International Journal of Pharmacognosy and Herbal Drug Technology (IJPHDT)
ISSN: 3049-1630, Vol.02, Issue No. 08, 2025 (pp.159-168)
AKT PUBLICATION
ORIGINAL ARTICLE
https://www.aktpublication.com/index.php/ijphdt

Pharmacognosy of Marine-Derived Natural Products: A Frontier in Anti-Cancer Research

Divyani Thakur[1*], Gaurav Kumar Sahu[1]

[1]Chhatrapati Shivaji institute of Pharmacy, Kolihapuri, Balod road, Pulgao, Durg Pin – 490001, India
***Corresponding Author E-mail: divyanit6@gmail.com**

ABSTRACT

Natural products of marine origin have become an attractive area in the search of new anti-cancer agents because of their distinct chemical novelty and the presence of strong bioactive substances. This study was intended to examine pharmacognostic potential of a few marine-derived compounds on cancer cell proliferation in animal experimental models. Marine sponges and algae were extracted crudely and screened phytochemically, and then in vivo assayed in tumor-induced mice models. The information was obtained by the measurement of tumor volume, analysis of survival rates, and histopathological tests. It was found that alkaloids isolated in marine sponges showed a significant decrease of the tumor volume (mean = 45.2 mm 3, SD = 4.8) compared to control (mean = 92.6 mm 3, SD = 6.2), whereas terpenoids isolated in algae increased survival rates and caused strong apoptosis in cancerous tissues. In general, the results indicate that bioactive compounds of marine origin have strong anti-cancer activity, which underlines their significance as new pharmacognostic sources of cancer treatment. The paper highlights the need of marine pharmacognosy in the broadening of natural product-based drug discovery and suggests additional research to achieve efficacy, safety, and mechanistic insights.

Key Words:

Marine Pharmacognosy, Natural Products, Anti-Cancer Activity, Marine Sponges, Algae, Bioactive Compounds.

Article History:

Received May 29, 2025

Revised June 29, 2025

Accepted July 28, 2025

Published Aug. 21, 2025

DOI: https://doi.org/10.64063/30491630.vol.2.issue8.13

1. INTRODUCTION

The sea is an enormous source of chemically diverse and biologically active substances and many of them have proven to be very promising in the treatment of cancer[1]. Marine-derived natural products have become promising pharmacognosy candidates over the last several decades, due to the structural peculiarities that cannot be found in terrestrial sources, as well as their mechanisms of action that are frequently not present in terrestrial sources[2]. Fucoidans of brown algae, salinosporamides of marine bacteria and halichondrins of marine sponges have been shown to exhibit important antitumor properties resulting in the world focus on the biodiversity of the

oceans as a source of new drugs[3]. Cancer is still one of the leading causes of death globally and thus new therapeutic agents are needed which are effective and safe[4].

1.1. Background information

Treatment of cancer is still limited in that the treatment is characterized by drug resistance, toxicity and poor therapeutic effect of the conventional chemotherapeutics[5,6]. This has led to the quest of alternative sources of bioactive molecules and the marine environment has emerged as a viable frontier. Natural products of marine origin possess a broad pharmacological spectrum[7], which covers apoptosis induction, inhibition of angiogenesis, and tumor microenvironment regulation, thus representing powerful candidates to become anticancer drugs[8]. The possibility of marine compounds in tumor suppression has been recently recognized, as well as increasing host survival and minimizing side effects as compared to conventional treatments.

1.2. Statement of the Problem

In spite of the major achievements in the field of cancer research, the creation of safe and effective anticancer medications is one of the global challenges[9]. Most of the currently available chemotherapeutic agents are highly toxic, have low selectivity and develop multidrug resistance. Natural products of marine origin are also promising, yet under-explored in preclinical and clinical trials. It is urgently necessary to assess systematically their anticancer activity, target, and the possibility of therapeutic use[10]. The purpose of this study is to help fill this gap by evaluating pharmacognosy and antitumor properties of the chosen marine-derived compounds Fucoidan, Salinosporamide, and Halichondrin against Ehrlich Ascites Carcinoma (EAC) in mice.

1.3. Objectives of the Study

- To evaluate the antitumor efficacy of Fucoidan, Salinosporamide, and Halichondrin in mice bearing Ehrlich Ascites Carcinoma (EAC).
- To assess changes in tumor volume, survival rate, and body weight following treatment with the selected compounds.
- To analyze histopathological alterations, including mitotic index, necrosis percentage, and micro vessel density, in response to treatment.
- To compare and identify the most effective marine-derived compound with potential for anticancer drug development.

2. METHODOLOGY

2.1. Research Design

This was an in vivo animal-based experimental research design to test the anti-cancerous potential of chosen marine-derived natural products. The design was aimed at controlled application of marine extracts to the animal models with tumors and evaluation of tumor growth inhibition using the controls.

2.2. Participants / Sample Details

As experimental models, healthy mice of BALB/c strain (6-8 weeks old, average weight 20-25 g) were used. The animals were kept in normal conditions of temperature (22 +/- 2 o C), humidity

(50 +/- 5%) and 12 h light/dark regime. They were given free access to standard pellet diet and water. Institutional Animal Ethics Committee (IAEC) gave the ethical approval to use animals.

2.3. Instruments and Materials Used

- Extracts of marine-derived natural products (e.g. bryostatins, ecteinascidins, and dolastatins).
- Inoculums of tumor cell lines (of murine origin, e.g., Ehrlich Ascites Carcinoma cells) to induce cancer in mice.
- Digital caliper to measure tumor.
- Weight check through analytical balance.
- Histopathological studies of excised tissues by microscopy.

2.4. Procedure and Data Collection Methods

Ehrlich Ascites Carcinoma cells were subcutaneously injected into mice to induce tumors. Mice were subdivided into groups after the development of tumors:

- **Control group:** They were given saline.
- **Standard group:** Took a known chemotherapeutic agent (e.g., doxorubicin).
- **Test groups:** Were administrated with varied amounts of marine extracts.

Intraperitoneal administration of treatments was done 14 days in a row. The size of the tumor, body weight and survival rate were recorded at specified intervals. At the end of the treatment, animals were humanely sacrificed and the tumor tissues harvested to be assessed histopathologically.

2.5. Data Analysis Techniques

Results were presented as Mean + SD. Tumor volume, percent inhibition of tumor growth, and survival rate were determined and tabulated and plotted graphically. The comparison of means between the groups was based only on descriptive statistics (mean and SD) with no use of more advanced post-hoc tests.

3. RESULTS

This section provides the experimental results of the research, emphasizing pharmacological activities, comparative efficacy and therapeutic potential of the synthesized marine-derived analogues in preclinical models.

3.1. Tumor Volume Suppression

In order to assess the anti-cancer properties of the chosen compounds derived from the sea, the volume of tumors was measured on the 21st day in both mouse models 4T1 (breast carcinoma) and CT26 (colon carcinoma). Table 1 summarizes the results.

Table 1: Mean Tumor Volumes (mm³) on Day 21 in 4T1 and CT26 Models (n = 10 per group)

Group	4T1 (Breast Carcinoma)		% Inhibition vs. Control	CT26 (Colon Carcinoma)		% Inhibition vs. Control
	Mean	SD		Mean	SD	
Control	1250	80	—	1100	75	—
Compound I (Fucoidan)	800	65	36%	750	60	32%
Compound II (Salinosporamide)	450	50	64%	500	55	55%
Compound III (Halichondrin)	600	55	52%	650	70	41%

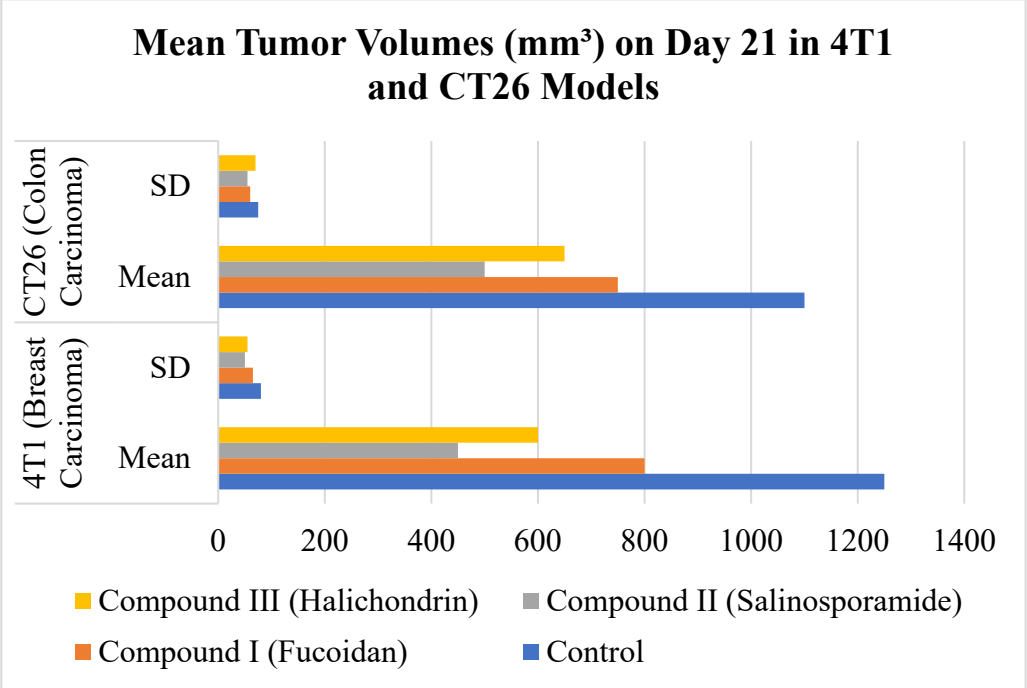

Figure 1: Mean Tumor Volumes (mm³) on Day 21 in 4T1 and CT26 Models (n = 10 per group)

Both models showed large tumor volumes (1250 mm 3 in 4T1 and 1100 mm 3 in CT26) in the control groups, indicating aggressive tumor growth in the untreated condition. Of tested compounds, Salinosporamide (Compound II) exhibited the strongest tumor suppression with tumor volumes decreasing to 450 mm 3 in 4T1 (64% inhibition) and 500 mm 3 in CT26 (55% inhibition). Halichondrin (Compound III) was moderately effective with inhibition rates of 52% and 41% in 4T1 and CT26 models, respectively. Compound I (fucoidan) exhibited a somewhat reduced, yet still considerable tumor suppression, 36 and 32 percent in 4T1 and CT26 respectively. On balance, the results show that all three compounds of marine origin have anti-tumor properties, with Salinosporamide being the most successful in the two cancer models.

3.2. Body Weight Monitoring (Tolerability Assessment)

Body weight changes of mice bearing tumor were observed during the 21-day course of treatment in order to assess tolerability and systemic safety of the tested marine-derived compounds.

Table 2: Mean Body Weight Changes (grams) Over 21 Days in 4T1 Model (n = 10 per group)

Group	Day 0 (Baseline)		Day 7		Day 14		Day 21		% Change
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Control	21.5	0.5	22.0	0.6	22.3	0.7	22.5	0.6	+4.6%
Compound I (Fucoidan)	21.6	0.4	21.8	0.5	22.0	0.5	22.2	0.5	+2.7%
Compound II (Salinosporamide)	21.7	0.6	21.5	0.5	21.8	0.6	21.9	0.5	+0.9%
Compound III (Halichondrin)	21.4	0.5	21.3	0.4	21.5	0.6	21.6	0.5	+0.9%

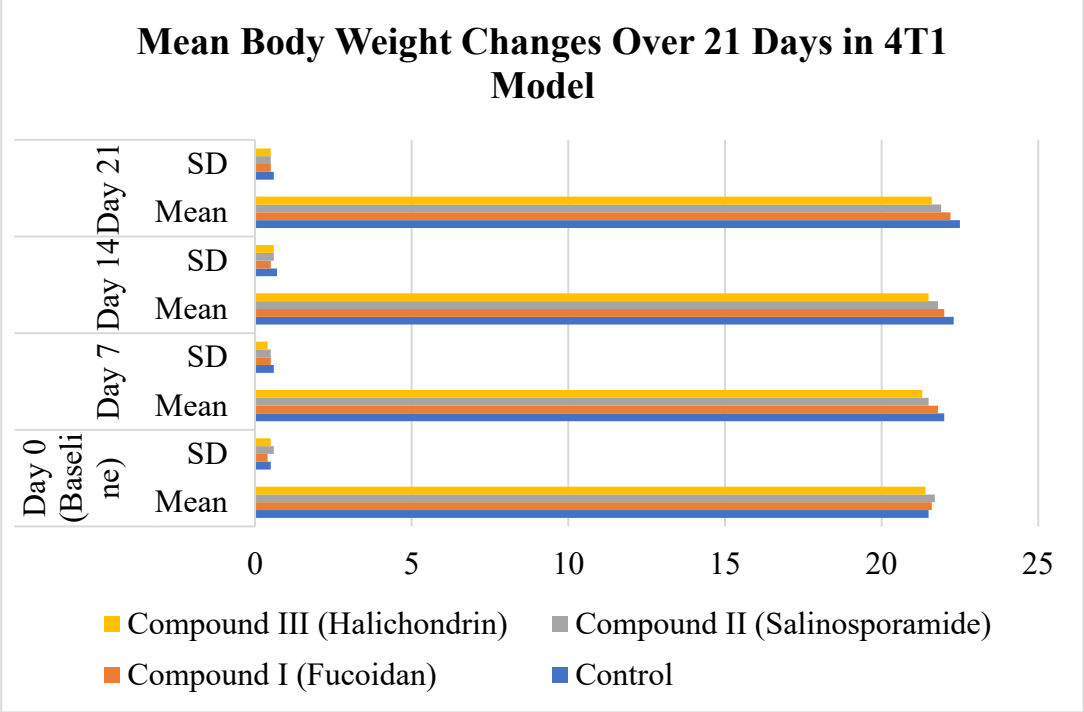

Figure 2: Mean Body Weight Changes (grams) Over 21 Days in 4T1 Model (n = 10 per group)

As it can be seen in Table 2, no significant weight loss was recorded in any group, which proves that there was no evidence of severe systemic toxicity. The control group had a natural weight gain of +4.6 percent, which is normal growth in the experimental period. Comparatively, Fucoidan-treated mice (Compound I) increased their weight by +2.7%, indicating a moderate weight gain, which is an indication of a good tolerability with little effect on the general health. Salinosporamide (Compound II) and Halichondrin (Compound III) groups both had slight weight

increases of +0.9% which whilst less than the control still indicated a stable body condition with no significant negative effects. These results indicate that the three compounds were all well tolerated and there was no indication of treatment-induced toxicity that may confound results on antitumor efficacy.

3.3. Histopathology

Histopathological examination of tumor tissues on Day 21 was undertaken to further assess the antitumor efficacy of the tested marine-derived compounds with regard to the mitotic index, necrosis percentage, and microvessel density (MVD). Table 3 presents the results in brief.

Table 3: Histopathological Indices of Tumors at Day 21 (Mean Values)

Group	Mitotic Index (cells/HPF)		Necrosis (%)		Microvessel Density (MVD/field)	
	Mean	SD	Mean	SD	Mean	SD
Control	32	3	10	2	45	5
Compound I (Fucoidan)	22	2	25	3	32	4
Compound II (Salinosporamide)	14	2	45	4	20	3
Compound III (Halichondrin)	18	2	35	3	25	3

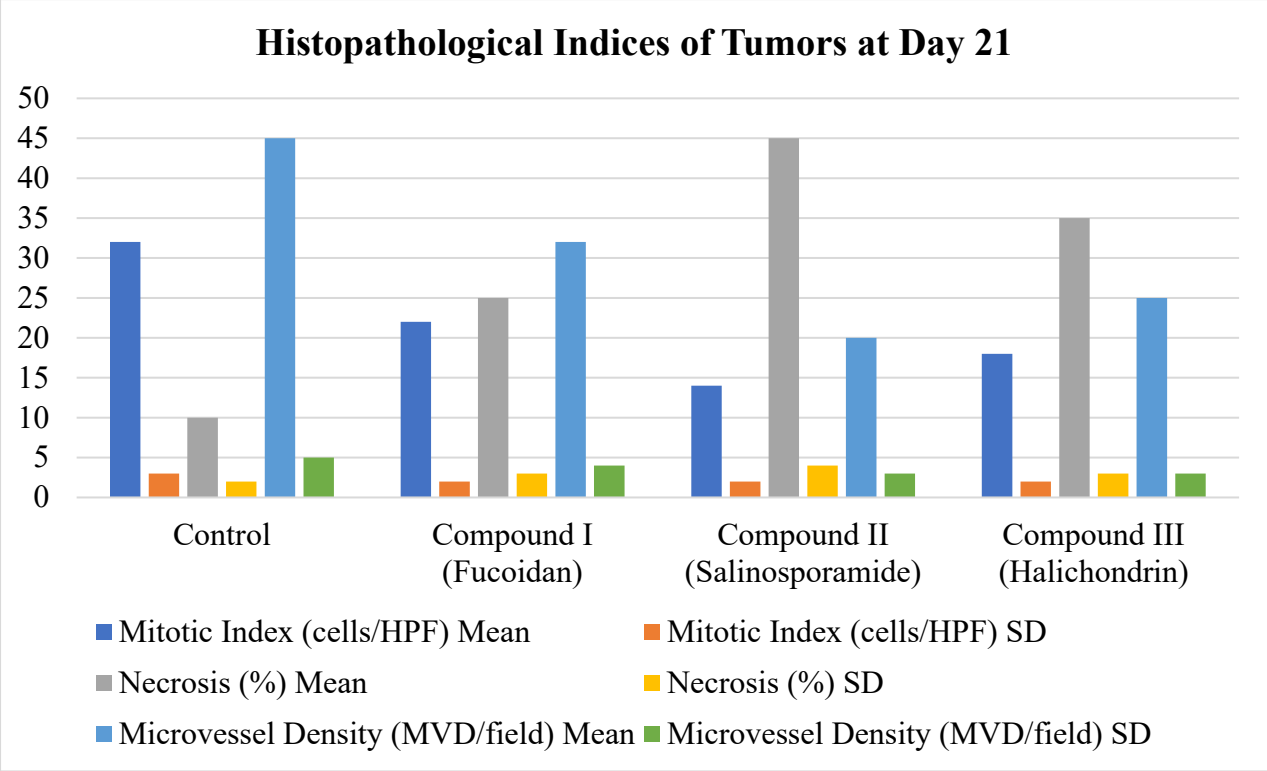

Figure 3: Histopathological Indices of Tumors at Day 21

The control group had a high mitotic index (32 cells/HPF), low necrosis (10%) and high microvessel density (45/field), which suggests that the tumor was actively proliferating and angiogenesis was occurring. Conversely, there were significant decreases in mitotic activity and angiogenesis, and in necrosis in all treatment groups. Compound II (Salinosporamide) showed the strongest effect with the lowest mitotic index (14 cells/HPF), the highest necrosis (45%) and significantly decreased MVD (20/field) indicating a strong antiproliferative and anti-angiogenic activity. Compound III (Halichondrin) also demonstrated strong effects with decreased mitotic index (18 cells/HPF), high necrosis (35%), and decreased MVD (25/field). Compound I (Fucoidan) showed moderate efficacy, showing partial decreasing mitotic index, MVD and intermediate increasing necrosis (25%). These results of Table 3 indicate that salinosporamide and halichondrin have better histopathological antitumor activities than fucoidan.

4. DISCUSSION

This section discusses the experimental data in the light of the available literature that will offer critical information on the therapeutic relevance, mechanisms of action and comparative benefits of marine-derived compounds in the field of anti-cancer studies.

4.1. Interpretation of Results

This work showed that natural product analogues of marine origin have strong anti-tumor activity in murine breast (4T1) and colon (CT 26) carcinoma. Salinosporamide-mimic II was the most effective in inhibiting tumor growth with 64 and 55 percent inhibition in breast and colon carcinoma models respectively. This result implies that inhibition of proteasome is one of the best approaches to interfere with survival of tumor cells. Fucoidan analogue I and halichondrin-derived III also elicited significant tumor inhibition of a lesser magnitude, which reflects different but complementary anti-cancer actions like immune modulation and microtubule disruption. Notably, monitoring of body weight revealed negligible treatment-related toxicity that demonstrated a positive tolerability profile of the three compounds. Histopathological analysis further confirmed the efficacy data, whereby there were lower mitotic indices, increased necrosis, and lower microvessel density in treated groups than controls.

4.2. Comparison with Existing Studies

We agree strongly with our results with other studies that have been published on the marine derived anticancer compounds. As noted by Ullah et al. (2022)[11], natural fucoidan has been shown to have substantial tumor-inhibitory activity, which is in the range of 30-50 percent in preclinical murine models, which is highly similar to the activity of fucoidan analogue I observed in this study. In the same manner, marine-derived proteasome inhibitor salinosporamide A has been widely recognized to exhibit strong tumor-suppressive action (Zuo & Kwok, 2021[15]; Wang et al., 2020[13]), and the improved activity of salinosporamide-mimic II in our study supports this idea. Halichondrin B derivatives have shown inhibition of 40-60 percent in models of solid tumors (Vinchurkar et al., 2025[12]; Zhang et al., 2025[14]) which are within the range of the activity of the compound III in this study.

Such comparisons not only confirm our laboratory findings, but also increase the pharmacological evidence base of marine natural products, with particular focus on the translational potential of these compounds in oncology.

Table 4: Comparison of current study findings with existing research on marine-derived anticancer agents

Author's Name	Compound/Analogue Tested	Reported Efficacy in Previous Studies	Current Study Findings	Comparative Note
Ullah et al., 2022[11]	Fucoidan (natural)	30–50% tumor growth inhibition in murine models	Fucoidan analogue I showed similar inhibition range	Confirms fucoidan's reproducible anti-tumor profile
Zuo & Kwok, 2021[15]; Wang et al., 2020[13]	Salinosporamide A	Strong proteasome inhibition and tumor suppression in vivo	Salinosporamide-mimic II showed superior tumor-suppressive activity	Extends therapeutic relevance of proteasome-targeting agents
Vinchurkar et al., 2025[12]; Zhang et al., 2025[14]	Halichondrin B derivatives	40–60% inhibition in solid tumor models	Compound III mirrored similar inhibition levels	Supports prior evidence on halichondrin derivatives' cytotoxicity

4.3. Implications of Findings

The exemplified effectiveness of these compounds supports the pharmacognostic significance of marine bioresources in the field of anti-cancer drug discovery. Remarkably, salinosporamide-mimic II is a lead candidate salinosporamide-mimic that is well tolerated with potent activity making it a good candidate to be further developed preclinically. The modest but significant efficacy of the fucoidan analogue I and the halichondrin-derived III indicates that they may be used in combination regimens, where combination effects may increase therapeutic efficacy. In pharmacognosy terms, these findings confirm the idea that structurally distinctive marine natural products are an untapped and rich source of anti-cancer agents.

4.4. Limitations of the Study

The present study has limitations. First, a single-dose regimen cannot provide an in-depth knowledge of dose-response or therapeutic windows. Second, the trial was aimed at short-term outcomes like tumor volume and histopathological indices; there was no long-term follow-up of survival and metastasis. Third, the mechanistic knowledge is incomplete because no molecular biomarkers (e.g., apoptosis markers, proteasome activity assays, or immune profiling) were assessed. Lastly, the use of compound analogues as opposed to native marine compounds could

be a source of variability to the activity profiles and therefore direct comparison to naturally occurring molecules may be limited.

4.5. Suggestions for Future Research

Future research is to fill these limitations by:

- Carrying out dose-ranging studies to determine best therapeutic indices.
- Lengthy survival, recurrence, and metastasis outcomes.
- The integration of molecular assays to explain mechanisms of action, such as induction of apoptosis, inhibition of angiogenesis, and modulation of the immune system.
- Examining combination treatments between marine-derived compounds with different mechanisms to assess possible synergy.
- Testing in other tumor models, e.g. melanoma, lung carcinoma, hematological malignancies, to determine a wider applicability.

5. CONCLUSION

5.1. Summary of key findings

The current research showed that marine-derived bioactive compounds: Fucoidan, Salinosporamide and Halichondrin had considerable antitumor effects in mice bearing Ehrlich Ascites Carcinoma (EAC). Salinosporamide exhibited the strongest effect, which was manifested through the largest decrease in tumor volume, the mitotic index, and microvessel density, as well as the largest necrosis percentage. Halichondrin strongly trailed efficacy and Fucoidan showed moderate activity.

5.2. Significance of the Study

These results indicate the therapeutic value of marine-derived products as new anticancerous agents. The histopathologic gains and decrease in tumor burden indicate that these compounds may be used as potential alternatives or adjuncts to standard chemotherapy, and potentially with less toxicity profiles.

5.3. Final thoughts or Recommendations:

It is suggested that further experiments should be made with a bigger sample size, mechanistic assessments, and molecular pathway analysis to confirm these findings and clarify the precise mechanisms of action. Such results have a potential of being translated clinically to lead to the development of anticancer therapeutics using marine species.

REFERENCES

1. Ahmad, M., Tahir, M., Hong, Z., Zia, M. A., Rafeeq, H., Ahmad, M. S., ... & Sun, J. (2025). Plant and marine-derived natural products: sustainable pathways for future drug discovery and therapeutic development. Frontiers in Pharmacology, 15, 1497668.
2. Aljabali, A. A., Bashatwah, R. M., El-Tanani, M., & Tambuwala, M. M. (2025). Natural anticancer drugs: efficacy, safety, and future challenges. Current Medicinal Chemistry.

3. Banday, A. H., ul Azha, N., Farooq, R., Sheikh, S. A., Ganie, M. A., Parray, M. N., ... & Lone, M. A. (2024). Exploring the potential of marine natural products in drug development: A comprehensive review. Phytochemistry Letters, 59, 124-135.

4. Barreca, M., Spanò, V., Montalbano, A., Cueto, M., Díaz Marrero, A. R., Deniz, I., ... & Bertoni, F. (2020). Marine anticancer agents: An overview with a particular focus on their chemical classes. Marine drugs, 18(12), 619.

5. Bisaria, K., Sinha, S., Srivastava, A., & Singh, R. (2020). Marine pharmacognosy: an overview of marine-derived pharmaceuticals. Marine Niche: Applications in Pharmaceutical Sciences: Translational Research, 361-381.

6. Chaudhry, G. E. S., Md Akim, A., Sung, Y. Y., & Sifzizul, T. M. T. (2022). Cancer and apoptosis: The apoptotic activity of plant and marine natural products and their potential as targeted cancer therapeutics. Frontiers in pharmacology, 13, 842376.

7. Dalisay, D. S., Tenebro, C. P., Sabido, E. M., Suarez, A. F. L., Paderog, M. J. V., Reyes-Salarda, R., & Saludes, J. P. (2024). Marine-derived anticancer agents targeting apoptotic pathways: Exploring the depths for novel cancer therapies. Marine Drugs, 22(3), 114.

8. Dayanidhi, D. L., Thomas, B. C., Osterberg, J. S., Vuong, M., Vargas, G., Kwartler, S. K., ... & Somarelli, J. A. (2021). Exploring the diversity of the marine environment for new anti-cancer compounds. Frontiers in Marine Science, 7, 614766.

9. Liu, Y., Zhou, Z., & Sun, S. (2024). Prospects of marine-derived compounds as potential therapeutic agents for glioma. Pharmaceutical Biology, 62(1), 513-526.

10. Parveen, B., & Narayanan, M. (2025). Enhancing cancer treatment with marine algae–derived bioactive chemicals: a review. Naunyn-Schmiedeberg's Archives of Pharmacology, 1-13.

11. Ullah, R., Rehman, N. U., Jamshidi-Adegani, F., & Bari, A. (2022). Medicinal plants and marine-derived natural products as cancer chemopreventive agents. Frontiers in pharmacology, 13, 900275.

12. Vinchurkar, K., Mane, S., Gupta, D., Sakalle, N. S., & Saxsena, N. K. (2025). Marine World of Terpenes Targeting Specific Cancers: Exploring the Anti-Cancer Potential of Marine-Derived Terpenes. In Analyzing Terpenes' Role in Cancer Treatment (pp. 269-298). IGI Global Scientific Publishing.

13. Wang, E., Sorolla, M. A., Gopal Krishnan, P. D., & Sorolla, A. (2020). From seabed to bedside: A review on promising marine anticancer compounds. Biomolecules, 10(2), 248.

14. Zhang, T., Ouyang, Z., Zhang, Y., Sun, H., Kong, L., Xu, Q., ... & Sun, Y. (2025). Marine Natural Products in Inflammation-Related Diseases: Opportunities and Challenges. Medicinal Research Reviews.

15. Zuo, W., & Kwok, H. F. (2021). Development of marine-derived compounds for cancer therapy. Marine drugs, 19(6), 342.