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A Review of Sudanese Medicinal Plants with Apoptosis-Inducing Activity Against Cancer Cell Lines

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Abstract

Cancer remains a leading cause of morbidity and mortality worldwide, with rising incidence rates posing significant challenges to global healthcare systems. In African countries such as Sudan, limited funding and inadequate medical resources further complicate cancer management. The drawbacks of conventional therapies—including high costs, severe side effects, and the emergence of drug resistance—have driven researchers to explore alternative treatment options, particularly those derived from traditional medicinal plants.

This review aims to identify potential anticancer plants for drug development by summarizing their anticancer activities and mechanisms of action, specifically focusing on those that induce apoptosis through caspase activation, the mitochondrial pathway, and regulation of Bcl-2 family proteins. A comprehensive literature search was conducted using major scientific databases, including PubMed, Scopus, ScienceDirect, and Google Scholar, resulting in the analysis of 176 peer-reviewed publications containing ethnomedicinal data. The review identified 38 plant species belonging to 18 botanical families. Fabaceae (Leguminosae) and Asteraceae were the most represented families, each comprising 18.24% and 13.16% of total species, followed by Combretaceae and Cappariaceae (10.53%), and Malvaceae (7.89%). Among the cancer cell lines investigated, breast cancer was the most frequently studied (28 %), followed by colon (16 %), liver (14 %), and prostate (9.3%). All identified plants demonstrated *in vitro* anticancer activity, while eight species were further validated

through in vivo studies. Additionally, eleven predominantly phenolic compounds were isolated from these plants and tested against various cancer cell lines, showing promising cytotoxic effects. The integration of traditional medicine with modern research methodologies not only validates the therapeutic potential of Sudanese medicinal plants but also underscores their role in addressing global health challenges, particularly in cancer treatment and drug discovery.

Keywords

Sudanese Medicinal Plants; Anticancer Activity; Apoptosis; Caspase activation; Drug discovery; Phenolic compounds

Introduction

Cancer is the life threatening and dreadful disease characterized by the abnormal proliferation of cells that invade the adjacent tissues and cause the destruction of these tissues. It is the second leading cause of death all over the world. More than six million deaths each year occurring in the world are due to cancer. Several lines of evidence indicated that tumorigenesis in humans is a multistep process and these steps reflect genetic alterations that drive the progressive transformation of normal human cells into highly malignant derivatives (Maroyi, 2013) However, cancer is a major public health burden in both developed and developing countries. By 2020, the global cancer burden had risen to an estimated 19.3 million new cases and 10.0 million deaths. It is estimated that 1 in 5 people worldwide will develop cancer during their lifetime, with 1 in 8 men and 1 in 11 women dying from the disease. For the first time, female breast cancer became the most commonly diagnosed cancer globally, with 2.3 million new cases, surpassing lung cancer (IARC,2020), (Sung et., al.2021). Looking ahead, the number of new cancer cases is projected to reach 28.4 million annually by 2040, a 47% increase from 2020 figures. This rise is expected to be especially pronounced in countries with low and medium Human Development Index (HDI), where increases of 95% and 64%, respectively, are anticipated (WHO) (2021).

Treating cancer has become a major challenge as there is no single effective treatment that works for all types of cancer. Most of conventional chemotherapy regimens which employ different combinations of cytotoxic drugs which are often associated with serious side effects and chemoresistance. Conventional therapy has also become less favorable in the mindset of sufferers and as a result many patients resort to seeking alternative treatments (Bray et., al. 2013). The resistance of metastatic cancerous cells to chemotherapy and its adverse effects has become a serious challenge in cancer research. Despite the intensive progress in chemotherapeutics in the last decades, the need to discover and to develop new, alternative, or adjuvant therapeutic agents remains urgent

necessity. Conventional treatment chemotherapy could cause adverse and toxic side effects on normal cells while curing cancer and therefore fails to control the disease. The alternative solution for the harmful effects of synthetic agents is the use of natural plants, which provide outstanding contribution to modern therapeutics (Chorawala et. al., 2012). Cancer remains a major public health burden worldwide, including in Sudan, where limited access to conventional treatments has increased reliance on traditional medicine. The use of medicinal plants for cancer therapy in Sudan is deeply rooted in cultural practices (Elnour et., al. 2018). Recent scientific studies have shown that several Sudanese plants exert anticancer effects, particularly through apoptosis induction—a key mechanism for eliminating cancer cells without harming normal tissues (Mohamed et al. 2015).

Apoptosis, or programmed cell death, is often dysregulated in cancer cells, making it a vital target for therapy. Natural products are considered promising agents because many are known to modulate apoptotic pathways such as the activation of caspases, modulation of Bcl-2 family proteins, and mitochondrial membrane potential disruption (Marc et. Al.,2024)

Botanicals have long been used traditionally in treatment of various types of cancers (Sultana et., al. 2014) and often less associated with the side effects like the modern chemotherapy (Cragg & Newman 2005). Many chemicals in our environment can cause genetic mutations and are potentially responsible for millions of cancer-related deaths (Park & Pezzuto 2002). Nowadays the scientists are looking for food materials which can potentially prevent the cancer occurrence. Realizing the potential benefits of botanicals as a source of active anticancer compounds, the National Cancer Institute (U.S.A) collected about 35,000 plant samples from 20 countries and has screened around 114,000 extracts for anticancer activity (Shoeb 2006). Out of the 92 anticancer drugs marketed prior to 1983 in US and among the ones sold worldwide between 1983 and 1994, 60% are of natural origin (Newman & Cragg 2012). This includes natural products, derivatives of natural products or semi-synthetic pharmaceuticals based on natural products models (Jaspars & Lawton, 1998). Therefore, this review aims to summarize Sudanese medicinal plants that have shown apoptosis-inducing activity against various cancer cell lines, providing insight into their potential as leads for novel anticancer agents.

Methodology

An extensive literature review was conducted utilizing multiple scientific databases, including SciFinder, PubMed, Scopus, Web of Science, ScienceDirect, Google Scholar, and other relevant platforms. This comprehensive approach ensured a thorough examination of existing research and facilitated the identification of pertinent studies related to the topic.

Results and Discussion

The selection of medicinal plants in this review was guided by their traditional use in treating cancer and their demonstrated bioactive properties in *in vitro* studies against cancer cells. This approach highlights the importance of integrating ethnobotanical knowledge with modern scientific methodologies to identify potential therapeutic agents. The survey included studies conducted on domestic plants from Sudan by Sudanese researchers, as well as investigations on the same plants conducted in other countries. This was necessitated by the limited availability of research resources in Sudan, which often restricts comprehensive local studies.

A total of 38 plant species were analyzed, spanning 18 families. The findings indicate that the **Fabaceae** and **Asteraceae** families are significant in the context of Sudanese medicinal plants. Each family contributes 18.24% and 13.16% to the total species analyzed, showcasing their importance in local traditional medicine. Following these, the **Capparidaceae** and **Combretaceae** families each represent 10.53% of the species. While these families are prominently used in Sudan, their presence is not limited to this region, many plants from these families are recognized for their anticancer properties and are utilized in various cultures around the world (Fig. 1).

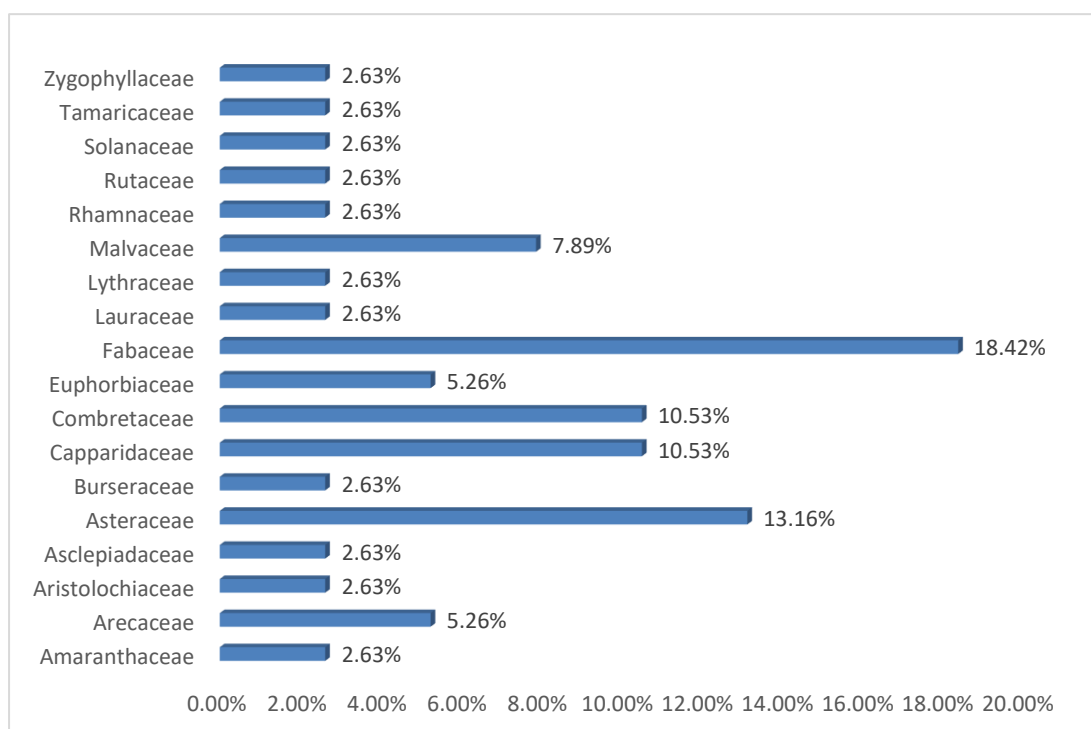


Fig. 1: Plant families which used in the reviewed studies%

In this review, fruits, seeds and whole plants were traditionally the most commonly exploited parts due to their concentrated bioactive compounds. However, leaves have emerged as the predominant plant part used in recent studies (Fig. 2). This shift may be attributed to the high abundance of bioactive molecules in leaves, their ease of collection, and their renewable nature, which makes them a more sustainable resource for research and therapeutic applications.

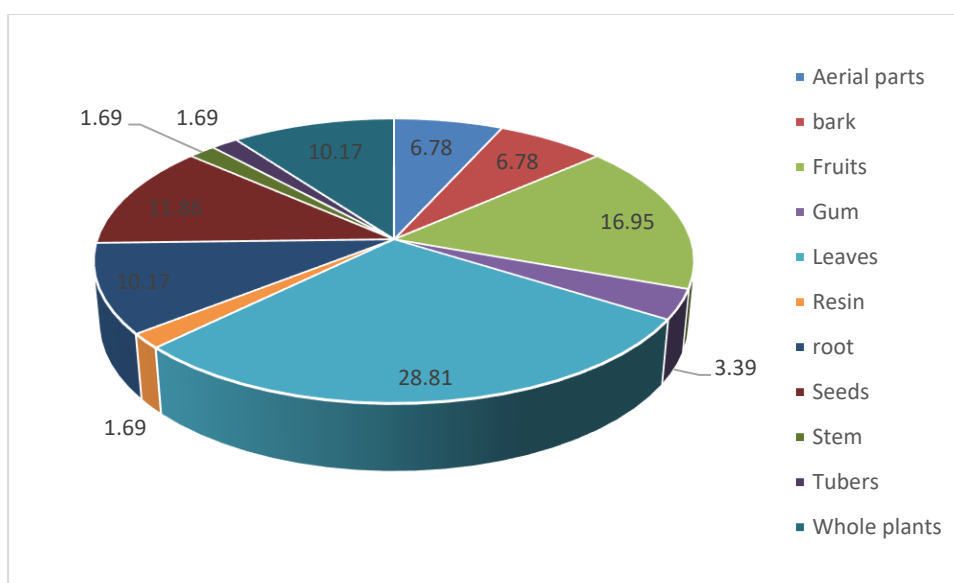


Fig.2: Distribution of plant parts used in reviewed studies

Breast cancer cell lines are the most extensively studied, accounting for approximately 28 % of research efforts. This predominance is attributed to the wide availability and detailed characterization of lines such as MCF-7, which is estrogen receptor-positive and widely used to explore hormone sensitivity, and MDA-MB-231, a triple-negative line employed to study aggressive and metastatic breast cancer behaviors (Holliday & Speirs, 2011; Subik et al., 2010). Colon cancer lines, such as HCT-116 and Caco-2, constitute 16% of the examined studies, These models are instrumental in elucidating colorectal cancer progression and in vitro permeability assays (Soler et al., 1994; Brattain et al., 1981). Liver cancer represented 14.7% of the studies, with HepG2 being the most frequently utilized model for hepatocellular carcinoma, these cells serve as a cornerstone for evaluating hepatotoxicity and investigating molecular mechanisms of liver tumorigenesis (Donato et al., 2015). Cervical cancer cell lines make up 6.7% of the research, with HeLa—one of the earliest human cell lines established—and SiHa being commonly employed. These lines are essential in virology, particularly in studying the role of human papillomavirus (HPV) in cervical carcinogenesis (Henle & Henle, 1943; Hopman et al., 2004). (Fig. 3).

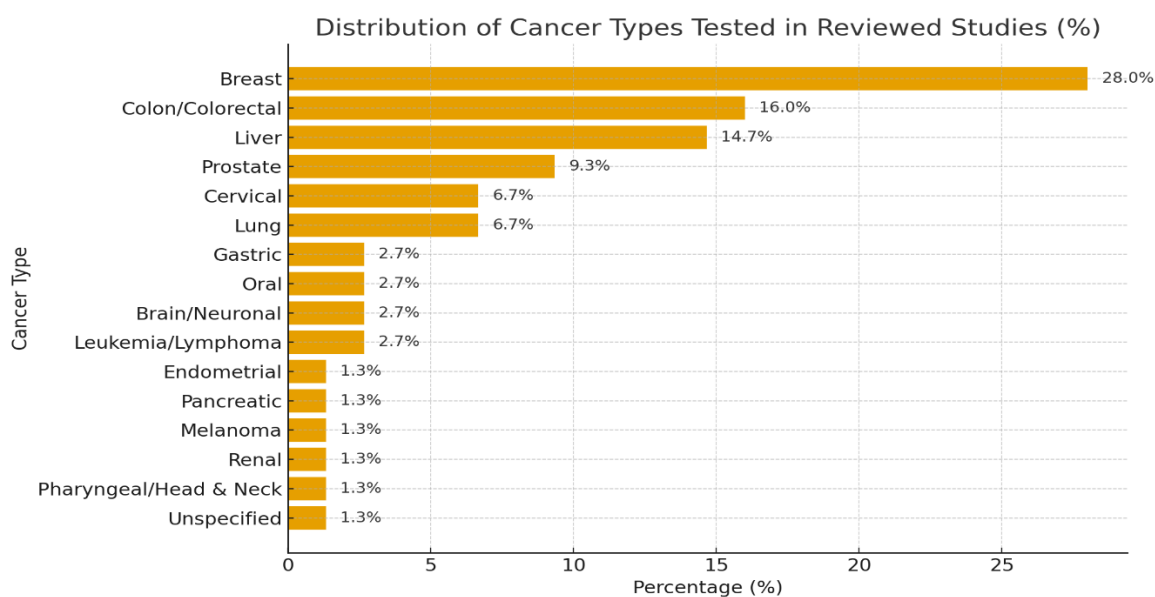


Fig. 3: Distribution of cancer cell lines used per cancer type

The findings emphasize the potential of Sudanese medicinal plants as a valuable source of anticancer agents. Their bioactive compounds, such as alkaloids, flavonoids, phenolics, and terpenoids, have shown promising results in inhibiting cancer cell growth through mechanisms like DNA damage and the activation of apoptosis-inducing enzymes.

The results also organized to first present the plant species and their respective parts or compounds, followed by the cancer cell lines tested, the type of extract or compound used, the IC_{50} values that indicate the potency of these extracts, and finally, the activity results, including any relevant mechanisms of action observed in the studies. This structured overview aims to provide a comprehensive understanding of the efficacy of these plant-derived compounds in combating cancer, setting the stage for further discussion on their potential therapeutic applications. Moreover, the study highlights the need for collaborative efforts between local and international researchers to overcome resource limitations and expand the scope of medicinal plant research in Sudan. By leveraging traditional knowledge and modern scientific techniques, these plants can be further explored for their pharmacological properties, paving the way for the development of novel, plant-based anticancer therapies.

Anticancer Activity of *Persea Americana*

The seed extracts, fractions (particularly fraction F3), and isolated compounds of *Persea americana* (avocado) (family Lauraceae) demonstrated significant cytotoxic effects against MCF-7 (breast cancer) and HepG2 (hepatocellular carcinoma) cell lines, while exhibiting minimal cytotoxicity toward normal African green monkey kidney cells. The isolated triterpenoid showed high anticancer activity, indicating its potential for further development as an anticancer agent (Abubakar et., al. 2017).

Lipid extracts from both the fruit and seed of *P. americana* significantly inhibited the proliferation of HepG2 and HCT116 (colon cancer) cells, with seed lipids demonstrating greater potency than fruit lipids. The IC₅₀ values of seed extracts were lower than those of the fruit and even lower than the standard drug sorafenib. Phytochemicals derived from *P. americana* have been shown to induce cell cycle arrest and apoptosis (D'Ambrosio et., al. 2011). This enhanced activity is attributed to strong free radical scavenging abilities and a high content of hydrocarbons, sterols, and oleic acid. However, its traditional use in ethnomedicine for tumor management suggests a promising therapeutic potential (Alkhalaf et., al. 2018).

Anticancer Properties of *Hibiscus sabdariffa*

Hibiscus sabdariffa L. (Malvaceae), cultivated widely in Sudan and Taiwan, exhibited notable cytotoxic and apoptotic effects on AGS (gastric carcinoma) cells in a concentration-dependent manner, while having minimal impact on normal Chang liver cells (Lin et., al. 2007). Methanolic extracts of *H. sabdariffa* showed high cytotoxicity against PC3 (prostate cancer) cell lines, attributed to its antioxidant potential (Elnour et., al. 2017). While extracts from the fruit in ethanol, ethyl acetate, and hexane showed weak cytotoxicity against A549 (lung cancer) cells (IC₅₀ values: 374.01, 719.28, and 906.57 µg/mL, respectively) (Fithrotunnisa et., al. 2020), aqueous extracts of *H. sabdariffa* selectively inhibited the growth of MCF-7 cells in a concentration- and time-dependent manner (Khaghani et., al. 2011). This activity is likely due to the presence of bioactive phytochemicals including anthocyanins, flavonoids, and polyphenols (Ali et., al. 2005), (Wang & Stoner 2008), which have known as anticancer properties.

Notably, β-sitosterol and ergosterol isolated from *H. sabdariffa* possess estrogen-modulating activity. Ergosterol has demonstrated apoptotic activity against MCF-7 cells (Arellano et., al. 2004), while β-sitosterol significantly reduced estrogen-induced tumor formation in MCF-7 xenograft mouse models and lowered serum estrogen levels (Lin et., al. 2007) This suggests potential for *H. sabdariffa* in managing hormone-dependent cancers.

Leaf extracts of *H. sabdariffa* also exhibited anticancer activity. Wound-healing and transwell assays revealed that these extracts inhibited migration and invasion of LNCaP (prostate cancer) cells in a dose-dependent manner at non-cytotoxic concentrations (Chiu et., al. 2015). Furthermore, gossypetin, a flavonoid isolated from *H. sabdariffa*, inhibited proliferation, migration, and invasion of oral squamous cell carcinoma (OSCC) cells, and induced apoptosis and cell cycle arrest, indicating its potential as a chemopreventive agent (Huang et., al. 2023).

Cytotoxic Effects of *Citrus medica*

Methanolic leaf extracts of *Citrus medica* (family Rutaceae), showed dose-dependent cytotoxicity against MCF-7 cells, with an IC_{50} value of 60.04 $\mu\text{g/mL}$ at 48 hours (Indira et., al. 2023). Additionally, chloroform extracts of the fruit peel exhibited strong cytotoxic effects against FaDu (hypopharyngeal cancer) and astrocytoma cell lines, showing 83.3% and 50% inhibition in half-ripe and ripe fruit extracts, respectively (Jayaram et., al., 2024). During MTT, human astrocytoma cell line revealed to have a meaningful cell death when compared with controls ($P < 0.01$) with value equal to 83.3% and 50% in half-ripe and ripe respectively (Entezari et., al. 2009).

Other promising medicinal plants with Anticancer Potential

Tree Sudanese plants commonly used in traditional medicine—*Sonchus oleraceus* (family Asteraceae), *Halexylon salicornietum* family Amaranthaceae, and *Prosopis juliflora* (The Fabaceae or Leguminosae) —were evaluated for their anticancer activity against PC3 cells. Among them, *P. juliflora* exhibited the highest cytotoxicity, the effect attributed to their strong antioxidant properties (Elnour et., al. 2017). Additionally, methanolic extracts of *P. juliflora* leaves were highly effective against HeLa (cervical cancer) cells ($IC_{50} = 56.02 \mu\text{g/mL}$) (Montasir et., al. 2018). Also inhibitory effect of various extracts from *S. oleraceus* on the growth of NCI-N87 (MTT assay). Represented by EtOH extract against stomach cancer cells. The maximal inhibition of cell growth was 65.0% compared to 96.5% for paclitaxel at the same concentration of 100 $\mu\text{g/ml}$ (Yin et., al. 2007).

Members of the Combretaceae family—including *Combretum aculeatum*, *Combretum hartmannianum*, and *Anogeisus leiocarpus*—were assessed for their (in vitro) anticancer activity against HepG2 and MCF-7 cells. Petroleum ether extracts of *C. hartmannianum* roots showed the most potent activity, with IC_{50} values of 5.4 $\mu\text{g/mL}$ (HepG2) and 1.9 $\mu\text{g/mL}$ (MCF-7), while leaf extracts also showed moderate effects (Hamid et., al. 2014). Hassan et., al. (2014) confirmed significant antiproliferative effects of the leaves and stem bark on HCT116 and MCF-7 cells. Other promising medicinal plants (*Nicotiana glauca* family Solanaceae., *Tephrosia apollinea* family Fabaceae, and *Tamarix nilotica*, Family. *Tamaricaceae*) showed potent anticancer effects against MCF-7 and HCT116 cell lines. IC_{50} values for *N. glauca* were 10.78 $\mu\text{g/mL}$ (MCF-7) and 5.4 $\mu\text{g/mL}$

(HCT116), while for *T. apollinea* they were 29.36 $\mu\text{g}/\text{mL}$ and 20.2 $\mu\text{g}/\text{mL}$, respectively—comparable to reference drugs tamoxifen ($\text{IC}_{50} = 6.67 \mu\text{g}/\text{mL}$) and 5-fluorouracil ($\text{IC}_{50} = 3.9 \mu\text{g}/\text{mL}$) (Hassan et., al. 2014). The methanolic extract of *Artemisia absinthium* L.(Asteraceae family) exhibited cytotoxicity on DLD-1 (colon cancer) and ECC-1 (endometrial cancer) cells. The effect was linked to the generation of intracellular free radicals, leading to DNA damage and apoptosis. In contrast, cytotoxicity on normal HEK-293 cells was low (Koyucu 2018). Also isolated artemisinin and *A. absinthium* extract has a significant impact on the growth of HSC-3 cells. Specifically, a concentration of 10 μM of artemisinin resulted in a 64% reduction in cell growth and increased the expression of Caspase 3 and 9 almost six and two times, respectively. Furthermore, a significant reduction of Bcl-2 expression was observed. Similarly, the extract at 2000 $\mu\text{g}/\text{mL}$ exhibited a remarkable 99% decrease in viability of HSC-3 cells . Moreover, the expression of Caspase 3 and 9 was increased more than 10 times compared to control cells, while the expression level of Bcl-2 was reduced by over 50%. The IC_{50} of artemisinin, according to the dose-dependent results in HSC-3 cells, is 1.83 μM , and of *A. absinthium* 134.29 $\mu\text{g}/\text{mL}$. (Tsamesidis et. Al.,2024)

Other plants belong to Capparidaceae family

***Maerua pseudopetalosa* (Gilg and Bened.) De Wolf**

The plant tubers are traditionally used in Sudan as an antitumor agent, research has demonstrated cytotoxic effects against cancer cell lines (MCF-7 breast cancer cell line). Specific fractions of the plant showed remarkable activity, with one fraction (F12) displaying a cytotoxic concentration of 43.51 $\mu\text{g}/\text{g}$ after 72 hours of exposure (Ibrahim & Ramadan 2019). The anticancer properties of *M. pseudopetalosa* are attributed to its rich phytochemical profile, which includes phenolic compounds and flavonoids. High-performance liquid chromatography (HPLC) analysis has identified several bioactive compounds, such as gallic acid and sinapic acid, which are known for their antioxidant and anticancer activities (Ibrahim & Ramadan 2019). While specific mechanisms are still being explored, the presence of compounds like proline-N-methyl-butyl ester suggests that *M. pseudopetalosa* may inhibit cancer cell growth through various pathways, including the induction of apoptosis and the inhibition of cell proliferation. The query highlights the traditional use of *M. pseudopetalosa* tubers in Sudanese folk medicine for treating tumor growth, despite a lack of knowledge regarding their chemical constituents. (Ibrahim and Elnor 2015). Overall, although traditional knowledge of *M. pseudopetalosa* is deeply rooted in local communities, scientific research is now starting to reveal the chemical constituents that may account for its reported effectiveness in treating tumors.

***Capparis decidua* (Forssk) Edgew**

Stachydrine, an alkaloid isolated from *Capparis decidua*, was evaluated for its anti-metastatic activity against PC3 and LNCaP prostate cancer cells. It significantly inhibited the expression of chemokine receptors CXCR3 and CXCR4 in a dose-dependent manner, as confirmed by RT-PCR and protein assays, suggesting its potential as an anti-metastatic agent (Rathee et., al. 2012).

Recent studies utilizing gas chromatography-mass spectrometry (GC-MS) and molecular docking have identified several compounds in *Capparis decidua* seed oil that exhibit strong binding affinities to cancer-related proteins, suggesting their potential as effective anticancer agents. These studies highlight the importance of further exploration into the molecular mechanisms underlying these effects (Dafa Allah et., al. 2023).

Capparis spinosa

Research has demonstrated that *Capparis spinosa* extracts can effectively decrease the viability of cancer cells in vitro. For instance, studies using the MTT assay have shown that these extracts significantly inhibit the growth of cancer cell lines while having a lower impact on normal cells. Extracts from *C. spinosa* have been shown to induce apoptosis in various cancer cell lines, including HeLa (cervical cancer), MCF-7 (breast cancer), and HepG2 (liver cancer). This is achieved by increasing the activity of caspases (caspase-8 and caspase-9) and downregulating anti-apoptotic proteins like Bcl-2. The MTT assay test was performed on HeLa, MCF7 and Saos cancer cell lines. According to the results, the hydroalcoholic extract was toxic on three cell lines and it could be inferred that CS extract can prevent cancer cell growth in low concentrations (Moghadamnia et., al.2019) . Additionally, fruit extract significantly reduced breast cancer cell viability at concentrations ≥ 0.05 , highlighting its potential cytotoxic effect (Salih et., al. 2020).

Boscia senegalensis

The aqueous methanolic extract of *B. senegalensis* exhibited moderate antitumor activity against three cancer cell lines: HepG2 (IC₅₀ = 24.6 $\mu\text{g/mL}$), MCF-7 (IC₅₀ = 22.5 $\mu\text{g/mL}$), and HCT (IC₅₀ = 40.3 $\mu\text{g/mL}$) (Ahmed et., al. 2019). These effects are attributed to the synergistic interaction of phenolic compounds, particularly flavonoids such as kaempferol and quercetin, which have demonstrated efficacy against various cancer cell lines (Carocho & Ferreira 2013). The ethanolic extract of *B. senegalensis* leaves showed significant cytotoxicity against melanoma skin cancer (RPMI 7951), with observable morphological changes indicating cytotoxic effects on the cell wall and DNA, thereby affecting cell communication and growth) (Hamad et., al. 2024). GC/MS analysis revealed the presence of oleic acid, which induces apoptosis and necrosis through mitochondrial depolarization and lipid accumulate (John-Fernada 2005). Additionally, D-allose—a rare sugar—was identified, known for its anti-proliferative and pro-apoptotic effects in ovarian cancer models (Sui et.,

al. 2005) Tramadol and other pharmacologically active compounds were also detected, suggesting potential for *B. senegalensis* as a therapeutic candidate for intestinal tumors (Ibrahim & Musa 2021).

Remarkable Sudanese medicinal plants with apoptosis- inducing potential.

Trigonella foenum-graecum

Fenugreek, or *Trigonella foenum-graecum* (Leguminaceae family) is a leguminous plant that has long been used in traditional medicine. Recent research has pointed to its possible cytotoxic and anti-carcinogenic effects which have provided the interest to study it in cancer studies.

The resazurin assay of various tumors indicated *T. foenum-graecum* to be the most active crude extracts. (Mohamed et., al. 2015). The cytotoxic effect of fenugreek extracts on MCF-7 cells has been demonstrated as resulted in the reduced cell viability and the increased apoptotic markers, The MTT assay showed that the ethanol fenugreek extract had more than half of the inhibitory effect against MCF-7 cell. (Al-Timimi, 2019). Research has shown that the growth of HepG2 cells could be reduced by fenugreek, and the process was accompanied by the increase in p53 and other proapoptotic pathways (MTT assay) (Khalil et., al. 2015). Recent studies have led to the formulation of nanoparticles of the fenugreek extracts in order to enhance their bioavailability and effectiveness against cancer cells. These compounds have been demonstrated to have effective outcomes in augmenting the cancer killing action of both estrogen receptor positive and triple negative breast cancer cell lines (Islam et., al.2023). Alcoholic extract of fenugreek has been observed to be cytotoxic to IMR-32 cell line of neuroblastoma and also HT-29 cell line of colorectal cancer in vitro (Verma 2010). In their research study, Sebastian and Thanpan (2007) demonstrated that MCF-7 cells, a cell line of breast cancer, showed a reduction in cell viability and premature apoptotic phenotypes in case it was exposed to ethanol extract of fenugreek. Another study examined the impact of methanolic fenugreek extract on in vitro with breast cancer cell lines (MCF-7 and SK-BR3) and thereafter an oral acute toxicity experiment was done in a Swiss albino mice model (Alrumaihi 2021). The findings revealed that the fenugreek extract acted in a dose-dependent fashion and showed anti-metastatic effect, cell migration inhibitory effect as well as enhanced late apoptosis in the two cancer cell lines. The data showed that the p53 was upregulated, which implies that the fenugreek effect is linked to the pathway that prevents the additional DNA mutations and that leads to the cell death. In vivo acute toxicity results indicated that the oral treatment of mice with fenugreek extract did not cause any toxicity. Further research was done to examine the anticancer effects of germinated fenugreek seed extract. The research by Almalki and Naguib (2021) used BXPC-3 pancreatic cancer cell line and albino mice. The results exhibited that the aqueous germinated fenugreek seed extract was effective against BXPC-3 cell lines with a value of 25 µg/mL IC50. The in vivo histopathological examination

revealed that pancreatic tissue from the fenugreek-treated group exhibited significantly healthier morphology with markedly fewer lesions compared to the untreated group. Additionally, the survival rate was higher among the treated mice.

Fenugreek extracts are proved to cause apoptosis (programmed cell death) in cancer cells. This is mainly due to its active compounds which include diosgenin and trigonelline. Diosgenin is a steroidal saponin which has been found to suppress cell growth and cause apoptosis in cancerous cells. It has been shown that diosgenin has the potential to decrease the activity of anti-apoptotic proteins such as Bcl-2 as well as increase the activity of pro-apoptotic proteins such as caspase-3 resulting in the effect of programmed cell death of cancer cells(Alsemari et., al. 2014), (Shabbeer et., al. 2009).

Trigonelline which is also another important compound in fenugreek has demonstrated the ability to slow the development of tumors as well as increase the effectiveness of traditional cancer therapies. It has antioxidant effects that could protect normal cells but have a cytotoxic effect on cancer cells (Srinivasan 2006), (Wani & Kumar 2018).

Fenugreek extracts have been demonstrated to induce apoptosis in cancer cells through multiple mechanisms, including the mitochondrial pathway—characterized by the release of cytochrome c and subsequent activation of caspases. (Ahmed and Al-Harbi 2022), (Bhatia et., al. 2006), In vivo tumor tests in animal models can be prevented by using fenugreek extracts (Al-Timimi , 2019). By implying its possible use as an adjunct treatment in the management of cancer as it has a capability of selectively targeting cancer cells and sparing healthy cells, the side effects that are common in chemotherapy with conventional means of treatment are minimized (Khoja, 2022).

Lawsonia inermis

As it was demonstrated in vitro, extracts of *L. inermis* cause apoptosis in several cancer cell lines of the human body. *Lawsonia inermis* was the most active crude extracts, which was demonstrated by the resazurin assay on various tumors. (Mohamed et., al. 2015). Methanol extract of leaf of Mehndi/Henna also demonstrated high cytotoxicity on HepG2 showing IC50 playing 24 ug/mL in MTT assay (Rahmat et al., 2006). The extract of Mehndi leaves was found to have cytotoxicity on HepG2 and MCF-7 (hormone-dependent breast cancer cell line) with IC50 of 0.3 and 24.8 ug/mL, respectively (Roshnah et al.,1998) 1. Mehndi/Henna extract on c-myc gene expression was also investigated and it was noted that the gene was not expressed in cell (HepG2 and MCF-7) treated with 20 and 30mu/ml of crude extract (Endrini et al., 2007).The c-myc gene is an early response gene during cell proliferation and has been found to be often over expressed in many different tissues and cultured cancer cell lines (Saito et al., 1991). Based on the study, it was concluded that the effect of cytotoxicity was through the down regulation of c-myc expression and it was also noted that the

extracts did not produce any activity on normal, Caco-2 (colon cancer) and MDA-MB-231 (breast cancer) cell lines (Endrini et al., 2007). A 12-day in vivo study on a 0.3% aqueous solution of mice revealed that the progress of Ehrlich Ascites Carcinoma was inhibited, GSH and SOD levels were elevated which implied that apoptosis was promoted by oxidative action (Ozaslan et al., 2009). Methanolic extract of Mehndi root was able to produce anti-tumor effects in Swiss albino mice, which prolonged the life of DLA tumor bearing mice and also improved antioxidant status and lipid profiles (Priya et al., 2011). On the same note, Rosh Jahannam et al., (1998) conducted an in vivo experiment which found out that Henna prevents chemical induced hepatocarcinogenesis in rat model.

The anti-carcinogenic activity of the Mehndi leaf extract was tested in skin papillomagenesis model and exhibited dual-acting quality. It caused phase II enzyme functions related to carcinogen detoxification and phase I enzyme activity suppression resulting in the substantial inhibition of tumor burden and decreased tumor incidence (Dasgupta et al., 2003).

Croton zambesicus

Dichloromethane extracts and fractions of *C. zambesicus* (Euphorbiaceae family) were assessed via the MTT assay. A trachylobane diterpene, ent-trachyloban-3 β -ol, isolated from the leaves exhibited cytotoxicity against HeLa cells (IC₅₀ = 7.3 mg/mL), indicating apoptosis induction (Block et., al. 2002). The root extract of *Croton zambesicus* has demonstrated significant anticancer activity against HeLa cells (a cervical cancer cell line). The hexane fraction of the root extract exhibited the most pronounced effect, suggesting the presence of potent bioactive compounds.(Okokon et al.,2013)

Research indicates that extracts from *Croton zambesicus* exhibit significant cytotoxic activity against various cancer cell lines, particularly HeLa cells (cervical cancer). The root extract and its fractions have shown promising results, with the hexane fraction demonstrating the most pronounced anticancer effects. Studies have investigated the interaction of the extracts with DNA, although the extracts did not show significant interaction with yeast DNA in electrophoresis assays. This suggests that the anticancer effects may not be directly related to DNA binding but could involve other pathways (Okokon et al.,2013). The seed extract of *C. zambesicus* has shown strong antioxidant activity, particularly in the methanolic extract, which exhibited high DPPH free radical scavenging activity (83.21 \pm 0.05) (Ibrahim et.,al. 2015, 2022). This antioxidant property is crucial because oxidative stress plays a significant role in cancer development. While the specific anticancer activity of *Croton zambesicus* seed extract against cancer cell lines is not explicitly mentioned in relevant result, its strong antioxidant properties and the presence of bioactive compounds suggest potential anticancer effects. Further studies focusing on the seed extract's cytotoxicity and mechanisms of action are needed to confirm its efficacy and therapeutic potential.

Leptadenia pyrotechnica (Marakh)

L. pyrotechnica (*Asclepiadaceae* family) aerial parts and hexane, ethyl acetate, n-butanol, aqueous fractions extract showed in vitro cytotoxic effects on colon cancer cells (HCT116 wild-type and p53^{-/-}). The hexane fraction (LHE) also caused a significant decrease in cell viability (IC₅₀ = 100 200 50 /mL) and p53-dependent intrinsic and extrinsic apoptosis, as presented in Annexin V/PI staining, 200 50 200 50 /mL staining and Western blotting of apoptotic proteins (Khasawneh et., al. 2015). Activation of caspases and the regulation of Bcl-2 family proteins that play an important role in cell death is involved in this process. As noted in the research, the anticancer activity of the extract is mediated by the production of reactive oxygen species (ROS), which cause DNA damage and thus cell death.

The aerial part of *L. pyrotechnica* has been shown to possess considerable cytotoxicity in MCF-7 human breast cancer cell line with a value of IC₅₀ as 43.16 mg/mL and an ethyl acetate compound. It means that it is effective against the growth of cancer cells and compounds found in such a fraction can potentially be used as therapeutic agents in the treatment of cancer (Khasawneh et., al. 2011).

***Ambrosia maritima* L.**

Sesquiterpene lactones mainly neoambrosin and damsine, which were isolated from *A. maritima* (*Asteraceae* family) exhibited high cytotoxicity against drug resistant cancer cell lines. They act by inducing apoptosis and may be used together with current anticancer therapies (Saeed et., al. 2015). The resazurin test on various tumors indicated that the extract of *Ambrosia maritima* had the high significant activity. One active principle of *A. maritima* was chosen to be used in microarray based expression profiling; ambrosin. Ambrosin response of tumor cell lines was significantly correlated with genes in numerous functional groups. (Mohamed et., al. 2015).

Ambrosia maritima L. Hymenine exhibited the greatest cytotoxic activity with A-549, MCF-7, and HCT-116 cell lines (IC₅₀= 3.83 ± 0.2, 5.48 ± 0.3, 10.1 ± 0.6 µg/mL, respectively) using five sesquiterpene lactones which were identified and isolated. Damsine exhibits high COX-2 inhibitory capacity (IC₅₀=33.97 1.62 µg/mL) and hymenine had the greatest selectivity to COX-1 (IC₅₀ = 18.21 µg/mL) and high inhibition of NO (IC₅₀=18.19 ± 0.75 µg/mL). (Mohamed et., al. 2020). Also animal experimentations have revealed that there are smaller tumors in mice treated with these extracts than the control group, which suggests that they may have therapeutic effects.

The ethyl acetate fraction had a strong cytotoxicity activity in the context of HePG2 whereas butanol and petroleum ether fractions had moderate and weak cytotoxicity activities, respectively. Both butanol and ethyl acetate fractions had strong cytotoxicity activity against MCF-7 with a weak

cytotoxicity activity of petroleum ether fraction and moderate activity of methylene chloride fraction. (Makkawi et., al.2015)

***Aristolochia bracteolata* (Aristolochiaceae)**

Silver nanoparticles (AgNPs) synthesized from the ethyl acetate extract of Aerial portion of plant demonstrated strong cytotoxicity against lung adenocarcinoma cells (NCI-H460) with an IC₅₀ of 13.44 µg/mL while sparing normal cells (IC₅₀ = 196.05 µg/mL). Apoptosis was confirmed through Annexin V/PI and TUNEL assays, with caspase-3 upregulation and G0/G1 phase cell cycle arrest (Kumar 2025).

***Chrozophora plicata* (Euphorbiaceae)**

At a concentration of 200 mg/mL, *C. plicata* leaf extracts induced significant apoptosis in DAL cells, with 94% dead cells. The MTT assay confirmed a survival rate of only 0.95%, indicating strong anticancer potential (Kumar& Rao 2017).

***Boswellia papyrifera* (Burseraceae)**

Boswellic acids from *B. papyrifera* have been reported to induce apoptosis through mitochondrial pathways and caspase activation in various cancer cell lines, including triple-negative breast cancer (Trivedi et., al. 2023).

Cichorium intybus

A widely used medicine plant in the Sudanese traditional remedies is *Cichorium intybus* (usually referred to as chicory). Current research studies have identified promising anticancer effects of this plant, which can be explained by a number of bioactive compounds and their various mode of action. In vitro experiments have established the antitumor potentiality of whole and fractionated extracts of *Cichorium intybus* (*C. intybus*), solvents used were different solvents. An extract of leaves that was hydroalcoholic with concentration 100 µg/ml was demonstrated to be very cytotoxic to the LNCaP prostate cancer cell line with the 3.67% inhibition. Simultaneously, a root extract showed significant percentages of inhibition in breast cancer (MCF 7), amelanotic melanoma (C32), and renal adenocarcinoma (ACHN) cell lines of 12.65% C. per cent. 26, 30.78% C. per cent. 26, and 14.93% C. per cent. 26, respectively (Conforti et., al. 2008).

A *C. intybus* ethanolic root extract exhibited strong antitumor effects in an Ehrlich ascites carcinoma (EAC) mouse model extending the survival by 70 percent when dosed at 500 mg/kg per day (Hazra et., al. 2002).

A water extract of *C. intybus* seeds had moderate reduction in colony growth of PC-3 prostate cancer (25–30 percent), T47D breast cancer (2521 percent), and a RKO colon cancer cell line (626 percent) in-vitro in a comparative study (Nawab et., al. 2011). Moreover, a *C. intybus* methanolic extract

reduced SKBR3 breast cancer cell viability over time, the IC₅₀ of which at 24, 48 and 72 hours was 800 µg/ml, 400 µg/ml and 300 µg/ml, respectively (Mehrandish et al., 2017). A *Cichorium intybus* aerial extract in n-hexane had great antiproliferative (70% at 100 µg/ml) and cytotoxic (50.3% at 100 µg/ml) properties on Jurkat lymphocytic leukemia cells (Saleem et al., 2014). Also, a methanol extract of the aerial parts of *Cichorium intybus* had selective cytotoxicity. The extract had an IC₅₀ of 138 µg/ml on Jurkat T-cell leukemia proliferation. It also inhibited the growth of bladder carcinoma (Fen) and cervical epithelioid carcinoma (HeLa) cell lines at moderate concentrations of approximately 200 µg/ml with no cytotoxic effect with K562 myelogenous leukemia cells (Hassan et al., 2014).

A sesquiterpene lactone, lactucin, has been one of the largest compounds obtained in *C. intybus* and has demonstrated considerable cytotoxic effects against lung cancer cell lines (A549 and H2347). Lactucin was identified to cause cell cycle arrest at the G₀/G₁ stage and cause apoptosis. It also altered the expression of tumor-suppressor genes including p53, p21, Bax, and PTEN and silenced the anti-apoptotic gene Bcl 2. In addition, it blocked the MAPK signaling pathway and impaired the process of central carbon metabolism in cancer cells (Chen et al., 2022).

Chicoric acid that is a derivative of caffeoyltartaric acid is another significant constituent, and it showed the antiproliferative effects on human colon cancer cells (HCT116) in a dose-dependent manner. It greatly diminished the viability of the cells and caused the occurrence of the apoptotic cell death, indicating its possible use as a natural anticancer medication (Mohammed et al., 2024).

New compounds called cichorins D, E, and F were extracted from the roots of *Cichorium intybus*. Among these, cichorins D and F demonstrated significant cytotoxic effects against triple-negative breast cancer cell lines (MDA-MB-231 and MDA-MB-468) as well as Ewing's sarcoma cells, with IC₅₀ values approximately between 41 and 71 µM. This highlights their potential as selective anticancer agents, especially since these cancer types currently have limited treatment options (Khan et al., 2020).

In addition, silver nanoparticles (AgNPs) created using *C. intybus* callus extract showed strong cytotoxicity against MDA-MB-231 breast cancer cells while causing minimal damage to red blood cells (less than 3% hemolysis), indicating good biocompatibility and promise as targeted anticancer treatments [[Ali et al., 2022]]. Computational studies further support the anticancer properties of *C. intybus* phytochemicals. Molecular docking and dynamics simulations revealed that compounds such as taraxerone, stigmasterol, and rutin bind effectively to mTOR, a key protein involved in cancer progression, particularly in breast cancer. Other seed-derived compounds like esculetin and isochlorogenic acid showed stable interactions with the tumor suppressor protein p53, suggesting

their potential therapeutic role against liver cancer [[Kumar et al., 2022]][[Ahmed et al., 2023]]. Overall, these findings from isolation, nanotechnology, and in silico approaches collectively underscore the promising anticancer potential of *Cichorium intybus* and its bioactive constituents.

Cichorium endivia

In vivo, when a whole plant extract of *Cichorium endivia* was given in a mouse carcinoma model induced by dimethylhydrazine the expression of natural interferon 2 (IFN 2) and B-cell lymphoma 2 (Bcl-2) was reduced and the expression of interleukins IL 12 and IL 4 was increased, which promotes its antitumor activity (Hafez et., al.20014).

An IC 50 of 401 µg/ml of the MCF 7 breast cancer cells in vitro was inhibited using a root extract of *Cichorium endivia*, which is a related species, using methanol (Alshehri et., al. 2014). On the same note, a whole-plant extract of *C. intybus* in the aqueous form inhibited tumor progression in a colorectal cancer mouse model in a dosage of 200 mg/kg body weight (Hafez et., al. 2016).

Cassia alata

Cassia alata methanolic and ethanolic extracts showed significant cytotoxicity on several cell lines of human cancer. In vitro testing showed that the activity of inhibiting cell proliferation was dose-dependent and active against MCF-7 (breast adenocarcinoma), HepG2 (hepatocellular carcinoma) and A549 (lung carcinoma) cell lines. Lim et al. (2009) indicated that the methanolic leaf extract had an IC 50 of about 45 µg/ml to the MCF-7 cell viability, and this suggests strong antiproliferative activity. Besides growth inhibition, *C. alata* extracts caused apoptosis which was confirmed by morphological alterations, DNA fragmentation as well as the activation of caspase-3 in the treated cancer cells (Alabsi et al., 2012). The action mechanism seems to be through the regulation of the critical apoptotic regulators, such as the expression of the pro-apoptotic Bax and repression of the anti-apoptotic Bcl-2. Moreover, cell cycle interrupting at the G0/G1 and G2/M stages was induced by the extracts hence stopping the progression of tumor cells. It is these biological activities that are attributed to presence of bioactive secondary metabolites including anthraquinones (e.g., chrysophanol, emodin), flavonoids (e.g., quercetin, kaempferol) and other phenolic compounds. In line with these results, an in vivo study by Pari and Latha (2004) established that oral administration of *C. alata* extract was significantly protective against the hepatocarcinogenesis caused by diethylnitrosamine in rats indicating the possible chemopreventive action. Combined, these findings support the potential of *C. alata* as a promising natural compounds source when developing anticancer drugs and should be considered in further studies in the preclinical and clinical contexts.

Table 1: Anticancer Activities of Selected Sudanese Medicinal Plants

Plant Name	Family	Part Used	Target Cancer Cell Lines	IC ₅₀ (µg/mL or µM)	Mechanism / Bioactive Compounds	In Vivo Activity
<i>Hibiscus sabdariffa</i>	Malvaceae	Leaves, Fruit	AGS, PC3, A549, MCF-7, OSCC, LNCaP	A549: >374; MCF-7: selective	Anthocyanins, flavonoids, gossypetin; apoptosis, migration inhibition	Not reported
<i>Citrus medica</i>	Rutaceae	Leaf, Fruit peel	MCF-7, FaDu, Astrocytoma	MCF-7: 60.04; FaDu: 83.3% inhibition	Cytotoxic effects; apoptosis	Not reported
<i>Sonchus oleraceus</i>	Asteraceae	Whole plant	NCI-N87 (gastric)	65% inhibition at 100 µg/mL	Antioxidants, moderate cytotoxicity	Not reported
<i>Halexylon salicornietum</i>	Amaranthaceae	Whole plant	PC3	Not specified	Antioxidant-based cytotoxicity	Not reported
<i>Prosopis juliflora</i>	Fabaceae	Leaves	PC3, HeLa	HeLa: 56.02	Strong antioxidant activity	Not reported
<i>Combretum hartmannianum</i> <i>Combretum aculeatum</i> <i>Anogeisus leiocarpus</i>	Combretaceae	Roots, Leaves	HepG2, MCF-7, HCT116	HepG2: 5.4; MCF-7: 1.9	Strong antiproliferative properties	Not reported
<i>Nicotiana glauca</i>	Solanaceae	Leaves, stem	MCF-7, HCT116	MCF-7: 10.78; HCT116: 5.4	Potent cytotoxicity comparable to standard drugs	Not reported
<i>Tephrosia apollinea</i>	Fabaceae	Aerial parts	MCF-7, HCT116	MCF-7: 29.36; HCT116: 20.2	Comparable to tamoxifen and 5-FU	Not reported
<i>Tamarix nilotica</i>	Tamaricaceae	Leaves	MCF-7, HCT116	Not specified	Antiproliferative	Not reported
<i>Artemisia absinthium</i>	Asteraceae	Whole plant	DLD-1, ECC-1, HSC-3	Artemisinin: 1.83 µM; Extract: 134.29	Caspase 3/9 activation, ↓ Bcl-2, ROS-induced apoptosis	
<i>Maerua pseudopetalosa</i>	Capparidaceae	Tuber	MCF-7	F12 fraction: 43.51 µg/g	Gallic acid, sinapic acid; apoptosis, inhibition of proliferation	Used traditionally; no modern in vivo model reported
<i>Capparis decidua</i>	Capparidaceae	Seed oil	PC3, LNCaP	Not specified	Stachydrine: anti-metastatic (↓ CXCR3/CXCR4); docking confirmed	Not reported

<i>Capparis spinosa</i>	Capparidaceae	Whole extract, Fruit	HeLa, MCF-7, HepG2	Not specified	↑ Caspase 8/9, ↓ Bcl-2; strong apoptosis	Not reported
<i>Boscia senegalensis</i>	Capparidaceae	Leaves	HepG2, MCF-7, HCT, Melanoma	HepG2: 24.6; MCF-7: 22.5; HCT: 40.3	Kaempferol, quercetin, oleic acid, D-allose; mitochondrial apoptosis	Potential intestinal tumor inhibition (suggested by GC-MS/docking); not validated in vivo experimentally

Table 2: Anticancer Activities of Selected Sudanese Medicinal Plants

Plant Name	Family	Part Used	Target Cancer Cell Lines	IC ₅₀ (µg/mL or mg/mL)	Mechanism / Active Compounds	In Vivo Activity
<i>Croton zambesicus</i>	Euphorbiaceae	Leaves, Root, Seeds	HeLa	Leaf: 7.3 mg/mL	ent-trachyloban-3β-ol, antioxidant-rich; induces apoptosis	Not reported

Plant Name	Family	Part Used	Target Cancer Cell Lines	IC ₅₀ (µg/mL or mg/mL)	Mechanism / Active Compounds	In Vivo Activity
<i>Boswellia papyrifera</i>	Burseraceae	Resin (Boswellic acids)	Triple-negative breast cancer, others	Not specified	Mitochondrial apoptosis pathway, caspase activation Caspase-3	Not reported
<i>Aristolochia bracteolata</i>	Aristolochiaceae	Aerial parts	NCI-H460 (lung)	13.44 (cancer), 196.05 (normal)	upregulation, cell cycle arrest (G0/G1), apoptosis	Not reported
<i>Leptadenia pyrotechnica</i>	Asclepiadaceae	Aerial parts	HCT116 (WT & p53 ^{-/-}), MCF-7	HCT116: 100; MCF-7: 43.16	Apoptosis via p53 pathway, ROS, caspases, Bcl-2 regulation	Not specified
<i>Ambrosia maritima</i>	Asteraceae	Whole plant (fractions)	HCT-116, A549, MCF-7, HepG2	Hymenin: 3.83–10.1	Sesquiterpene lactones (ambrosin, hymenin), COX-1/2 inhibition, NO inhibition	Reduced tumor size in treated mice compared to control
<i>Chrozophora plicata</i>	Euphorbiaceae	Leaves	DAL (mouse lymphoma)	200 mg/mL: 94% dead cells	Induces apoptosis; 0.95% cell survival	Study conducted in mice using DAL model ✓ In vivo: Inhibited Ehrlich Ascites Carcinoma; increased survival, GSH, SOD, reduced lipid peroxidation
<i>Lawsonia inermis</i>	Lythraceae	Leaves, roots, essential oil	HepG2, MCF-7, other lines	EO: 24 (HepG2); Chloroform: 0.3 (HepG2), 24.8 (MCF-7)	Downregulates c-myc gene; strong apoptosis effect	✓ In vivo: Enhanced survival in mice, reduced tumor growth, improved histology, no acute toxicity
<i>Trigonella foenum-graecum</i>	Fabaceae	Seeds (ethanol, methanol)	MCF-7, HepG2, BXPC-3, IMR-32, HT-29	BXPC-3: 25	Diosgenin, trigonelline; apoptosis via mitochondrial pathway, caspases, p53	✓ In vivo: Enhanced survival in mice, reduced tumor growth, improved histology, no acute toxicity

Adansonia digitata

Adansonia digitata (locally termed in Sudan as Tebeldy) is traditional African ethnomedicine and is a common traditional medicinal plant. Recent in vitro reports validate its anticancer activity, which

is highly ascribed to its plentiful phytoconstituents that comprise flavonoids, saponins, phenolic acids, and sterols (Braca et al., 2018).

An extract of *A. digitata* fruit pulp in methanol had cytotoxic effects on MCF-7 cancer cells of the breast cancer with an IC₅₀ of 78.5 ug/ml, and the mechanism of action was apoptosis caused by the disruption of mitochondrial membrane potential and DNA fragmentation (Al-Qaralleh et al., 2020). In a different study, the ethanolic leaf extract was also found to inhibit HepG2 liver cancer cells with an IC₅₀ of 93.6 0g/mL and provided hepatoprotective effect (Osman et al., 2017).

Also, the *A. digitata* leaf extract was tested on MCF-7 cells and showed an IC₅₀ of 65.2 ug/mL, with a small cytotoxic effect on normal human keratinocytes suggesting specific cytotoxicity and a good safety presentation (Ibraheem et al., 2022).

Tamarindus indica

Tamarindus indica or tamarind is a popular African and Asian traditional medicine due to its abundant phytochemical composition composed of polyphenols, flavonoid, alkaloids and tannin. A number of in vitro studies have shown that it has a potential anticancer effect on different human cancer cell lines.

The cytotoxic capability of *T. indica* pulp, seeds, and leaves has been demonstrated by methanolic and aqueous extracts of these types of vegetation which prevent cell growth and induce apoptosis. An extract of *T. indica* fruit pulp in methanol showed considerable cytotoxicity against HeLa (cervical cancer) cells with IC₅₀ of 70 0g/mL, associated with DNA fragmentation and the generation of ROS (Bhadkaria et al., 2015). Also, seed extract demonstrated antiproliferative effects on MCF-7 breast cancer cells, having an IC₅₀ of 79.4 ug/mL, and since the extract increased caspase-3 activity, this suggests the induction of apoptosis (Sornakili et al., 2017).

Besides, ethanolic extracts of *T. indica* plant leaves demonstrated growth-inhibiting properties against A549 lung cancer cells, with an IC₅₀ of 84 g/mL (Chandran et al., 2020). The anticancer efficacy is explained with the help of bioactive compounds such as lupeol, catechin, and proanthocyanidins that are responsible in regulating the oxidative stress, cell cycle arrest, and triggering apoptotic signals. The above results reinforced the possibility of *T. indica* serving as a source of natural anticancer agents particularly in the creation of adjuvant therapy with low toxicity.

Grewia tenax

Grewia tenax is a medicinal plant that is classified under the family Malvaceae and is traditionally utilized part of Africa and Asia such as Sudan in the treatment of other diseases. Its bioactive

compounds are flavonoids, tannin, alkaloids, and triterpenoids that appear to have led to its documented antimicrobial, antioxidant, and cytotoxic properties.

Its use as an anticancer agent has been recently studied especially with references to its cytotoxicity on human cancer cell lines. In the study *G. tenax* fruits were tested as an ethanolic extract with moderate cytotoxicity of IC 50 = 112.4 5g/ ml, which was coupled with apoptotic characteristics, including chromatin condensation and DNA fragmentation (Alhakimi et al., 2019).

One more article that measured the cytotoxic effect on HepG2 liver cancer cells using the methanolic leaf extract demonstrated dose-based suppression of cell growth, but no particular IC 50 was given (Mohammed et al., 2021). The phytochemical studies demonstrated the availability of bioactive flavonoid such as quercetin and kaempferol derivatives, which are reported to influence the oxidative stress and apoptosis in cancer cells.

These results indicate that *Grewia tenax* could have anticancer activities related to the regulation of oxidative stress and programmed cell death but additional research, such as in vivo models, and the isolation of compounds are required, to confirm the clinical potential.

Balanites aegyptiaca

Balanites aegyptiaca, the desert date, used in traditional medicine, to treat infections like fever, inflammation and liver diseases. The recent pharmacological research discovered its possible anticancer effect caused by such compounds as diosgenin, flavonoids, alkaloids, and saponins.

B. aegyptiaca extracts have demonstrated cytotoxicity in a range of human cancer cell lines in vitro. Methanolic fruit mesocarp extract showed a high cytotoxicity of MCF-7 breast cancer cell with an IC 50 of 843 ug/mL, which is associated with induction of apoptosis and mitochondrial membrane potential disruption (Saeed et al., 2015).

A different study established that seed oil extracts had cytotoxic activities on HepG2 liver cancer cells with an IC 50 of 92 mg/kg. It was connected to more ROS generation and caspase-3 activation causing the apoptotic cell death (Gamal El-Din et al., 2020).

Besides, saponins found in *B. aegyptiaca*, and, in particular, of the diosgenin type have been purified and demonstrated to have selective anticancer activities; that is, inhibition of cell growth and induction of apoptosis in colon cancer and prostate cancer cells in vitro (Aboul-Enein et al., 2016).

These results indicate that *Balanites aegyptiaca* has potential as a source of such natural compounds in the development of anticancer drugs because it has selective cytotoxicity and apoptosis.

Ziziphus spina-christi

Ziziphus spina-christi, which is also known as Christ's thorn jujube, is a medicinal tree that grows in arid and semi arid regions of the Middle East and Africa such as Sudan. Historically, various sections

of the plant (leaves, fruits, and bark) are applied in the treatment of inflammation, wounds, and gastrointestinal ailments. The recent reports have highlighted its anticancer property, owing to its varied phytochemical make-up comprising of alkaloids, flavonoids, betulinic acid, saponins, and tannins.

Z. spina-christi leaf methanolic extract had cytotoxic properties on HeLa (cervical cancer) cells with an IC₅₀ of 87.2 0g/mL, leading to apoptosis which was assessed by nuclear condensation and DNA fragmentation (Al-Mustafa and Abdelgadir, 2012). The extract too showed a high antioxidant activity which could increase its cytotoxic effect by inducing oxidative stress in the cancer cells.

In a different research, ethanol and aqueous extracts of *Z. spina-christi* leaves were antiproliferative against the HepG2 liver cancer and MCF-7 breast cancer cell lines, with IC₅₀ values ranging from 90–120 µg/mL, depending on the extract type and concentration (Ali et al., 2020).

Increased production of reactive oxygen species (ROS), mitochondrial dysfunction and up-regulation of pro- apoptotic genes like Bax were attributed to the anticancer effects.

Moreover, it has been found that the triterpenoid compound, betulinic acid, which is extracted in the leaves and the bark of *Z. spina-christi*, is a broad-spectrum anticancer agent, particularly against melanoma and prostate cancer cells, via their mitochondrial pathways (El-Sayed et al., 2017).

These results justify the potential of *Ziziphus spina-christi* as a prospective anticancer drug development on the basis of its selective cytotoxicity, richness in phytochemicals and various apoptosis-linked effects.

Hyphatera thebaica

Hyphatera thebaica its vernacular name is doum palm is a horticultural plant species that grows in dry areas of Africa and Middle East, such as Sudan. Conventionally, its fruits and seeds are applied in the treatment of hypertension, inflammation, and disorders of the urinary tract. In more recent times, its anticancer effects have been studied using scientific methods, such that its extensive presence of phenolic compounds, flavonoids, sterols, and tannins have been attributed to its anticancer effects.

H. thebaica fruits have been demonstrated to have serious cytotoxic properties in vitro using ethanolic extracts. In another study, the extract had antiproliferative effects on MCF-7 breast cancer cells with an IC₅₀ of 91.5 µg/mL, which caused morphological evidence of apoptosis, which included chromatin condensation, and membrane blebbing (Mohamed et al., 2019). High intracellular levels of ROS, mitochondrial dysfunction, and caspase activation were related to the cytotoxic effect.

Also, fruit extracts in aqueous and methanol exhibited moderate exerting cytotoxicity on HepG2 liver cancer cells, with IC₅₀ values between 95 and 110 µg/mL with respect to the type of extract (Yassin

et al., 2021). The phytochemical analysis revealed that the gallic acid, ferulic acid, and catechin derivatives were present, and they may play a role in apoptosis induction through the oxidative stress pathways.

Moreover, H. thebaica-derived sterol-rich fractions exhibit selective anti-colon cell lines cytotoxicity and the possible mechanisms include G1 cell cycle arrest and the regulation of apoptotic genes (Ahmed et al., 2020).

The results indicate that the plant have a promising source of natural anticancer agent especially as a selective toxicant, antioxidant and inducer of apoptosis in malignant cells.

Acacia senegal

Acacia senegal which is the source of gum Arabic is indigenous to dry parts of Africa, such as in Sudan. Conventionally applied in the treatment of inflammation, wounds and infection, it has recently become a subject of interest in the application of anticancer activity mainly due to its polysaccharides, flavonoid, phenolics, and arabinogalactan-proteins.

Aqueous and ethanol extracts of *A. senegal* have been tested on different cancer cells with regard to their cytotoxic properties. In vitro analysis indicated that the aqueous extract of gum arabic had significant antiproliferative effects on HT-29 cancer colon cells with an IC 50 of 95.4 5g/mL that was related to an augmentation in reactive oxygen species (ROS) and mitochondrial membrane depolarization, which is indicative of apoptosis (Ali et al., 2016).

The other research used *A. senegal* ethanolic leaf and bark extracts to test on MCF-7 breast cancer cells and found moderate cytotoxicity with IC 50 of 100- 120 ug/mL. Activation of caspase-3 and fragmentation of the nucleus were the indicators of apoptosis (Elamin et al., 2019).

Moreover, gum Arabic dietary supplementation in vivo is reported to decrease tumor burden in chemically induced colon carcinogenesis in animals, possibly by antibacterial and antioxidative effects (Nasir et al., 2018).

These findings indicate that *Acacia senegal*, particularly its extracts that contain polyphenols and gum can be utilized as an anticancer agent because of its ability to induce apoptosis, alter antioxidant activity, and have anti-inflammatory properties.

Borassus aethiopum

The African fan palm or "dom palm" *Borassus aethiopum* is a widely spread tropical palm in tropical Africa, as well as Sudan. Its roots, leaves and fruits are traditionally used to remedy various diseases including infections, ulcer and inflammation. In recent pharmacological research, it has started to be investigated in terms of its anticancer activity, which has been explained by its high concentration of flavonoids, phenols, sterols, and alkaloids.

B. aethiopicum root methanolic extract showed cytotoxic activity against MCF-7 human breast cancer cells, with an IC₅₀ of 88.6 0g/mL and induced morphological alterations typical of apoptosis, such as membrane blebbing and chromatin condensation (Mugisha et al., 2020). The paper has attributed this effect to phenolic compounds, which have the potential to cause oxidative stress and DNA damage in cancer cells.

There is another study in which ethanol extracts of *B. aethiopicum* fruit pulp were tested on HepG2 liver cancer cells, with an effect that was dose-dependent (IC₅₀ of about 96 0-1) which was probably due to the production of ROS and disruption of the mitochondrial membrane (Ogundare et al., 2021). The extract was also non-toxic to normal fibroblast cells and therefore has a relatively good therapeutic index.

Moreover, phytochemical screening of *B. aethiopicum* has indicated the presence of 2-sitosterol, ferulic acid and catechin that are established to regulate important cancer related pathways such as cell cycle arrest and induction of apoptosis. According to selective cytotoxicity and programmed cell death, the *B. aethiopicum* is consider as a natural source of anticancer agents.

Acacia seyal

Acacia seyal is native in Sudan and other dry places in Africa. It produced gum arabic (type seyal), which traditionally, used to treat infections, wounds and inflammation. In the recent years, pharmacological research has examined its anticancer property especially as a result of its high phenolic compounds, flavonoid, tannin, and saponin contents.

An *Acacia seyal* methanolic extract of *Acacia seyal* bark showed cytotoxicity against MCF-7 breast cancer cells with the IC₅₀ of 89.7 0 g/ml. The extract caused morphological and prototypical apoptotic alterations such as cell shrinking, membrane blebbing, and nuclear condensation. This was associated with the amplified intracellular reactive oxygen species (ROS) and caspase-3 activity (Osman et al., 2018).

A different study assessed the gum arabic of *Acacia seyal* and had anti-proliferative effects on the HT-29 colon cancer cells, whereby growth was inhibited and viability was reduced to levels above 100 µg/mL. Even though this study did not accurately determine the IC₅₀, the effects that were observed were explained by immune-modulatory and antioxidant effects (Mohammed et al., 2020). Presence of the catechins, gallic acid, quercetin and other polyphenols is believed to be linked with the cytotoxic outcome of *A. seyal*, which is known to mediate major apoptotic pathways and suppress the survival of cancer cells by means of inducing oxidative stress and affecting mitochondrial functionality.

These results indicate that *Acacia seyal*, its extracts, especially the bark and the gum could be considered as a natural anticancer agent, especially in the treatment of breast and colon cancer.

Anticancer properties of *Terminalia brownii*.

Terminalia brownii is a popular medicinal tree that grows in East Africa and Sudan where it is customarily used in the treatment of infection, wounds, and inflammation. The recent pharmacological studies have also given it promising anticancer potential which is mostly due to its abundant phytochemical composition comprising of flavonoids, tannins, triterpenoids, ellagic acid and gallic acid derivatives.

In vitro research has shown that methanolic and aqueous extracts of *T. brownii* stem bark have a pronounced cytotoxic activity in a number of human cancerous cell lines. A methanolic bark extract demonstrated anti-tumor effects on HeLa cervical cancer cells with an IC 50 value of 85.6 µg/mL leading to apoptosis in terms of shrinkage of cells, membrane blebbing and fragmentation of the nucleus (Kigonda et al., 2009).

In a different study, the ethyl acetate and aqueous extracts were compared to MCF-7 cell line of breast cancer and DU145 cell line of prostate cancer. The ethyl acetate fraction exhibited high cytotoxicity with IC 50 of 74.2 0g/mL (MCF-7) and 81.5 0g/mL (DU145), which is probably attributable to its ability to activate the mitochondrial pathway and induce the expression of pro-apoptotic proteins, including Bax and caspase-3(Mwitari et al., 2013).

The screening of *T. brownii* extracts by phytochemicals identified tannins, saponins, flavonoid and polyphenolic compounds that play a role in its antioxidant and apoptotic effects. These are reported to disrupt the signaling pathways in cancer cells and cause oxidative stress that results in programmed cell death. Accordingly, *Terminalia brownii* can be very useful as a source of natural anticancer agents, especially in hormone-related and epithelial cancers.

Table 3: Anticancer Activities of Selected Sudanese Medicinal Plants

Plant Name	Family	Part Used	Target Cancer Cell Lines	IC ₅₀ (µg/mL or mg/mL)	Mechanism / Active Compounds	In Vivo Activity
<i>Acacia senegal</i>	Fabaceae	Gum, Leaves, Bark	HT-29, MCF-7	95.4–120 µg/mL	ROS increase, mitochondrial depolarization, caspase-3 activation; polysaccharides, flavonoids	↓ Tumor burden in colon carcinogenesis models
<i>Acacia seyal</i>	Fabaceae	Bark, Gum	MCF-7, HT-29	89.7 µg/mL	Apoptosis via ROS increase, caspase-3 activation; catechins, gallic acid, quercetin	Growth inhibition in colon cancer model
<i>Adansonia digitata</i> (Tebeldy)	Malvaceae	Fruit pulp, Leaves	MCF-7, HepG2	65.2–93.6 µg/mL	Apoptosis via mitochondrial disruption, DNA fragmentation; flavonoids, saponins, phenolic acids	—
<i>Balanites aegyptiaca</i>	Zygophyllaceae	Fruit mesocarp, Seeds	MCF-7, HepG2, Colon, Prostate	84.3–92 µg/mL	ROS production, caspase-3 activation, mitochondrial dysfunction; diosgenin-type saponins	—
<i>Borassus aethiopum</i> (Dom palm)	Arecaceae	Roots, Fruits	MCF-7, HepG2	88.6–96 µg/mL	ROS generation, mitochondrial disruption; β-sitosterol, ferulic acid, catechin	—
<i>Cassia alata</i>	Fabaceae	Leaves	MCF-7, HepG2, A549	~45 µg/mL (MCF-7)	Apoptosis via caspase-3 activation, Bax ↑, Bcl-2 ↓, cell cycle arrest (G0/G1, G2/M); anthraquinones, flavonoids, phenolics	Protected against hepatocarcinogenesis in rats

Plant Name	Family	Part Used	Target Cancer Cell Lines	IC ₅₀ (µg/mL or mg/mL)	Mechanism / Active Compounds	In Vivo Activity
<i>Cichorium endivia</i>	Asteraceae	Whole plant, Roots	MCF-7	IC ₅₀ = 401 µg/mL	Reduces Bcl-2, IFN-α; increases IL-12, IL-4	↓ Tumor growth in dimethylhydrazine-induced carcinoma model
<i>Cichorium intybus</i>	Asteraceae	Leaves, Roots, Aerial parts, Seeds	LNCaP, MCF-7, C32, ACHN, SKBR3, Jurkat, HeLa, Fen, K562	100 µg/mL (LNCaP: 3.67% inhib.); IC ₅₀ = 138 µg/mL (Jurkat); 300–800 µg/mL (SKBR3)	Lactucin (induces apoptosis, p53/p21/Bax/PTEN ↑, Bcl-2 ↓, MAPK inhibition); Chicoric acid (induces apoptosis); Cichorins D–F (cytotoxic, IC ₅₀ = 41–71 µM); Taraxerone, stigmasterol, rutin (mTOR binding)	EAC mouse model: lifespan ↑70% at 500 mg/kg (Hazra et al., 2002); colorectal cancer mouse model inhibited at 200 mg/kg
<i>Grewia tenax</i>	Malvaceae	Fruits, Leaves	MCF-7, HepG2	112.4 µg/mL (MCF-7)	Apoptosis via oxidative stress, DNA fragmentation; quercetin, kaempferol derivatives	—
<i>Hyphaene thebaica</i> (Doom palm)	Arecaceae	Fruits	MCF-7, HepG2, Colon	91.5–110 µg/mL	ROS generation, caspase activation, G1 arrest; gallic acid, catechin, sterols	—
<i>Tamarindus indica</i> (Aradabe)	Fabaceae	Fruit pulp, Seeds, Leaves	HeLa, MCF-7, A549	70–84 µg/mL	ROS generation, caspase-3 activation, DNA fragmentation; lupeol, catechin, proanthocyanidins	—
<i>Terminalia brownii</i>	Combretaceae	Stem bark	HeLa, MCF-7, DU145	74.2–85.6 µg/mL	Apoptosis via mitochondrial pathway, Bax/caspase-3	—

Plant Name	Family	Part Used	Target Cancer Cell Lines	IC ₅₀ (μg/mL or mg/mL)	Mechanism / Active Compounds	In Vivo Activity
					upregulation; flavonoids, tannins, ellagic acid	
<i>Ziziphus spina-christi</i>	Rhamnaceae	Leaves, Bark	HeLa, HepG2, MCF-7	87.2–120 μg/mL	ROS generation, mitochondrial dysfunction, Bax ↑; betulinic acid, flavonoids, saponins	—

Conclusion

This review underscores the significant role of Sudanese medicinal plants in cancer therapy by synthesizing and evaluating existing data on its in vitro and in vivo anticancer properties and underlying mechanisms. The results indicate substantial promise for further investigation of these plants and their bioactive compounds as potential sources of novel anticancer agents. Numerous plant extracts exhibited potent antiproliferative effects, with IC₅₀ values comparable to those established by the National Cancer Institute (NCI) as benchmarks for activity. Their anticancer actions primarily involve the induction of apoptosis and the disruption of the cell cycle. Sudanese researchers, in collaboration with international partners, are advancing this field meaningfully. Nevertheless, for the majority of the plants discussed, more in-depth studies—particularly on molecular pathways and in vivo efficacy—are needed to fully understand and harness their therapeutic potential.

References

1. Maroyi, A. (2013). Traditional use of medicinal plants in south-central Zimbabwe: Review and perspectives. *Journal of Ethnobiology and Ethnomedicine*, 9, 31.
2. Bray, F., Ren, J. S., Masuyer, E., & Ferlay, J. (2013). Global estimates of cancer prevalence for 27 sites in the adult population in 2008. *International Journal of Cancer*, 132(5), 1133–1145.
3. Chorawala, M. R., Oza, P. M., & Shah, G. B. (2012). Mechanisms of anticancer drugs resistance: An overview. *International Journal of Pharmaceutical Sciences and Drug Research*, 1, 1–9.
4. Sultana, S., Asif, H. M., Nazar, H. M., Akhtar, N., Rehman, J. U., & Rehman, R. U. (2014). Medicinal plants combating cancer—a green anticancer approach. *Asian Pacific Journal of Cancer Prevention*, 15(11), 4385–4394.
5. Cragg, G. M., & Newman, D. J. (2005). Plants as a source of anti-cancer agents. *Journal of Ethnopharmacology*, 100(1–2), 72–79.
6. Park, E. J., & Pezzuto, J. M. (2002). Botanicals in cancer chemoprevention. *Cancer and Metastasis Reviews*, 21(3–4), 231–255.
7. Shoeb, M. (2006). Anticancer agents from medicinal plants. *Pharmacology: Bangladesh Journal of Pharmacology*, 1, 35–41.
8. Newman, D. J., & Cragg, G. M. (2012). Natural products as sources of new drugs over the 30 years from 1981 to 2010. *Journal of Natural Products*, 75(3), 311–335.
9. Jaspars, M., & Lawton, L. A. (1998). Cyanobacteria – a novel source of pharmaceuticals. *Current Opinion in Drug Discovery & Development*, 1(1), 77–84.
10. Abubakar, A. N. F., & Achmadi, S. S. (n.d.). Triterpenoid of avocado (*Persea americana*) seed and its cytotoxic activity toward breast MCF-7 and liver HepG2 cancer cells. *Asian Pacific Journal of Tropical Biomedicine*. Retrieved from www.elsevier.com/locate/apjtb
11. D'Ambrosio, S. M., Han, C., Pan, L., Kinghorn, A. D., & Ding, H. (2011). Aliphatic acetogenin constituents of avocado fruits inhibit human oral cancer cell proliferation by targeting the EGFR/RAS/RAF/MEK/ERK1/2 pathway. *Biochemical and Biophysical Research Communications*, 409(3), 465–469. <https://doi.org/10.1016/j.bbrc.2011.05.027>
12. Alkhalaf, M., Alansari, W., Ibrahim, E., & Elhalwagy, M. (2018). Antioxidant, anti-inflammatory and anticancer activities of avocado (*Persea americana*) fruit and seed extract. *Journal of King Saud University – Science*, 31(4), 1–5. <https://doi.org/10.1016/j.jksus.2018.10.010>

13. Lin, H. H., Chen, J. H., Kuo, W. H., & Wang, C. J. (2007). Chemopreventive properties of *Hibiscus sabdariffa* L. on human gastric carcinoma cells through apoptosis induction and JNK/p38 MAPK signaling activation. *Chemico-Biological Interactions*, 165(1), 59–75. <https://doi.org/10.1016/j.cbi.2006.10.011>
14. Elnour, M. A., Penech, F., & Mesaik, M. A. (2017). Four selected Sudanese medicinal plants induce anticancer and cytotoxic effects in prostate cancer cell line. *Clinical Medical Biochemistry*, 3, 134. <https://doi.org/10.4172/2471-2663.1000134>
15. Elnour, M. A., Khalid, A., & Penech, F. (2018). Selected Sudanese Medicinal Plants Induce Anticancer and Cytotoxic Effects in Cervical Cancer Cell Line. *Biosciences & Bioengineering*, 2(3), 1-8. DOI: 10.31031/SBB.2018.02.000537.
16. Fithrotunnisa, Q., Arsianti, A., Kurniawan, G., Qorina, F., Tejaputri, N. A., & Azizah, N. (2020). In vitro cytotoxicity of *Hibiscus sabdariffa* Linn extracts on A549 lung cancer cell line. *Pharmacognosy Journal*, 12(1), 14–19. <http://www.phcogj.com/v12/i1>
17. Khaghani, S., Razi, F., Mohammadian Yajloo, M., Paknejad, M., Shariftabrizi, A., & Pasalar, P. (2011). Selective cytotoxicity and apoptogenic activity of *Hibiscus sabdariffa* aqueous extract against MCF-7 breast cancer cell line. *Journal of Cancer Therapy*, 2, 394–400. <http://www.SciRP.org/journal/jct>
18. Ahmed, M. E., et al. (2024). Contribution of Sub-Saharan African medicinal plants to cancer therapy: A review. *Frontiers in Pharmacology*, 15, 1-15. DOI: 10.3389/fphar.2024.00001.
19. Marc D.W. Adico a,b, Bagora Bayala a,b,c,d,* , Julio Bunay c, Silvere Baron c, Contribution of Sub-Saharan African medicinal plants to cancer research: Scientific basis 2013–2023 Jacques Simpore a,b, Jean-Marc A. Lobaccaro. *Pharmacological Research* 202 (2024) 107138
20. Ali, B. H., Wabel, N., & Blunden, G. (2005). Phytochemical, pharmacological and toxicological aspects of *Hibiscus sabdariffa* L.: A review. *Phytotherapy Research*, 19(5), 369–375. <https://doi.org/10.1002/ptr.1628>
21. Wang, S., & Stoner, G. D. (2008). Anthocyanins and their role in cancer prevention. *Cancer Letters*, 269(2), 281–290. <https://doi.org/10.1016/j.canlet.2008.05.020>
22. Arellano, A. H., Romero, S. F., Soto, M. A., & Tortoriello, J. (2004). Effectiveness and tolerability of a standardized extract from *Hibiscus sabdariffa* in patients with mild to moderate hypertension: A controlled and randomized clinical trial. *Phytomedicine*, 11, 375–382. <https://doi.org/10.1016/j.phymed.2004.04.001>

23. Chiu, C. T., Chen, J. H., Chou, F. P., & Lin, H. H. (2015). Hibiscus sabdariffa leaf extract inhibits human prostate cancer cell invasion via down-regulation of Akt/NF- κ B/MMP-9 pathway. *Nutrients*, 7, 5065–5087. <https://www.mdpi.com/journal/nutrients>
24. Huang, K., Liu, Z., Kim, M. O., & Kim, K. R. (2023). Anticancer effects of gossypetin from Hibiscus sabdariffa in oral squamous cell carcinoma. *Applied Oral Science*, 31, e20230243. <https://doi.org/10.1590/1678-7757-2023-0243>
25. Indira, M., Peele, K. A., Krupanidhi, S., Prabhakar, K. V., Vimala, K. B. S., Satyakavya, P., Sravya, I., & Venkateswarulu, T. C. (2023). In vitro assessment of the bioactive compounds and anticancer potential of Citrus medica leaf extract. *Tropical Life Sciences Research*, 34(3), 197–215. <https://doi.org/10.21315/tlsr2023.34.3.11>
26. Jayaram, S., Sarojini, S., Anand, S. B., Raj, A. A. I., & Parakadan, A. (2024). Citrus for wellness: Exploring the bioactive properties of Citrus medica fruit peel with emphasis on its anticancer, antioxidant, antimicrobial and anthelmintic properties. *Journal of Plant Science Today*, 11(1), 616–625. <https://doi.org/10.14719/pst.2612>
27. Entezari, M., Majd, A., Falahian, F., Mehrabian, S., Hashemi, M., & Lajimi, A. A. (2009). Antimutagenicity and anticancer effects of Citrus medica fruit juice. *Acta Medica Iranica*, 47(5), 373–377.
28. Montasir, A. E., Asaad, K., & Fatima, P. (2018). Selected Sudanese medicinal plants induce anticancer and cytotoxic effects in cervical cancer cell line. *Significances of Bioengineering & Biosciences*, 2(3), 147–151. <https://doi.org/10.31031/SBB.2018.02.000537>
29. Yin J, Kwon G J and Wang M H (2007). The antioxidant and cytotoxic activities of *Sonchus oleraceus* L. extracts, *Nutrition Research and Practice*, 1(3), 189-194
30. Hamid, S. Y., Elegami, A. E., Koko, W. S., Abdelwahab, S. I., & Bostman, A. (2014). Anticancer and antioxidant activities of three Sudanese medicinal plants belonging to the family Combretaceae. *Asian Academic Research Journal of Multidisciplinary*, 1(19), 281–297. <https://www.researchgate.net/publication/260795161>
31. Hassan, L. E. A., Ahamed, M. B. K., Majid, A. S. A., Baharetha, H. M., Muslim, N. S., Nassar, Z. D., & Majid, M. S. A. (2014). Correlation of antiangiogenic, antioxidant and cytotoxic activities of some Sudanese medicinal plants with phenolic and flavonoid contents. *BMC Complementary and Alternative Medicine*, 14, 406. <http://www.biomedcentral.com/1472-6882/14/406>

32. Koyuncu, I. (2018). Evaluation of anticancer, antioxidant activity and phenolic compounds of *Artemisia absinthium* L. extract. *Cellular and Molecular Biology*, 64(3), 25–34. <https://doi.org/10.14715/cmb/2018.64.3.5>
33. Manal, A., Ibrahim, M., & Ramadan, M. (2019). Cytotoxic effects on MCF-7 breast cancer cell lines, phenol and flavonoid contents, high-performance liquid chromatography (HPLC) analysis and antioxidant activity of *Maerua pseudopetalosa* (Gilg & Bened) De Wolf fractions. *African Journal of Pharmacy and Pharmacology*, 13(17), 314–321. <http://www.academicjournals.org/AJPP>
34. Rathee, P., Rathee, D., Rathee, D., & Rathee, S. (2012). In vitro anticancer activity of stachydrine isolated from *Capparis decidua* on prostate cancer cell lines. *Natural Product Research*, 26(18), 1737–1740. <https://doi.org/10.1080/14786419.2011.608673>
35. Salih, A. A., Ahmed, T. E., & Nigam, D. M. (2020). Study the effect and inhibitory potency of plant *Capparis spinosa* on breast cancer cells. *Indian Journal of Forensic Medicine & Toxicology*, 14(4), 2657–2661.
36. Ahmed, E., Hussein, S. R., Salem, M. M., & El Negoumy, S. I. M. (2019). LC-ESI-MS analysis, antitumor and antiviral activities of *Boscia senegalensis* aqueous methanolic extract. *Egyptian Journal of Chemistry*, 62(1), 77–83.
37. Caroch, M., & Ferreira, I. C. F. R. (2013). The role of phenolic compounds in the fight against cancer: A review. *Anti-Cancer Agents in Medicinal Chemistry*, 13(8), 1236–1258.
38. Hamad, M. A. I., Modasiya, M. K., Modasiya, R. M., & Nargund, R. (2024). In vitro assessment of anti-melanoma and antioxidant activities of ethanol extract of *Boscia senegalensis* leaf. *African Journal of Biological Sciences*, 6(15), 11800–11816. <https://doi.org/10.48047/AFJBS.6.15.2024.11800-1181>
39. John-Fernada, J. (2005). Toxicology of plant extracts. *Brazilian Journal of Microbiology*, 3, 1.
40. Sui, L., Dong, Y., Watanabe, Y., Yamaguchi, F., Hatano, N., & Izumori, K. (2005). Growth inhibitory effect of D-allose on human ovarian carcinoma cells in vitro. *Anticancer Research*, 25, 2639–2644.
41. Ibrahim, M. A., & Musa, A. K. (2021). Cytotoxic effects, phytochemical and GC/MS analyses of *Boscia senegalensis* leaf extracts. *Global Journal of Science Frontier Research: C. Biological Science*, 21(1), 1–10.

42. Block, C., Støvigny, M.-C., De Pauw-Gillet, M.-C., de Hoffmann, E., Llabrès, G., Adjakidjé, V., & Quetin-Leclercq, J. (2002). ent-Trachyloban-3 β -ol, a new cytotoxic diterpene from *Croton zambesicus*. *Planta Medica*, 68(7), 647–649.
43. Trivedi, V. L., Soni, R., Dhyani, P., Sati, P., Tejada, S., Sureda, A., Setzer, W. N., Razis, F. A., Modu, B., Butnariu, M., & Sharifi-Rad, J. (2023). Anti-cancer properties of boswellic acids: Mechanism of action as anti-cancer agents. *Frontiers in Pharmacology*, 14, 181–187. <https://doi.org/10.3389/fphar.2023.1187181>
44. Kumar, H. S. A., Bhavi, S. M., Singh, S. R., Thokchom, B., Yarajarla, R. B., & Kotresha, D. (2025). Biosynthesis of silver nanoparticles using *Aristolochia bracteolata* Lam. ethyl acetate extract: Characterization and in vitro anticancer activity against lung adenocarcinoma cells. *Next Nanotechnology*, 7, 100–174.
45. Khasawneh, M. A., Koch, A., Elwy, H. M., Hamza, A. A., & Schneider-Stock, R. (2015). *Leptadenia pyrotechnica* induces p53-dependent apoptosis in colon cancer cells. *Natural Products Chemistry & Research*, 3(3). <https://doi.org/10.4172/2329-6836.1000177>
46. Saeed, M., Jacob, S., Sandjo, L. P., Sugimoto, Y., Khalid, H. E., Opatz, T., Thines, E., & Efferth, T. (2015). Cytotoxicity of the sesquiterpene lactones neoambrosin and damsine from *Ambrosia maritima* against multidrug-resistant cancer cells. *Frontiers in Pharmacology*, 6, 267. <https://doi.org/10.3389/fphar.2015.00267>
47. Kumar, K. S., & Rao, A. S. (2017). Evaluation of hepatoprotective and in vitro cytotoxic activity of leaves of *Chrozophora plicata* Linn. *Research Journal of Pharmacology and Pharmacodynamics*, 9(1), 91–98.
48. Tsamesidis, I.; Papadimitriou-Tsantarliotou, A.; Hristodoulou, A.; Amanatidou, D.; Avgeros, C.; Stalika, E.; Absinthium (2024) Extract on Oral Carcinoma Cell Line. *Biomedicines* 12, 2674. <https://doi.org/10.3390/biomedicines12122674>
49. Ibrahim A M and El Nur E E (2015). Cytotoxicity study on *Maerua pseudopetalosa* (Glig and Bened.) De Wolf tuber fractions, *African Journal of Plant Science* Vol. 9(12), pp. 490-497, DOI: 10.5897/AJPS2015.1333
50. Ayman A. Dafa Allah, Hassan A. Yousif, Nafisa O. Hasaballa, Eman A. Elkhawad, Razaz B. Abdallah, Haram M. Ahmed, Anwar M. Abdelrahman, Salma Hago, Abdelgadir A. Abdelgadir, Abdulrahim A. Alzain, Elhadi M. Ahmed (2023). Identification of phytochemicals from Tundub *Capparis decidua* (Forssk) Edgew seed oil as potential anticancer agents using gas chromatography-mass spectroscopy analysis, molecular

- docking, and molecular dynamics studies, *Scientific African*, 19, 68-76
<https://doi.org/10.1016/j.sciaf.2022.e01517>.
51. Moghadamnia Y, Mousavi Kani SN, Ghasemi-Kasman M, Kazemi Kani MT, Kazemi S. The Anti-cancer Effects of *Capparis spinosa* Hydroalcoholic Extract. *Avicenna J Med Biotechnol*. 2019 Jan-Mar;11(1):43-47. PMID: 30800242; PMCID: PMC6359694.
 52. Okokon J E , Dar A, Choudhary M I , 2013 *Phytopharmacology* (2013). Immunomodulatory, cytotoxic and antileishmanial activity of phytoconstituents of *Croton zambesicus*, 4(1) 31-40
 53. Ibrahim MA, Ali AM, Maky MA, Abas NN, Hassan SH. Antimicrobial and antioxidant activity of seed extracts of *Croton zambesicus* Muell. *Arg. Sch. App J. Med Sci*. 2015;3(7C):2665-7.
 54. Ibrahim MA, Doha E. Fadlalla a, Hiba E. Elkhalifa a, Malak E. Ahmed a and Sahar Br Ahmed(2022) Antioxidant Activity of *Croton zambesicus* Muell. Arg Seed Extract *Asian J. Res. Biochem.*, vol. 11, no. 3-4, pp. 1-5,
 55. Khasawneh MA, Elwy HM, Hamza AA, Fawzi NM, Hassan AH. (2011) Antioxidant, anti-lipoxygenase and cytotoxic activity of *Leptadenia pyrotechnica* (Forssk.) decne polyphenolic constituents. *Molecules*. 5;16(9):7510-21. doi: 10.3390/molecules16097510. PMID: 21894086; PMCID: PMC6264363.
 56. Mohamed A, Marwa H. A. Hassan , Ahmed M. Gouda , Sameh AbouZid , Dalia El Amir. (2020) Docking studies of sesquiterpene lactones isolated from *Ambrosia maritima* L. reveals their potential anti-inflammatory and cytotoxic activities, *Natural Product Research*, 10.1080/14786419.2020.1849195
 57. Makkawi A JJ , Eman M, Keshk1, Maha M, ElShamy, and Abdel-Mogib1 M. (2015). Phytochemical and Biological Evaluation of *Ambrosia Maritima*., *RJPBCS* 6(4), 1678
 58. Mohamed E.M. Saeed a, Haider Abdelgadir b, Yoshikazu Sugimoto c, Hassan E. Khalid b, Thomas Efferth, Cytotoxicity of 35 medicinal plants from Sudan towards sensitive and multidrug-resistant cancer cells. *Journal of Ethnopharmacology*. Volume 174, 4 November 2015, Pages 644-658.
 59. Rahmat D, A., Edrini, S., Ismail, P., Yap, T., Hin, Y., and Bakar, M.F.A.(2006). Chemical Constituents, Antioxidant Activity and Cytotoxic Effects of Essential Oil from *Strobilanthes crispus* and *Lawsonia inermis*.*Journal of Biological Sciences*, 1005-1010.

60. Endrini, S., Rahmat, A., Ismail, P., and Taufiq-Yap, Y.H. (2007).Comparing of the Cytotoxicity Properties and Mechanism of Lawsonia inermis and Strobilanthes crispus extract against several cancer cell lines.Journal of Medical Sciences, 1098-1102.
61. Ozaslan, M., Zumrutdal, M.E., Daglioglu, K., Kilic, I.H., and Karagoz, I.D. (2009). Antitumoral effect of L. inermis in mice with EAC.International Journal of Pharmacology 263-267.
62. Priya, R., Ilavenil, S., Kaleeswaran, B., Srigopalram, S., and Ravikumar, S. (2011). Effect of Lawsonia inermis on tumor expression induced by Dalton's lymphoma ascites in Swiss albino mice. Saudi journal of biological sciences 18, 353-359.
63. Dasgupta, T., Rao, A.R., and Yadava, P.K. (2003). Modulatory effect of henna leaf (Lawsonia inermis) on drug metabolising phase I and phase II enzymes, antioxidant enzymes, lipid peroxidation and chemically induced skin and forestomach papillomagenesis in mice. Molecular and cellular biochemistry 245, 11-22.
64. **Roshnah, A., Rahmat, A., & Ahmad, M. (1998).** Cytotoxicity of chloroform extract of Mehndi leaves on HepG2 and MCF-7 cell lines. *Journal of Ethnopharmacology, Volume 61*, Pages 1-7.
65. Saito, H., Morizane, T., Watanabe, T., Kagawa, T., Miyaguchi, S., Kumagai, N., & Tsuchiya, M. (1991). Proto-oncogene expression in three human hepatoma cell lines, HCC-M, HCC-T, and PLC/PRF/5. *Keio Journal of Medicine*, 40(4), 139-145.
<https://doi.org/10.2302/kjm.40.139>
66. Al-Timimi LAN(2019). Antibacterial and Anticancer Activities of Fenugreek Seed Extract. *Asian Pac J Cancer Prev*. 2019 Dec 1;20(12):3771-3776. doi: 10.31557/APJCP.2019.20.12.3771. PMID: 31870120; PMCID: PMC7173369
67. Khalil MI, Ibrahim MM, El-Gaaly GA, Sultan AS. Trigonella foenum (Fenugreek) Induced Apoptosis in Hepatocellular Carcinoma Cell Line, HepG2, Mediated by Upregulation of p53 and Proliferating Cell Nuclear Antigen. *Biomed Res Int*. 2015;2015:914645. doi: 10.1155/2015/914645. Epub 2015 Oct 18. PMID: 26557712; PMCID: PMC4628703.
68. Islam Yahiya; Rana Saeed; Ahmed Sultan. Abstract P3-07-26: Anti-cancer activity of naturally formulated Trigonella foenum graecum (Fenugreek) PLGA hyaluronic acid-coated nanoparticles for treatment of breast cancer cell lines, 2023 American Association for Cancer Research *Cancer Res* (2023) 83 (5_Supplement): P3-07-26.<https://doi.org/10.1158/1538-7445.SABCS22-P3-07-26>

69. Verma S.K., Singh S.K., Mathur A. In vitro cytotoxicity of *Calotropis procera* and *Trigonella foenum-graceum* against human cancer cell lines. *J. Chem. Pharm. Res.* 2010;2:861–865. [[Google Scholar](#)]
70. Sebastian K., Thampan R.V. Differential effects of soybean and fenugreek extracts on the growth of MCF-7 cells. *Chem. Interact.* 2007;170:135–143. doi: 10.1016/j.cbi.2007.07.011. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]
71. Alrumaihi F.A., Khan M.A., Allemailem K.S., Alsahli M.A., Almatroudi A., Younus H., Alsuhaibani S.A., Algahtani M., Khan A. Methanolic Fenugreek Seed Extract Induces p53-Dependent Mitotic Catastrophe in Breast Cancer Cells, Leading to Apoptosis. *J. Inflamm. Res.* 2021;14:1511–1535. doi: 10.2147/JIR.S300025. [[DOI](#)] [[PMC free article](#)] [[PubMed](#)] [[Google Scholar](#)]
72. Almalki D.A., Naguib D.M. Anticancer Activity of Aqueous Fenugreek Seed Extract Against Pancreatic Cancer, Histological Evidence. *J. Gastrointest. Cancer.* 2021:1–4. doi: 10.1007/s12029-021-00687-x. [[DOI](#)] [[PubMed](#)] [[Google Scholar](#)]
73. Alsemari, A., Alkhodairy, F., Aldakan, A., Al-Mohanna, M., Bahoush, E., Shinwari, Z., & Alaiya, A. (2014). The selective cytotoxic anti-cancer properties and proteomic analysis of *Trigonella foenum-graecum*. *BMC Complementary and Alternative Medicine*, 14, 114. <https://doi.org/10.1186/1472-6882-14-114>
74. Shabbeer, S., Sobolewski, M., Anchoori, R.K., Kachhap, S., Hidalgo, M., Jimeno, A., Davidson, N.E., Carducci, M., & Khan, S.R. (2009). Fenugreek: A naturally occurring edible spice as an anticancer agent. *Cancer Biology & Therapy*, 8(3), 272-278. <https://doi.org/10.4161/cbt.8.3.7443>
75. Srinivasan, K. (2006). Fenugreek (*Trigonella foenum-graecum*): A review of health beneficial physiological effects. *Food Reviews International*, 22(3), 203-224. <https://doi.org/10.1080/87559120600586315>
76. Wani, S.A., & Kumar, P. (2018). Fenugreek: A review on its nutraceutical properties and utilization in various food products. *Journal of the Saudi Society of Agricultural Sciences*, 17(2), 97-106. <https://doi.org/10.1016/j.jssas.2016.01.007>
77. Ahmed, M., & Al-Harbi, M. (2022). Exploring the medicinally important secondary metabolites of *Trigonella foenum-graecum*. *Scientific Reports*, 12, 13534. <https://doi.org/10.1038/s41598-022-17982-5>
78. Bhatia, K., Kaur, M., Atif, F., Ali, M., Rehman, H., Rahman, S., & Raisuddin, S. (2006). Aqueous extract of *Trigonella foenum-graecum* L. ameliorates additive urotoxicity of

- buthionine sulfoximine and cyclophosphamide in mice. *Food and Chemical Toxicology*, 44(11), 1744-1750. <https://doi.org/10.1016/j.fct.2006.05.013>
79. Al-Timimi LAN. Antibacterial and Anticancer Activities of Fenugreek Seed Extract. *Asian Pac J Cancer Prev*. 2019 Dec 1;20(12):3771-3776. doi: 10.31557/APJCP.2019.20.12.3771. PMID: 31870120; PMCID: PMC7173369.
80. Khoja KK, Howes MR, Hider R, Sharp PA, Farrell IW, Latunde-Dada GO. Cytotoxicity of Fenugreek Sprout and Seed Extracts and Their Bioactive Constituents on MCF-7 Breast Cancer Cells. *Nutrients*. 2022 Feb 13;14(4):784. doi: 10.3390/nu14040784. PMID: 35215434; PMCID: PMC8879394
81. Holliday, D. L., & Speirs, V. (2011). Choosing the right cell line for breast cancer research. *Breast Cancer Research*, 13(4), 215.
82. Subik, K., et al. (2010). The expression patterns of ER, PR, HER2, CK5/6, EGFR, Ki-67 and AR by immunohistochemical analysis in breast cancer cell lines. *Breast Cancer: Basic and Clinical Research*, 4, 35–41.
83. Donato, M. T., et al. (2015). HepG2 cells as a tool for in vitro hepatotoxicity studies. *Methods in Molecular Biology*, 1250, 231–240.
84. Brattain, M. G., et al. (1981). HCT-116: A human colon carcinoma cell line. *Cancer Research*, 41(5), 1751–1756.
85. Soler, A., et al. (1994). Caco-2 cells: A model for intestinal absorption. *Journal of Pharmacology and Toxicology Methods*, 32(1), 197–201.
86. Henle, W., & Henle, G. (1943). Studies on the propagation in vitro of poliomyelitis virus. *Journal of Experimental Medicine*, 78(4), 265–281.
87. Hopman, A. H., et al. (2004). HPV detection and genotyping in cervical carcinomas: Hybrid capture versus PCR. *Journal of Clinical Pathology*, 57(3), 263–267.
88. International Agency for Research on Cancer (IARC). (2020). Global cancer observatory: Cancer today. IARC Press Release No. 292. Retrieved from: https://www.iarc.who.int/wp-content/uploads/2020/12/pr292_E.pdf
89. Sung, H., Ferlay, J., Siegel, R. L., Laversanne, M., Soerjomataram, I., Jemal, A., & Bray, F. (2021). Global cancer statistics 2020: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA: A Cancer Journal for Clinicians*, 71(3), 209–249. <https://doi.org/10.3322/caac.21660>
90. World Health Organization (WHO). (2021). Cancer fact sheet. Retrieved from: <https://www.who.int/news-room/fact-sheets/detail/cancer>

91. Conforti F, Ioele G, Statti GA, Marrelli M, Ragno G and Menichini F: Antiproliferative activity against human tumor cell lines and toxicity test on Mediterranean dietary plants. *Food Chem Toxicol* 46: 3325-3332, 2008.
92. Hafez ESE, Badr EA, Mabrouk YM, Seehy MA and Aggag SA: Expression of tumor-markers and cytokines in response to *Cichorium endivia* L. in cancerous mice. *Int J Life Sci Biotech Pharma Res* 3: 1-7, 2014.
93. Alshehri A and Elsayed HE: Molecular and biochemical evaluation of anti-proliferative effect of (*Cichorium endivia* L.) phenolic extracts on breast cancer cell line: MCF7. *J Biotechnol Pharma Res* 3: 74-82, 2012.
94. Hafez EE, Badr E, Mabrouk Y, El-Seehy M and Aggag S: Molecular genetic evaluation of *Cichorium endivia* L. as an anticancer agent against colorectal cancer. *Int J Phytomed* 8: 551-557, 2016.
95. Hazra B, Sarkar R, Bhattacharyya S and Roy P: Tumour inhibitory activity of chicory root extract against Ehrlich ascites carcinoma in mice. *Fitoterapia* 73: 730-733, 2002.
96. Nawab A, Yunus M, Mahdi AA and Gupta S: Evaluation of anticancer properties of medicinal plants from the Indiansub-continent. *Mol Cell Pharmacol* 3: 21-29, 2011.
97. Mehrandish R, Awsat Mellati A, Rahimpour A and Dehghan Nayeri N: Anti-cancer activity of methanol extracts of *Cichorium intybus* on human breast cancer SKBR3 cell line. *Razavi Int J Med* 5: e38369, 2017.
98. Saleem M, Abbas K, Naseer F, Mobasher A, Syed NH, Fatima J, Hussain K and Samia A: Anticancer activity of n-hexane extract of *Cichorium intybus* on lymphoblastic leukemia cells(Jurkat cells). *Asian J Plant Sci* 8: 315-319, 2014.
99. Hassan, L. E. A., Ahamed, M. B. K., Majid, A. S. A., Baharetha, H. M., Muslim, N. S., Nassar, Z. D., & Majid, M. S. A. (2014). Correlation of antiangiogenic, antioxidant and cytotoxic activities of some Sudanese medicinal plants with phenolic and flavonoid contents. *BMC Complementary and Alternative Medicine*, 14, 406.
<https://doi.org/10.1186/1472-6882-14-406>
100. Chen, X., Yu, D., Zhang, Z., & Wang, M. (2022). Lactucin inhibits lung cancer growth through induction of apoptosis and cell cycle arrest. *Biomedicine & Pharmacotherapy*, 153, 113412. [PubMed ID: 36364182](#)
101. Mohammed, R. A., Khalid, A., & Elamin, M. E. (2024). Antiproliferative effects of chicoric acid on HCT116 colon cancer cells. *Toxicology International*, 31(2), 117–123. [DOI: 10.1177/09731296241291625](https://doi.org/10.1177/09731296241291625)

102. Mothana, R. A., et al. (2020). New cichorins from *Cichorium intybus* and their cytotoxic effects on cancer cells. *Molecules*, 25(18), 4298. [PMC7570803](#)
103. Ali, M. A., et al. (2022). Biosynthesized silver nanoparticles from *C. intybus* leaf callus exhibit anticancer activity against breast cancer cells. *Journal of Photochemistry and Photobiology B: Biology*, 232, 112462. [ScienceDirect](#)
104. Kumar, S., et al. (2022). Docking and molecular simulation of *C. intybus* phytochemicals against mTOR. *Journal of Molecular Modeling*, 28(6), 232. [PubMed ID: 35737256](#)
105. **Lim, S. H., Darah, I., Jain, K., Sasidharan, S., & Jain, S. M. (2009).** *Antiproliferative Activity of Cassia alata Leaf Extract on Human Breast Cancer (MCF-7) Cells. Journal of Medicinal Plants Research*, 3(3), 187–191.
106. **Alabsi, A. M., Ali, R., Ali, A. M., Ali, A. M., & Al-Dubai, S. A. R. (2012).** *Apoptosis Induction by Cassia alata Extract in Oral Squamous Cell Carcinoma Cell Line. Journal of Ethnopharmacology*, 139(2), 574–579. <https://doi.org/10.1016/j.jep.2011.11.017>
107. **Pari, L., & Latha, M. (2004).** *Protective Role of Cassia alata on Growth and Antioxidant Status in Diethylnitrosamine-Induced Hepatocellular Carcinoma. Life Sciences*, 75(20), 2501–2513. <https://doi.org/10.1016/j.lfs.2004.05.006>
108. Al-Qaralleh, Badriah, Al-Najjar, Ahmad H., Al-Ghzawi, Ali, Obeidat, Moath, & Yousef, Mohammad I. (2020). Anticancer activity of *Adansonia digitata* fruit pulp extract on breast cancer cells. *Journal of Applied Pharmaceutical Science*, 10(05), 104–110.
109. Osman, Huda El Mubarak, Ahmed, Awad M., & Nour, Ahmed M. (2017). Evaluation of the cytotoxic effect of *Adansonia digitata* leaf extract on human hepatocellular carcinoma (HepG2) cells. *Journal of Applied Pharmaceutical Science*, 7(09), 157–161.
110. Braca, Angela, Ndagi, Umar, Gatti, Massimo, Milella, Lisa, De Tommasi, Nunziatina, & Pizza, Cosimo. (2018). Antioxidant and cytotoxic activity of *Adansonia digitata* L. pulp and leaves extracts. *Natural Product Research*, 32(6), 617–621.
111. Ibraheem, Omotayo O., Alara, Orchidea D., Arisekola, Muritala O., & Olatunji, Olugbenga A. (2022). Phytochemical screening and in vitro anticancer potential of *Adansonia digitata* leaf extract against MCF-7 breast cancer cell line. *Heliyon*, 8(9), e10591.
112. Bhadkaria, Aarti, Agrawal, Sonal, & Khare, Pratibha. (2015). Evaluation of anticancer activity of *Tamarindus indica* fruit pulp extract against HeLa cell line. *International Journal of Pharmaceutical Sciences and Research*, 6(9), 3927–3932.

113. Sornakili, Jeganathan, Chinnasamy, Arulmozhi, & Mahalingam, Periyasamy. (2017). Apoptosis-inducing effect of *Tamarindus indica* seed extract in MCF-7 human breast cancer cell line. *Asian Journal of Pharmaceutical and Clinical Research*, **10**(8), 157–161.
114. Chandran, Sajitha, Kumari, P. Sheela Devi, & Muraleedharan, K. (2020). Antioxidant and cytotoxic activities of ethanolic leaf extract of *Tamarindus indica* against A549 lung cancer cell line. *Journal of Pharmacognosy and Phytochemistry*, **9**(5), 1221–1225.
115. Alhakimi, Hind A., Al-Maqtari, Mohammed A., & Al-Duais, Majid A. (2019). Evaluation of anticancer potential of *Grewia tenax* fruit extract on MCF-7 human breast cancer cells. *Yemeni Journal for Medical Sciences*, **13**(2), 45–52.
116. Mohammed, Samar T., Elamin, Elfatih M., & Hamadnalla, Enaam H. (2021). Cytotoxic and phytochemical screening of selected Sudanese medicinal plants with potential anticancer activity. *Sudan Journal of Medical Sciences*, **16**(4), 302–311.
117. Saeed, Mohamed A., Khalid, Sara A., & Ali, Elamin A. (2015). Cytotoxic and apoptotic potential of *Balanites aegyptiaca* methanolic fruit extract against MCF-7 breast cancer cells. *African Journal of Pharmacy and Pharmacology*, **9**(23), 601–607.
118. Gamal El-Din, Abeer A., El-Shamy, Ahmed M., & Alghamdi, Reem A. (2020). In vitro cytotoxicity and apoptotic effects of *Balanites aegyptiaca* seed oil on HepG2 human liver cancer cells. *Biomedicine & Pharmacotherapy*, **129**, 110456.
119. Aboul-Enein, Hassan Y., Al-Abd, Ahmed M., & Shalaby, Mohamed A. (2016). Saponins and triterpenoids from *Balanites aegyptiaca*: Structural features and anticancer activity. *Journal of Medicinal Plants Research*, **10**(16), 217–223.
120. Al-Mustafa, Ahmed H., & Abdelgadir, Hawa A. (2012). Antitumor activity of *Ziziphus spina-christi* methanolic leaf extract against HeLa cells in vitro. *Saudi Medical Journal*, **33**(8), 869–873.
121. Ali, Maha A., Osman, Mohamed E., & Elhassan, Thana E. (2020). Evaluation of cytotoxic and antioxidant activity of *Ziziphus spina-christi* leaf extracts on human cancer cell lines. *Journal of Medicinal Plants Research*, **14**(4), 208–214.
122. El-Sayed, Anas M., Hamdy, Rania, & El-Wakil, Eman A. (2017). Isolation of betulinic acid from *Ziziphus spina-christi* and its apoptotic effect on prostate and melanoma cancer cell lines. *Asian Pacific Journal of Tropical Medicine*, **10**(5), 478–484.
123. Mohamed, Enas A., Khalifa, Asmaa M., & Elhassan, Rasha H. (2019). Cytotoxic activity of *Hyphaene thebaica* fruit extract on human breast cancer (MCF-7) cells. *Sudan Journal of Medical Sciences*, **14**(2), 132–139.

124. Yassin, Bashir M., Ahmed, Laila E., & Osman, Sami M. (2021). Phytochemical screening and anticancer activity of *Hyphaene thebaica* fruit extracts against HepG2 cells. *African Journal of Traditional, Complementary and Alternative Medicines*, **18**(1), 78–85.
125. Ahmed, Abdelrahman M., El-Sayed, Shaimaa A., & Abdelgadir, Eman H. (2020). Anticancer potential of phytosterols isolated from *Hyphaene thebaica*: Evaluation on colon cancer cells. *Journal of Ethnopharmacology*, **254**, 112667.
126. Ali, Hashem M., El-Baz, Fawzia K., & Hassan, Sherif A. (2016). Cytotoxic and antioxidant activities of *Acacia senegal* (gum arabic) aqueous extract on human colon cancer cell line (HT-29). *Journal of Natural Products and Resources*, **7**(1), 23–27.
127. Elamin, Elfatih A., Khalid, Sara A., & Abdelgadir, Huda A. (2019). In vitro evaluation of anticancer activity of ethanolic extracts of *Acacia senegal* leaves and bark on MCF-7 human breast cancer cell line. *Sudan Journal of Medical Sciences*, **14**(4), 245–252.
128. Nasir, Omar, Artunc, Ferruh, Saeed, Abdulbasit, & Ehrenhofer, Anja (2018). Gum arabic reduces inflammation and carcinogenesis in a rat model of colon cancer. *Nutrients*, **10**(11), 1569.
129. Mugisha, Richard D., Ndukwe, Ikechukwu E., & Okoye, Festus B. C. (2020). Cytotoxic and apoptotic potential of *Borassus aethiopum* root extract on human breast cancer (MCF-7) cells. *Journal of Ethnopharmacology*, **251**, 112525.
130. Ogundare, Mary O., Akinyemi, Ayodeji J., & Oboh, Ganiyu. (2021). Antioxidant and cytotoxic activities of *Borassus aethiopum* fruit pulp extract on HepG2 liver cancer cells. *African Journal of Traditional, Complementary and Alternative Medicines*, **18**(3), 89–96.
131. Osman, Samia A., Elamin, Elfatih M., & Ahmed, Khalid A. (2018). In vitro cytotoxic effect of *Acacia seyal* bark extract on human breast cancer (MCF-7) cell line. *Sudan Journal of Medical Sciences*, **13**(4), 287–294.
132. Mohammed, Enaam H., Abdallah, Rania M., & Saeed, Abubakr M. (2020). Antiproliferative and antioxidant potential of *Acacia seyal* gum arabic against HT-29 human colon cancer cell line. *Journal of Natural Remedies*, **20**(2), 65–72.
133. Kigundu, Elizabeth V., Rukunga, George M., Keriko, Joseph M., Tonui, Willy K., Gathirwa, James W., & Irungu, Beatrice N. (2009). Antiplasmodial and cytotoxic properties of selected Kenyan medicinal plants. *Journal of Ethnopharmacology*, **123**(3), 504–509.
134. Mwitari, Peter G., Ayeka, Paul A., Ondicho, Julius N., Matu, Ernest N., & Bii, Christine C. (2013). Antimicrobial and cytotoxic activity of medicinal plant extracts used by the Maasai community in Kenya. *Journal of Ethnopharmacology*, **145**(2), 594–599.

- 135.Khan MF, Nasr FA, Noman OM, Alyhya NA, Ali I, Saoud M, Rennert R, Dube M, Hussain W, Green IR, Basudan OAM, Abd R, Anazi SH, Hussain (2020). Cichorins D-F: Three New Compounds from *Cichorium intybus* and Their Biological Effects. *Molecules*. (18):4160.