Date of Publication 25 06, 2026, Date of Current Version 20 06, 2026.

Digital Object Identifier: https://doi.org/10.63912/kjaise.v1i0.0005

Cytotoxic Effects of *Salvia officinalis* Extraction MCF-7 Human Breast Cancer Cells

Sama Naziyah Shaban[1*], Solachuddin Jauhari Arief Ichwan[2], Basma Ezzat Mustafa Alahmad[3], Khairani Idah Mokhtar[3], Raida Khalil[4]

[1]Faculty of Dentistry, Qaiwan International University, Sulaymaniyah, Kurdistan Region, Iraq-46001

[2]Institute of Health Sciences, University Brunei Darussalam, Brunei.

[3]Faculty of Dentistry, International Islamic University Malaysia

[4]Faculty of Science, Philadelphia University, Jordan.

Corresponding Author: *Sama Naziyah (e-mail:sama.nazih@uniq.edu.iq).

ABSTRACT: *Salvia officinalis* (sage) is a medicinal plant recognized for its antioxidant and potential anticancer properties. This study has been designed to assess the cytotoxic properties of sage plant on human breast cancer cells (MCF-7). MCF-7cells were treated with variable concentrations of sage extract, and cell viability was evaluated by means of the MTT assay. The results showed a dose-dependent reduction in cell viability, the highest extract concentration reducing viability by approximately 60%. The estimated IC_{50} value indicated moderate cytotoxic potency. These findings suggest that *Salvia officinalis* contains bioactive compounds capable of inhibiting breast cancer cell proliferation. Further studies are recommended to explain the underlying mechanisms and assess its healing potential *in-vivo*.

KEY WORDS: MCF-7, Breast cancer, *Salvia officinallis*, Cytotoxicity.

I. INTRODUCTION

Salvia officinalis (common sage) is a medicinal and culinary plant long valued in traditional healing systems. Species of *Salvia* have been used worldwide for various ailments, and local traditions often employ sage in treating infections, inflammation, memory loss, and even cancer [1]. In South Africa, for example, several sage species are traditionally used against microbial infections, malaria and other conditions [1]. This broad ethnobotanical usage reflects the rich phytochemistry of sage. Analytical studies of sage essential oils show that its leaves contain abundant terpenoids–notablyα-thujone, camphor, borneol, γ-muurolene and sclareol – across different growing conditions [2]. These bioactive constituents have been linked to diverse pharmacological activities, suggesting that sage's historic uses may have scientific basis.

Recent research has indeed confirmed multiple biological effects of sage extracts. For example, sage extracts exhibit strong antioxidant capacity, which correlates with high level of phenolic compounds [3]. In controlled experiments, sage (and related herbs like thyme and marjoram) showed significant free-radical scavenging activity, supporting their potential as natural antioxidants [3]. In parallel, several *in-vitro* studies indicate that sage can inhibit cancer cell growth. Kontogianni *et al.* Found that sage extract impaired viability and induced apoptotic cell death in rat insulinoma (RINm5F) cells [4]. Likewise, components of sage oil (e.g. caryophyllene) have been reported to prevent proliferation of human cancer cell lines such as MCF-7 breast adenocarcinoma and HCT-116 colon carcinoma [5]. These findings suggest sage contains constituents capable of anti-proliferative and cytotoxic actions.

Given the established safety profile and multifunctional properties of natural products, there is growing interest in identifying new anticancer agents from plants. Indeed, dietary plant compounds (e.g. flaxseed lignans) have been associated with reduced cancer severity, prompting investigation of other botanicals. Sage's potent antioxidant and anti-growth activities make it a promising candidate for cancer research. Among cancer models, human MCF-7 breast cancer cell line is one of the most widely used systems for screening potential therapeutics. MCF-7 cells, originally derived from metastatic breast adenocarcinoma, are estrogen receptor–positive and representative of hormone-responsive breast cancer. They serve as a standard *in-vitro* model to study breast tumor biology and to evaluate cytotoxic compounds.

In this context, our study is motivated by the need to explore sage's effects on breast cancer cells specifically. Although sage has shown anticancer effects in various models, its impact on MCF-7 cells has not been fully characterized. By testing *Salvia officinalis* extract against the MCF-7 cell line,

the aim is to build on the existing evidence of sage's bioactivity [3][4], and to assess potential relevance for human breast cancer therapy. This approach aligns with a broader interest in natural product research and leverages sage's traditional usage and experimental bioactivities as rationale.

II. MATERIALS AND METHODS

2.1 Natural Extracts

Plant extracts used in this study were prepared at the Faculty of Science, Philadelphia University, Amman, Jordan using Soxhlet extraction method and ethanol as a medium of extraction. The leaves of sage plants are used.

2.2 Cell Culture

The MCF-7 human breast cancer cell line was cultured in Dulbecco's Modified Eagle Medium (DMEM) supplemented with 10% fetal bovine serum (FBS) and 5% penicillin. Cells were maintained at 37°C in a humidified incubator with 5% CO_2 [6]. Once 90% confluence was reached, cells were washed with PBS, treated with 1mL trypsin, and incubated for 2–3 minutes until detachment. After neutralization with 4mL DMEM, cells were seeded into new 60 mm dishes and incubated for 48 h.

2.3 Cytotoxicity Assessment–MTT Assay

Cell viability was assessed using the MTT assay. After treatment with different extract concentrations Table 1, 30µL of MTT solution was added to each well and incubated for 3–4 h at 37°C. Then, 150µL of DMSO (Dimethyl Sulfoxide) was added to solubilize the formazan crystals. A purple color indicated viable cells, whereas a yellow color suggested growth inhibition or cell death [7].

TABLE 1

SAMPLE DISTRIBUTION IN A 96-WELL PLATE SE= SAGE EXTRACT, -VE CONTROL= NEGATIVE CONTROL, DMSO= POSITIVE CONTROL

-	1	2	3	4	5	6	7	8	9	10	11	12
A	SOE 100µg/ml			SOE 50µg/ml			SOE 25µg/ml			SOE12.5µg/ml		
B	SOE 100µg/ml			SOE 50µg/ml			SOE 25µg/ml			SOE12.5µg/ml		
C	SOE 100µg/ml			SOE 50µg/ml			SOE 25µg/ml			SOE12.5µg/ml		
D	-ve control			-ve control			-ve control			-ve control		
E	-ve control			-ve control			-ve control			-ve control		
F	-ve control			DMSO			DMSO			DMSO		
G	DMSO			DMSO			DMSO			DMSO		
H	DMSO			DMSO			Blank			MTT		

I. RESULTS

Table 2 shows the mean for the cell viability of MCF-7 cell line against water extract of sage (*salvia officinallies*) in four different concentration using MTT assay. The table also contains the mean of the negative control which is the cells with no treatment and the positive control, the DMSO, to compare our results. The controls were used in only one concentration. MTT assay is performed in a 24-hour time line and the readings were triplicated; Figure (1) shows MTT assay results after 24h incubation with sage oil crude extract: the negative control = cells with no treatment, positive control = DMSO and the half maximum inhibitory concentration (IC_{50}).

TABLE 2

MEAN/AVERAGE OF MCF7 CELL VIABILITY AGAINST SAMPLE EXTRACTS IN DIFFERENT CONCENTRATIONS PLUS NEGATIVE AND POSITIVE CONTROL

Treatment	Mean Conc.1=100 µg/ml	Mean Conc.2=50 µg/ml	Mean Conc.3=25 µg/ml	Mean Conc.4=12.5 µg/ml
Sage	0.13948	0.13671	0.16799	0.19302
DMSO	0.14302	-	-	-
No Treatment	0.24327	-	-	-

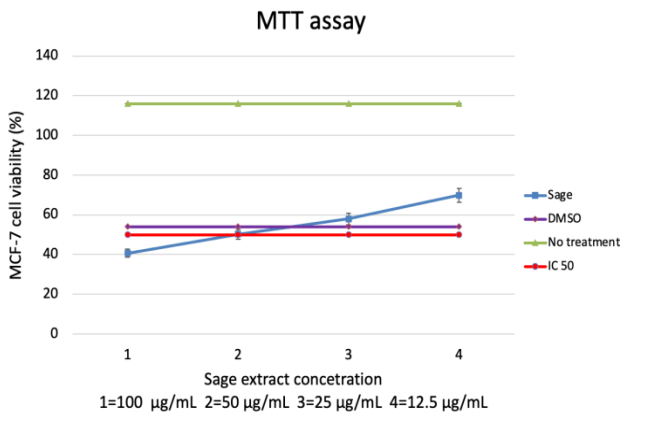

FIGURE 1: Dose dependent effect of sage extract on MCF-7 cells in comparison with (+) and (-) control. Error bars represent standard error mean cell proliferation as determined by repeated experiments. Values are expressed as Mean±SD (n=3).

III. DISCUSSION

In the MTT assay, untreated MCF-7 cells (negative control) are designated as 100% viable. The absorbance of dissolved formazan was measured to quantify viability: greater absorbance means metabolically active (viable) cells, and lower absorbance indicates fewer viable cells (cytotoxicity). In this experiment, increasing concentrations of the *Salvia officinalis* extract produced progressively lower viability, demonstrating a clear dose–response relationship [8]. By 24h, only the highest extract dose had a dramatic effect, reducing viability to about 40% of control (i.e. ~60% cell death), whereas the lower concentrations left around half of the cells alive. This pattern is typical of cytotoxic agents: more concentrated treatments kill more cells [8].

The IC_{50} value (half-maximal inhibitory concentration) quantifies potency in such assays. By definition, the IC_{50} is the concentration at which cell viability is 50% of untreated control [8]. Equivalently, it is the dose that "reduces the

number of viable cells by half" [9]. The control is set at 100% viability [8], the IC_{50} point occurs when treated wells read ~50% on that scale. In general, a lower IC_{50} implies a stronger cytotoxic (antiproliferative) effect [8]. In the data obtained, the lowest viability (~40%) was observed only at the highest extract concentration, meaning the IC_{50} lies near that level. (In practice, one would interpolate from the full dose–response curve to estimate the precise IC_{50}.)

Compared to controls, the sage extract showed pronounced toxicity. DMSO is used as a solvent control. Although DMSO is often considered inert, it can itself be cytotoxic at sufficiently high percentage [8]. In fact, our extract treatment killed more MCF-7 cells than the DMSO- treated control, indicating the extract's effect was substantial. This suggests that the observed killing is due to bioactive compounds in the extract rather than simply solvent effects.

Thus, our observed cytotoxicity (viability down to ~40% at high dose) is in line with the known anticancer potential of sage extracts and its phytochemicals [10].

IV. CONCLUSION

This study demonstrated that *Salvia officinalis* (sage) extract exerts a concentration-dependent cytotoxic effect on MCF-7 human breast cancer cells, significantly reducing cell viability at higher doses. The observed reduction in viability and the estimated IC_{50} value suggest that sage contains potent bioactive compounds with anticancer potential. These findings support the potential role of *S. officinalis* as a natural source of therapeutic agents for breast cancer. However, further investigations are required to isolate and characterize the active constituents, elucidate the mechanisms faction, and evaluate their efficacy and safety *in-vivo*.

ACKNOWLEDGMENT

The authors thank Qaiwan International University, Iraq, Philadelphia University, Jordan, and International Islamic University Malaysia, Malaysia for their support and assistance throughout the study.

References:

1. G. P. P. Kamatou, N. P. Makunga, W. P. N. Ramogola, and A. M. Viljoen, "South African *Salvia* species: A review of biological activities and phytochemistry," *J. Ethnopharmacol.*, vol. 119, no. 3, pp. 664–672, Oct. 2008, doi: 10.1016/j.jep.2008.06.030.
2. R. Tundis, M. Leporini, M. Bonesi, S. Rovito, and N. G. Passalacqua, "*Salvia officinalis* L. from Italy: A comparative chemical and biological study of its essential oil in the Mediterranean context," *Molecules*, vol. 25, no. 24, Art. no. 5826, 2020, doi: 10.3390/molecules25245826.
3. M. H. H. Roby, M. A. Sarhan, K. A. H. Selim, and K. I. Khalel, "Evaluation of antioxidant activity, total phenols and phenolic compounds in thyme (*Thymus vulgaris* L.), sage (*Salvia officinalis* L.), and marjoram (*Origanum majorana* L.) extracts," *Ind. Crops Prod.*, vol. 43, pp. 827–831, Jan. 2013, doi: 10.1016/j.indcrop.2012.08.029.
4. V. G. Kontogianni *et al.*, "Phytochemical profile of *Rosmarinus officinalis* and *Salvia officinalis* extracts and correlation to their antioxidant and anti-proliferative activity," *Food Chem.*, vol. 136, no. 1, pp. 120–129, Jan. 2013, doi: 10.1016/j.foodchem.2012.07.091.
5. S. B. Moghadam, R. Masoudi, and M. Monsefi, "*Salvia officinalis* induces apoptosis in mammary carcinoma cells through alteration of Bax to Bcl-2 ratio," *Iran. J. Sci. Technol. Trans. A Sci.*, vol. 42, no. 1, pp. 297–303, Mar. 2018, doi: 10.1007/s40995-018-0496-x.
6. M. U. Rashid and K. M. Coombs, "Serum-reduced media impacts on cell viability and protein expression in human lung epithelial cells," *J. Cell. Physiol.*, vol. 234, no. 6, pp. 7718–7724, Jun. 2019, doi: 10.1002/jcp.27890.
7. A. Bahuguna, I. Khan, V. K. Bajpai, and S. C. Kang, "MTT assay to evaluate the cytotoxic potential of a drug," *Bangladesh J. Pharmacol.*, vol. 12, no. 2, pp. 115–118, 2017, doi: 10.3329/bjp.v12i2.30892.
8. P. Kumar, A. Nagarajan, and P. D. Uchil, "Analysis of cell viability by the MTT assay," *Cold Spring Harb. Protoc.*, vol. 2018, no. 6, Jun. 2018, Art. no. pdb.prot095505, doi: 10.1101/pdb.prot095505.
9. M. Sánchez-Díez *et al.*, "Assessment of cell viability in drug therapy: IC50 and other new time-independent indices for evaluating chemotherapy efficacy," *Pharmaceutics*, vol. 17, no. 2, Art. no. 247, 2025, doi: 10.3390/pharmaceutics17020247.
10. H. M. El-Rafie, S. M. A. El-Aziz, and M. K. Zahran, "In vitro cytotoxicity against breast cancer using biogenically synthesized gold and iron oxide nanoparticles derived from the hydroethanolic extract of *Salvia officinalis* L.," *Chem. Pap.*, vol. 77, no. 1, pp. 361–373, Jan. 2023, doi: 10.1007/s11696-022-02464-x.