidence to evaluate Tulsi's molecular mechanisms in cancer prevention and therapy. A systematic literature search was performed across PubMed, Scopus, AYUSH Research Portal, Google Scholar, and ScienceDirect for studies published between 2000 and 2025. Evidence reveals that Tulsi exerts multi-targeted actions including apoptosis induction, cell cycle arrest, inhibition of angiogenesis and metastasis, antioxidant effects, and immunomodulation. These findings support Tulsi as a viable adjunct in integrative oncology. However, robust clinical trials and standardization of formulations remain essential.***

Keywords: Tulsi, Ocimum sanctum, Anti-cancer activity, Apoptosis, Metastasis inhibition, Angiogenesis inhibition, Immunomodulation, Antioxidants, Ayurveda, Phytochemicals, Rasayana

1. Introduction

Cancer is characterized by dysregulated cell proliferation, genomic instability, evasion of apoptosis, and metastatic dissemination. Although chemotherapy, radiotherapy, immunotherapy, and targeted therapy have improved survival outcomes, many patients face treatment resistance, severe toxicity, and high financial burden.

Ayurveda correlates cancer-like conditions to **Arbuda** and **Granthi**, arising from aggravated *Tridoṣa*, accumulation of *Ama*, and depletion of *Ojas*. Tulsi (Ocimum sanctum Linn.), revered as a Rasayana, Shothahara, and Krimighna herb, possesses pharmacological properties that align.

1.1 Botanical Description of Tulsi

Parameter	Description
Botanical Name	*Ocimum sanctum* Linn.
Family	Lamiaceae
Common Names	Tulsi, Holy Basil
Useful Parts	Leaves, seeds, roots, essential oil
Major Phytochemicals	Eugenol, Ursolic acid, Apigenin, Rosmarinic acid, β-Caryophyllene

1.2 Relevance of Tulsi to Cancer

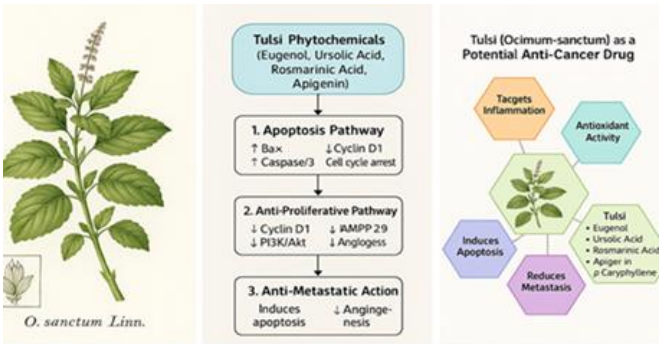
Ayurvedic properties correlate with modern pharmacological actions:

- **Deepana-Pachana:** Reduces *Ama* → decreases metabolic toxins
- **Shothahara:** Reduces inflammatory cytokines
- **Rasayana:** Enhances immunity and cellular regeneration
- **Krimighna:** Cytotoxic effects against abnormal cell growth

These traditional actions reflect modern pathways including oxidative stress reduction, apoptosis induction, inhibition of inflammation, and improved immune surveillance.

2. Disease Background - Cancer

Pathological Factor	Modern Mechanism	How Tulsi Helps
Genetic mutations	p53 suppression, RAS activation	DNA protection via antioxidants
Inflammation	↑ IL-6, TNF-α, COX-2	Eugenol ↓ NF-κB, COX-2
Oxidative stress	↑ ROS	Rosmarinic acid enhances SOD, CAT, GPx
Angiogenesis	↑ VEGF	Ursolic acid ↓ VEGF
Metastasis	↑ MMP-2/9	Tulsi suppresses MMP-2/9, EMT



A *Ocimum sanctum* Linn. B Anti-Cancer Mechanistic Pathways C Graphichal Abstract

3. Materials and Methods

3.1 Inclusion Criteria

a) In vitro Studies

Evaluating Tulsi extracts/phytochemicals on cancer cells using:

- MTT, SRB, LDH assays
- Flow cytometry for apoptosis
- Caspase activation studies
- ROS measurements
- Cell cycle analysis

b) In vivo Studies
Animal models assessing:
- Tumor volume regression
- Metastasis suppression
- Survival analysis
- Immunomodulation markers

c) Molecular Mechanism Studies
Focusing on:
- Caspase regulation
- Bax/Bcl-2 ratio
- PI3K/Akt/mTOR pathway
- VEGF expression
- MMP-2/9 activity
- Antioxidant systems

d) Time Frame
Publications: **2000-2025**.

3.2 Exclusion Criteria

- Non-oncological studies
- Poor methodological quality
- Polyherbal formulations
- Non-English studies
- Reviews without empirical evidence

3.3 Objective

To evaluate Tulsi's anti-cancer actions across cellular, molecular, and Ayurvedic domains, identifying translational applications and gaps for future research.

3.4 Search Strategy

Databases: PubMed, Scopus, Web of Science, Google Scholar, ScienceDirect, AYUSH Portal.
Keywords: "Ocimum sanctum," "Tulsi," "Eugenol," "Ursolic Acid," "Cancer," "Apoptosis," "Metastasis."

4. Results

4.1 Summary of Tulsi's Anti-Cancer Actions

- Induces apoptosis
- Arrests cell cycle
- Suppresses metastasis
- Inhibits angiogenesis
- Reduces oxidative stress
- Immunomodulatory action

4.2 Major Mechanistic Pathways

1) Apoptosis Induction
- Caspase-3/8/9 activation
- Increased Bax, decreased Bcl-2
- Mitochondrial apoptotic pathway activation

2) Cell Cycle Arrest
- Downregulation of Cyclin D1
- PI3K/Akt/mTOR inhibition
- Arrest at G1/S or G2/M checkpoints

3) Anti-Metastatic Effects
- Downregulation of MMP-2, MMP-9
- EMT inhibition
- Reduced cellular invasion

4) Angiogenesis Inhibition
- VEGF downregulation
- Reduced endothelial migration

5) Antioxidant Effects
- Restores SOD, CAT, GPx
- Reduces ROS-induced DNA damage

6) Immunomodulation
- Enhances NK cells, macrophages
- Regulates IFN-γ, IL-2, IL-6

5. Discussion

Tulsi demonstrates efficacy against major hallmarks of cancer through its phytochemical synergy. Eugenol modulates NF-κB; ursolic acid inhibits PI3K/Akt; rosmarinic acid suppresses ROS; apigenin induces cell cycle arrest.

Ayurveda-Modern Biomedicine Integration

Ayurvedic View	Modern Correlation
Rasayana	Immunomodulation, cytoprotection
Shothahara	Anti-inflammatory action
Ama-pachana	Oxidative stress reduction
Krimighna	Anti-proliferative effects

This alignment supports Tulsi as a candidate for integrative oncology frameworks.

6. Conclusion

Tulsi (Ocimum sanctum Linn.) is a highly promising botanical drug with robust preclinical evidence supporting its anti-cancer actions. Its Rasayana and Shothahara properties, validated by modern biochemical research, highlight its role in apoptosis induction, angiogenesis and metastasis inhibition, and immune enhancement. Further **clinical trials**, **phytochemical standardization**, and **pharmacokinetic studies** are essential before Tulsi can be recommended as an adjunctive cancer therapeutic.

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