

Metal-Based Ayurvedic Nanomedicines in Breast Cancer: Mechanistic Insights, Pharmacological Evidence, and Translational Relevance

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Running Title: Ayurvedic Nanomedicines in Breast Cancer

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Abstract: Breast cancer remains the most frequently diagnosed malignancy globally, with recent estimates surpassing 2.26 million new cases and nearly 685,000 annual deaths. [1] Despite the progress in mastectomy, chemotherapy, and hormonal interventions, these standard modalities are often restricted by systemic toxicity, the emergence of multi-drug resistance, and a significant decline in patient quality of life. [2] This clinical bottleneck has catalyzed interest in integrative oncology, particularly the traditional Ayurvedic system of Rasa Shastra, which utilizes incinerated metal and mineral preparations known as Bhasmas. [3] These formulations are increasingly understood as ancient forms of "ethno-nanomedicine", where rigorous pharmaceutical processes transform bulk, toxic elemental metals into biocompatible nano-structured particles. [4] This review synthesizes current scientific understanding regarding the preparation, physicochemical nature, and therapeutic potential of major Bhasmas such as Swarna (gold), Abhraka (mica), and Tamra (copper) in breast cancer management. [5] By highlighting mechanisms such as the induction of p53-dependent apoptosis, modulation of reactive oxygen species (ROS), and the polarization of pro-tumor macrophages, this work underscores the potential of these drugs as adjunct or alternative therapeutic agents. [6]

Keywords: Breast cancer, Ayurvedic Bhasma, herbo-mineral nanomedicine, apoptosis, oxidative stress, translational oncology

1. Introduction

Breast cancer remains one of the leading causes of cancer-related deaths worldwide, accounting for nearly 15% of the global cancer mortality rate. [7] In countries such as India, breast cancer ranks as the second most prevalent cancer among women, with most being diagnosed at late stages of the disease, where conventional therapies alone do not have a high effectiveness rate. [8] Although standard chemotherapy is meant to decimate tumor mass, it usually cannot differentiate between malignant and normal dividing cells and causes very strong side effects, including neutropenia, cardiotoxicity, and immunosuppression. [9]

Moreover, particular subtypes, including triple-negative breast cancer (TNBC), are a serious obstacle, as they are aggressive and do not have any specific receptor (such as an estrogen receptor (ER), progesterone receptor (PR), or HER2). [10] Nearly two-thirds of the world's population have turned to some kind of complementary or alternative medicine (CAM) in order to alleviate such difficulties, resulting in a nano-Ayurvedic change of research focus. [11] The aim of this integration is to improve on the use of traditional herbo-metallic wisdom using current pharmacological models to design safer and more specific intervention methods in breast cancer victims. [12]

2. Ayurvedic Metallopharmacology

Ayurvedic metallopharmacology, also known as Rasa Shastra, refers to the medical utilization of metals and minerals that have undergone two key steps, which are Shodhana and Marana. [13] Shodhana, which means purification, is a vital detoxification process where raw metals are heated till red-hot, then extinguished in a special liquid medium, e. g., herbal decoctions, milk, or lime water. [14] This helps to eliminate the impurities on the surface and start the destruction of the crystalline structure of the bulk metal. [15]

After purification, the metal is taken through Marana, a repeated burning procedure called "Putra," in a closed vessel of earth referred to as "Sharav Samputa." [16] In such cycles, the metal is crushed in the herbal juices (Bhavana) and occasionally mixed with a catalyst such as mercury or sulfur. This is an example of ancient processes using iatrochemistry, which enables a so-called nano-transformation, in which bulk constituents are converted to stable nano-sized particles of bioaccessibility, usually between 5 and 100 nm. The nature of these nanomedicines is reflected by conventional tests, namely, Varitaratva, where the particles gather on the top of the water, indicating that the particles are so light and have the possibility of being absorbed. [17]

3. Major Metal-Based Preparations

A number of bhasmas have been used as an indicator of Arbuda (tumors) and Stanarbuda (breast tumors). Swarna Bhasma is polycrystalline, spherical gold nanoparticles of 5-20 nm diameter, which is classically processed. Although mercury was commonly employed as a growth-directing catalyst in the process of its production, it was analytically confirmed that, in the final medicine compound, there was no mercury at all since it evaporates during incineration. [18]

Abhraka Bhasma is a multi-element compound, composed of oxides of iron, silica, alumina, and magnesium, which is characterized by mica. It is also used traditionally because of its Rasayana (rejuvenating) and Lekhana (scraping)

properties to eliminate abnormal and excess muscle tissue growth. [19] Tamra Bhasma is a copper-based compound, which is known to have anti-inflammatory and antioxidant effects, and copper nanoparticles obtained induced a large scale of intracellular ROS production.

In the associated Siddha tradition, Naaga Chendhooram is a zinc-based treatment, which is particularly used in the treatment of breast cancer based on the effect of zinc in regulating the differentiation of cells and the programmed cell death. [20] Another commonly used backbone Ayurvedic oncology therapy is lauha bhasma (iron) and rajata bhasma (silver), which are used to treat systemic debility and anemia. [21] Table 1 indicates a summary of the traditional and modern mechanistic understanding of metal-based preparation.

Table 1: Summary of Traditional vs. Modern Mechanistic Understanding

Preparation	Traditional Concept	Modern Correlation	Mechanism of Action
Swarna Bhasma	<i>Rasayana (Rejuvenation)</i>	Immunomodulation	M1 macrophage polarization; cytokine regulation
Tamra Bhasma	<i>Lekhana (Scraping)</i>	Anti-proliferative	ROS-mediated apoptosis
Abhraka Bhasma	<i>Dhatu-Pushtikara</i>	Genoprotection	Enhanced DNA base excision repair in healthy cells
Naaga (Zinc)	<i>Molecular Action</i>	Differentiation	Regulation of cell proliferation signaling

4. Mechanistic Insights in Breast Cancer

Metallic Ayurvedic drugs have a dual action in breast cancer, that is, direct cytotoxicity and immunomodulation. [22] The induction of apoptosis is one of the main pathways, which is commonly mediated by p53-dependent processes that result in cell shrinkage, chromatin condensation, and nuclear fragmentation. [23] It can be induced frequently by the sheer production of ROS at the surface of nanoparticles of metals, leading to oxidative injury of malignant cell membranes and proteins. [24]

Moreover, there is a significant immunomodulatory effect of green-synthesized Ginkgo biloba (GB-AuNPs) or mango peel

phytochemical (NSB) -functionalized gold nanoparticles, which convert pro-tumor M2 macrophages into anti-tumor M1-like phenotypes. [25] This is associated with an increased production of anti-tumor cytokines, including TNF-2, IFN-G, and IL-12, and a decreased production of pro-tumor cytokines, including IL-6 and IL-10.

Moreover, the drugs have shown a possible effect in the inactivation of the NF- κ B as well as the PI3K/Akt signaling pathways, which are essential in the tumor migration and angiogenesis. [27] Other recipes, such as Abhraka Bhasma, also have genoprotection to normal cells by promoting intrinsic DNA base excision repair (BER) ability. [28]

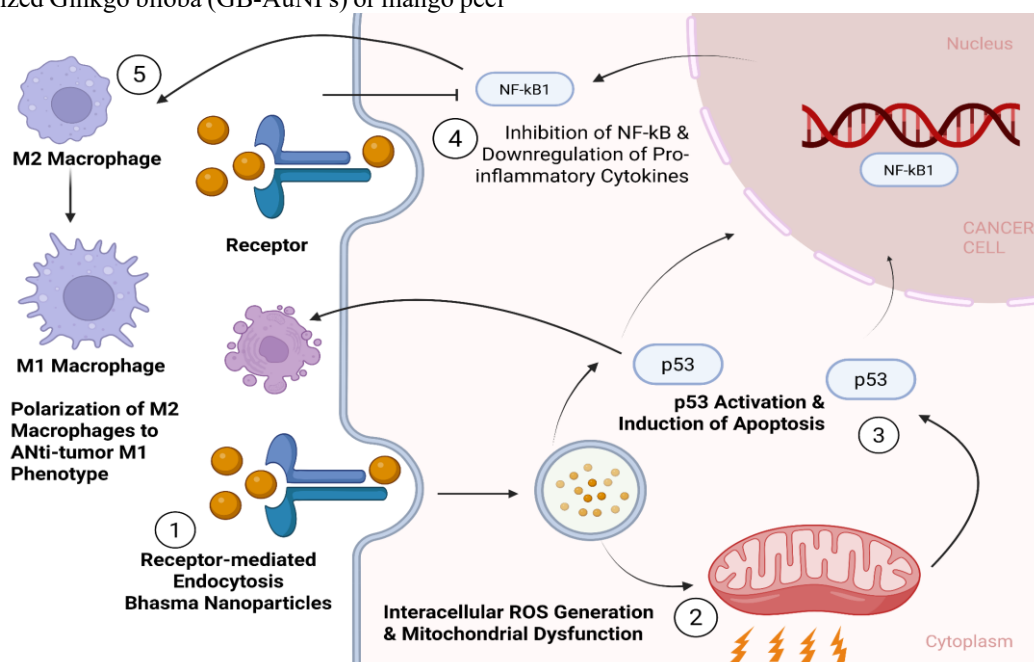


Figure 1: “Schematic representation illustrating the proposed molecular mechanisms of metal-based Ayurvedic drugs in breast cancer therapy, highlighting their potential role in inducing apoptosis, suppressing tumor cell proliferation, and modulating key signaling pathways involved in breast cancer progression.” Created with BioRender. com.

5. Pharmacological and Clinical Evidence

Dose and cell death in preclinical studies in MCF-7 (ER+) and MDA-MB-231 (TNBC) breast cancer cell lines have been shown to be dose-dependent. [29] The oral Nano Swarna Bhasma (NSB), in contrast to the placebo control, led to more than 80 percent tumor volume reduction in aggressive TNBC xenograft models. These results were translated successfully into pilot studies in human clinical trials, which were implemented within the guidelines of the AYUSH policies.

The clinical benefit rate among patients with metastatic breast cancer in the use of NSB as adjuvant therapy to conventional care was 100 percent, and contrasting the results with only the use of conventional care, there was a 0 percent clinical benefit rate.

Moreover, retrospective studies on chemo-recovery kits of incinerated coral (Praval) and pearl (Mouktik) bhasmas have indicated a statistically significant decrease in side effects of chemotherapy such as fatigue, vomiting, nausea, and change of skin coloration. [30] These kits also assisted in maintaining levels of hemolytic proteins and Karnofsky performance scores, which led to well-being and adherence towards treatment. [31]

6. Safety and Analytical Validation

The main issue regarding metal-based drugs is the safety of the drugs, which is achieved by standardization and analytical validation. [32] The ancient procedures, such as the Shodhana and Marana, are aimed at eliminating toxicity, such as the 75-step purification of mercury in some preparations to eliminate all the conventional chemotherapeutic toxicity. [33] The phase purity and crystalline character of these nanomedicines are confirmed by the use of advanced analysis techniques, including X-ray diffraction (XRD). [34]

ICP-AES and AAS measure the element composition and help in maintaining a safe level of noxious elements like lead, arsenic, and cadmium to safe regulation levels. Microscopic techniques like SEM and TEM are used to visualize homogenous nanoparticle morphology, and in most cases, they reveal particles with a spherical shape in the size range of 5-100 nm. [35] The quantitative toxicology experiments depict that standard preparations such as Swarna and Abhraka Bhasmas have high LD50 (>2000 mg/kg), which is non-toxic according to the OECD guidelines. [36]

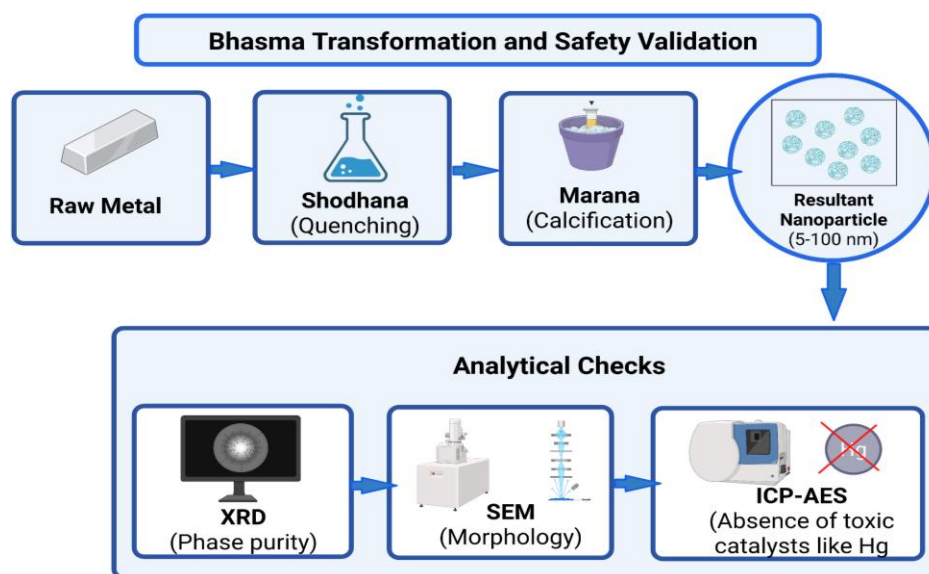


Figure 2: “Transformation of Bhasma during traditional processing and its safety validation using modern analytical techniques.” The diagram highlights important steps such as purification and calcination, along with characterization methods used to ensure the quality, stability, and safety of the final formulation. ” Created with BioRender. com.

7. Comparison with Modern Nanomedicine

Ayurvedic Bhasmas and contemporary metallic nanoparticles are similar with respect to size and structural characteristics; however, they are different regarding their mode of synthesis as well as the mode of interaction with the structure. [37] Toxic reducing agents are frequently employed in modern-day chemical synthesis, and Bhasma preparation uses electron-rich plant phytochemicals as reducing as well as stabilizing agents, providing the use of green nanotechnology. [38]

This natural functionalization forms a phytochemical corona that has a stronger bioavailability and so may be endocytosed

by receptors into tumor cells but not into normal healthy endothelial tissue. [39] However, the nano-Ayurvedic agent, such as GB-AuNPs or NSB, is selective in its cytotoxicity and immunomodulatory phenotype, unlike cisplatin, which kills both malignant cells and normal ones in an indiscriminate manner. Also, classical Bhasmas use Anupanas (media such as honey or ghee) as programmed drug delivery systems, and these might assist in the liberation of reversible agglomerates and increase cellular contact with the surface on delivery. [40]

8. Future Perspectives

The future of Bhasma studies lies in the novel approach of combining traditional knowledge and the contemporary

omics platform. This requires genomics, proteomics, and metabolomics in order to find out which molecular fingerprints these drugs impose on cancer cells and the microenvironment around their location. [41] Systems biology and network pharmacology can also offer a better view of the multi-target behavior of herbo-metallic complexes. The only way to overcome the translational gap between preclinical promise and clinical application is by delivering a large and multicenter randomized controlled trial (RCT), thus creating Level 1 clinical evidence. Joint nanotechnology research with oncology research on the standardization of drugs and a rigorous trial design will place Ayurvedic metal-based drugs as powerful adjuvant therapeutic drugs in contemporary cancer treatment. [42]

9. Conclusion

Metallic Ayurvedic medications such as Swarna, Abhraka, and Naaga Bhasmas provide a complex pharmacological transition between ancient Ayurvedic holistic medicine and nanomodern medicine. These recipes attain biocompatible nanostructures through the pharmaceutical rigor of Shodhana and Marana that selectively target breast cancer with apoptosis instigation, ROS regulation, and immunogenic stimulation. Although preclinical data and pilot clinical trials are very positive, it should be scientifically validated with the help of large-scale RCTs. The standardization of these ancient nanomedicines will allow these drugs to be properly and safely incorporated into global translational oncology with future potential to improve survival and quality of life of breast cancer patients across the globe.

Conflict of Interest

The authors declare that there is no conflict of interest related to this work.

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Ethical Approval

Ethical approval was not required for this review article, as it is based entirely on previously published literature.

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Author Contributions

Sruthi S. carried out the literature review and prepared the initial manuscript draft. Sneha S. and Sadhana Goswami assisted in data collection and manuscript review. Dr. J. Anbu contributed to the study concept, critical revision, and overall supervision of the manuscript. All authors approved the final manuscript.

References

[1] Soman Pillai D, Karavettekudy Ranjit A. Abhraka Bhasma (mica-based nanomedicine): an ayurvedic herbomineral perspective in breast cancer management.

Front Pharmacol.2025 Dec 19; 16: 1656846. doi: 10.3389/fphar.2025.1656846. PMID: 41487493; PMCID: PMC12757690.

- [2] Sardeshmukh, S., Deshmukh, V., Patil, T., Gujar, S., Godse, V., Kulkarni, S., Datar, S., Deshpande, D., Sardeshmukh, N., Bhuvad, S., Sardeshmukh, B., Chavan, S., & Gupta, V. (2025). Role of a Chemo-Recovery Kit with Ayurvedic formulations-containing coral in managing chemotherapy adverse effects and maintaining quality of life in breast cancer patients. *Journal of Ayurveda and integrative medicine*, 16 (2), 101012. <https://doi.org/10.1016/j.jaim.2024.101012>
- [3] Kantak, S., Rajurkar, N., & Adhyapak, P. (2020). Synthesis and characterization of Abhraka (mica) bhasma by two different methods. *Journal of Ayurveda and integrative medicine*, 11 (3), 236–242. <https://doi.org/10.1016/j.jaim.2018.11.003>
- [4] Chatterjee, Somsuvra & Ghosh, Chandrachur & Roy, Partha. (2024). Application of Ayurvedic Bhasma for the Treatment of Cancer. *Indian Journal of Ayurveda and Integrative Medicine KLEU.5.3-12.10.4103/ijaim.ijaim_61_23*.
- [5] Patil-Bhole, T., Wele, A., Gudi, R., Thakur, K., Nadkarni, S., Panmand, R., & Kale, B. (2021). Nanostructured gold in ancient Ayurvedic calcined drug 'swarnabhasma.' *Journal of Ayurveda and Integrative Medicine*, 12 (4), 640–648. <https://doi.org/10.1016/j.jaim.2021.06.017>
- [6] Kulkarni, Abhay & Mohan, Mahalaxmi & Patil, Pankaj & Wagh, Mayuri & Pande, Shishir & Kulkarni, Rajshree. (2024). SAFETY ASSESSMENT OF AYURVEDIC GOLD MEDICATION SUVARNA BHASMA, IN WISTAR RATS. *INDIAN DRUGS.61.65-71.10.53879/id.61.04.14066*.
- [7] Sardeshmukh, Sadanand, et al. "Role of a Chemo-Recovery Kit with Ayurvedic Formulations—Containing Coral—in Managing Chemotherapy Adverse Effects and Maintaining Quality of Life in Breast Cancer Patients." *Journal of Ayurveda and Integrative Medicine* vol.16, 2 (2025): 101012. doi: 10.1016/j.jaim.2024.101012
- [8] Prieto-Callejero, B., Rivera, F., Fagundo-Rivera, J., Romero, A., Romero-Martín, M., Gómez-Salgado, J., & Ruiz-Frutos, C. (2020). Relationship between chemotherapy-induced adverse reactions and health-related quality of life in patients with breast cancer. *Medicine*, 99 (33), e21695. <https://doi.org/10.1097/MD.00000000000021695>
- [9] Mehrotra, R., & Yadav, K. (2022). Breast cancer in India: Present scenario and the challenges ahead. *World journal of clinical oncology*, 13 (3), 209–218. <https://doi.org/10.5306/wjco.v13.i3.209>
- [10] Dai, Xiaofeng, et al. "Breast Cancer Cell Line Classification and Its Relevance with Breast Tumor Subtyping." *Journal of Cancer*, vol.8, 16, 3131-3141.12 Sep.2017, doi: 10.7150/jca.18457
- [11] Sarfraz, Muhammad, et al. "Nanotechnology-Based Drug Delivery Approaches of Mangiferin: Promises, Reality and Challenges in Cancer Chemotherapy." *Cancers* vol.15, 16, 4194.21 Aug.2023, doi: 10.3390/cancers15164194
- [12] Khoobchandani, Menka, et al. "New Approaches in Breast Cancer Therapy Through Green Nanotechnology

- and Nano-Ayurvedic Medicine—Pre-Clinical and Pilot Human Clinical Investigations. ” *International Journal of Nanomedicine*, vol.15, 181-197.13 Jan.2020, doi: 10.2147/IJN.S219042
- [13] Wele, A., De, S., Dalvi, M., Devi, N., and Pandit, V. (2021). Nanoparticles of biotite mica as Krishna Vajra Abhraka Bhasma: synthesis and characterization. *Journal of Ayurveda Integration Medicine*.12 (2), 269–282. doi: 10.1016/j. jaim.2020.09.004
- [14] Chaudhary, Anand, and Neetu Singh. “Herbo-mineral formulations (rasaoushadhies) of ayurveda an amazing inheritance of ayurvedic pharmaceuticals. ” *Ancient science of life*, vol.30, 1 (2010): 18-26.
- [15] Savrikar SS, Ravishankar B. Introduction to ‘rasashastra,’ the iatrochemistry of ayurveda. *African Journal of Traditional, Complementary, and Alternative Medicines Afr J Tradit Complement Altern Med*.2011; 8 (5 Suppl): 66e82. <https://doi.org/10.4314/ajtcam.v8i5S.1>.
- [16] Soman Pillai D and Karavetekudy Ranjit A (2025) Abhraka Bhasma (mica-based nanomedicine): an ayurvedic herbomineral perspective in breast cancer management. *Front. Pharmacol*.16: 1656846. doi: 10.3389/fphar.2025.1656846
- [17] Patil Bhole, Trupti & Wele, Asmita & Gudi, Ramacharya & Thakur, Kapil & Nadkarni, Shailesh & Panmand, Rajendra & Kale, Bharat. (2021). Nanostructured gold in ancient Ayurvedic calcined drug ‘swarnabhasma.’ *Journal of Ayurveda and Integrative Medicine*.12.10.1016/j. jaim.2021.06.017.
- [18] Hornos Carneiro, M. F., & Barbosa, F., Jr. (2016). Gold nanoparticles: A critical review of therapeutic applications and toxicological aspects. *Journal of toxicology and environmental health. Part B, Critical reviews*, 19 (3-4), 129–148. <https://doi.org/10.1080/10937404.2016.1168762>
- [19] Lakshmi, K. & Nandagopalan, Geetha. (2024). Anticancer and Immunomodulatory Properties of Herbomineral Formulation Abhrak Bhasma on Breast Cancer. *Indian Journal of Pharmaceutical Sciences*.86.10.36468/pharmaceutical-sciences.1429.
- [20] S, Janani & K, Megala & M. D, Saravana & V, Velpandian. (2022). Physiochemical and sophisticated instrumental analysis—FTIR and SEM of herbomineral formulation naaga chendhooram through PLIM guidelines. *International Journal of Pharmaceutics and Drug Analysis*.46-53.10.47957/ijpda. v10i2.504.
- [21] Sheikh, Saba, et al. “Toxicity of a novel herbomineral preparation LAS01 on human cancer cell lines and its safety profile in humans and animals. ” *Evidence-based complementary and alternative medicine: eCAM* vol.2012 (2012): 948375. doi: 10.1155/2012/948375
- [22] Pommerenke, Claudia, et al. “Molecular Characterization and Subtyping of Breast Cancer Cell Lines Provide Novel Insights into Cancer Relevant Genes. ” *Cells*, vol.13, 4 301.6 Feb.2024, doi: 10.3390/cells13040301
- [23] Park, S. J., Kim, Y. Y., Han, J. Y., Kim, S. W., Kim, H., and Ku, S. Y. (2024). Advancements in human embryonic stem cell research: clinical applications and ethical issues. *Tissue Eng. Regen. Med*.21 (3), 379–394. doi: 10.1007/s13770-024-00627-3
- [24] Tamhankar, Y. L., and Gharote, A. P. (2020). Effect of puta on in vitro anticancer activity of shataputi abhraka bhasma on lung, leukemia, and prostate cancer cell lines. *J. Ayurveda Integr. Med*.11, 118–123. doi: 10.1016/j. jaim.2017.07.007
- [25] Thipe, Velaphi C., et al. “Nano-Ayurvedic Medicine Approaches Using Ginkgo Biloba-Phytochemicals Functionalized Gold Nanoparticles Against Breast Cancer. ” *Nanotechnology, science and applications* vol.17 189-210.23 Sep.2024, doi: 10.2147/NSA.S478533
- [26] Farhadi, Pegah et al. “Cell line-directed breast cancer research based on glucose metabolism status. ” *Biomedicine & pharmacotherapy = Biomedecine & pharmacotherapie* vol.146 (2022): 112526. doi: 10.1016/j. biopha.2021.112526
- [27] El-Deeb NM, Khatib SM, Abu-Youssef MA, Badr AMA. Green synthesis of novel stable biogenic gold nanoparticles for breast cancer therapeutics via the induction of extrinsic and intrinsic pathways. *Sci Rep*.2022; 12 (1). doi: 10.1038/s41598-022-15648-y
- [28] Kulala, D. S., Prasad, K., Reddy, P. S., Maruthiyodan, S., Joshi, M. B., Satyamoorthy, K., et al. (2023). Understanding the effects of abhraka bhasma on genotoxicity and its DNA repair potential in a mouse model. *J. Ayurveda Integr. Med*.14 (2), 100598. doi: 10.1016/j. jaim.2022.100598
- [29] van Meerloo, Johan, et al. “Cell sensitivity assays: the MTT assay. ” *Methods in molecular biology (Clifton, N. J.)* vol.731 (2011): 237-45. doi: 10.1007/978-1-61779-080-5_20
- [30] Barreto, J. C., Trevisan, M. T., Hull, W. E., Erben, G., de Brito, E. S., Pfundstein, B., Würtele, G., Spiegelhalder, B., & Owen, R. W. (2008). Characterization and quantitation of polyphenolic compounds in bark, kernel, leaves, and peel of mango (*Mangifera indica* L.). *Journal of Agricultural and Food Chemistry*, 56 (14), 5599–5610. <https://doi.org/10.1021/jf800738r>
- [31] Gadisa DA, Assefa M, Tefera GM, Yimer G. Patterns of anthracycline-based chemotherapy-induced adverse drug reactions and their impact on relative dose intensity among women with breast cancer in Ethiopia: a prospective observational study. *J Oncol* 2020; 2020: 2636514. <https://doi.org/10.1155/2020/2636514>.
- [32] Pandit, Vijaya Anil et al. “Toxicity profile of standardized Krishna Vajra Abhraka Bhasma made from biotite mica. ” *Journal of Ayurveda and Integrative Medicine*, vol.15, 6 (2024): 100980. doi: 10.1016/j. jaim.2024.100980
- [33] Maurya, S. K., Seth, A., Laloo, D., Singh, N. K., Gautam, D. N., & Singh, A. K. (2015). Śodhana: An Ayurvedic process for detoxification and modification of therapeutic activities of poisonous medicinal plants. *Ancient science of life*, 34 (4), 188–197. <https://doi.org/10.4103/0257-7941.160862>
- [34] Thakur, Kapil, et al. “Preparation and Characterization of Suvarna Bhasma Parada Marit. ” *Journal of Pharmacopuncture*, vol.20, 1 (2017): 36-44. doi: 10.3831/KPI.2017.20.007
- [35] Guo, T L et al. “Mercuric chloride induces apoptosis in human T lymphocytes: evidence of mitochondrial

- dysfunction. ” *Toxicology and Applied Pharmacology*, vol.153, 2 (1998): 250-7. doi: 10.1006/taap.1998.8549
- [36] Gopinath, Harish, and Muruges Shivashankar. “A study on toxicity and anti-hyperglycemic effects of Abhrak Bhasma in rats. ” *Journal of Ayurveda and Integrative Medicine*, vol.12, 3 (2021): 443-451. doi: 10.1016/j.jaim.2021.03.004
- [37] Karunakaran, Gauthaman. (2004). *Scientific Basis for Ayurvedic Therapies*.
- [38] Ferreira, Aryel H., et al. “Green Nanotechnology Through Papain Nanoparticles: Preclinical in vitro and in vivo Evaluation of Imaging Triple-Negative Breast Tumors. ” *Nanotechnology, science and applications* vol.17, 211-226.25 Sep.2024, doi: 10.2147/NSA.S474194
- [39] Abed AS, Khalaf YH, Mohammed AM. Green synthesis of gold nanoparticles as an effective opportunity for cancer treatment. *Results Chem.*2023; 5. doi: 10.1016/j.rechem.2023.100848
- [40] Rajapakse, Niranjan & Kim, Se-Kwon. (2011). Chapter 2. Nutritional and Digestive Health Benefits of Seaweed.10.1016/B978-0-12-387669-0.00002-8.
- [41] Xu, Yongcheng, et al. “Recent research progress on metal ions and metal-based nanomaterials in tumor therapy. ” *Frontiers in bioengineering and biotechnology*, vol.13, 1550089.7 Feb.2025, doi: 10.3389/fbioe.2025.1550089
- [42] Khoobchandani, Menka & Katti, Kavita & Raphael Karikachery, Alice & Thipe, Velaphi & Srisrimal, Deepak & Dhurvas, Darsha & Darshakumar, Rashmi & Joshi, Chintamani & Katti, Kattesh. (2020). *New Approaches in Breast Cancer Therapy Through Green Nanotechnology and Nano-Ayurvedic Medicine—Pre-Clinical and Pilot Human Clinical Investigations*. *International Journal of Nanomedicine*.15.181-197.10.2147/IJN.S219042.