Phytochem Rev
https://doi.org/10.1007/s11101-024-09957-5

Medicinal plants cultivated in Egypt with anticancer potential; a systematic review

Iman Abdelhady Elshnoudy · Abdallah M. Elkhouly · Mira Masoud · Hanin A. Rabea · Fotouh R. Mansour

Received: 14 June 2023 / Accepted: 13 March 2024

Abstract The increase in cases of various cancers, the number of cancer patients, and the serious side effects of current chemical treatments have encouraged researchers to discover novel and more effective drugs from plant sources. In this review, PubMed and Scopus were searched for English-language peer-reviewed articles published since 1994, using the keywords: Medicinal plants, Egypt, and Cancer. The inclusion criteria for this systematic review were English peer-reviewed original research articles. A total of 286 studies were included. Studies have shown that the active compounds in certain plants can have anticancer activities by various mechanisms, such as cell cycle arrest, apoptosis induction, and antioxidant effects. Additionally, it is evident that medicinal plants can act as inhibitors of cancer cells. Plants can also act as immune checkpoint inhibitors, which inhibit proteins such as PD-L1 on tumor cells, PD-1 and CTLA-4 on T cells, and help to regulate immune responses. This review also discusses the efficacy of nanoparticles of these plants against cancer cells. The findings indicate the high potential of investigating the bioactive anticancer components of Egyptian medicinal plants for advancing novel treatments that are more effective in combating cancer. The extracts and active compounds of the medicinal plants detailed in this review could provide the foundation for further clinical trials to be conducted, to develop new anticancer drugs.

Keywords Cancer · Cytotoxic · Medicinal plants · Egypt · Apoptosis · Herbal medicine

Abbreviations

AA	Artemisia annua
A498	Renal cell line
ARI	Acute respiratory illness
ALK	Anaplastic lymphoma kinase
AuNP	Gold nanoparticle
Bcl-2	B-cell lymphoma 2
CL	Chronic lymphocytic leukemia

I. A. Elshnoudy · A. M. Elkhouly
Faculty of Medicine, Tanta University, Tanta, Egypt
e-mail: eman.31011021@med.tanta.edu.eg

A. M. Elkhouly
e-mail: abdallah30986576@med.tanta.edu.eg

M. Masoud
Department of Pharmacognosy, Faculty of Pharmacy, Damanhour University, Damanhour 22516, Egypt
e-mail: Mira.masoud@pharm.dmu.edu.eg

H. A. Rabea
Faculty of Pharmacy, Pharos University in Alexandria, Alexandria, Egypt
e-mail: hanin.abdelhamied255@gmail.com

F. R. Mansour (✉)
Department of Pharmaceutical Analytical Chemistry, Faculty of Pharmacy, Tanta University, Elgeish Street, The Medical Campus of Tanta University, Tanta 31111, Egypt
e-mail: fotouhrashed@pharm.tanta.edu.eg

Published online: 24 April 2024

CRC	Colorectal cancer
CPS	Capsaicin
EGCG	Epigallocatechin-gallate
EGFR	Epidermal growth factor receptor
FNAT/FNTB	Farnesyltransferase A/B
GBEP	Ginkgo biloba exocarp polysaccharides
GBM	Glioblastoma
HCC	Hepatocellular carcinoma
HePG2	Human hepatocellular carcinoma
Hep-2	Pharynx cancer cell line
HT-1080	Fibrosarcoma cell line
HGPIN	High-grade prostatic intraepithelial neoplasia
IGFR	Insulin-like growth factor 1 receptor
MDR	Multidrug resistance
MMP	Matrix metalloproteinase
MPBE	Moringa peregrina bark extract
MPLE	Moringa peregrina leaf extract
NF-B	Nuclear factor B
NF-kb	Nuclear factor kappa B
OS	Osteosarcoma
PARP	Poly (ADP-ribose) polymerase
PC12	Adrenal phaeochromocytoma cell line
PDGFR	Platelet-derived growth factor receptor
PEITC	Phenethyl isothiocyanate
PI3K	Phosphatidylinositol 3-kinase
PFE	Pomegranate fruit extract
PLGA	Poly(lactic-co-glycolic acid)
Ras	Rat sarcoma protein
RECK	Reversion-inducing-cysteine-rich protein with Kazal motifs
SK-OV-3	Human ovarian cancer cell line
T-24	Bladder carcinoma cell line
TIMP-2	Tissue inhibitor of metalloproteinases 2
TQ	Thymoquinone
UMSCC1	University of Michigan squamous cell carcinoma 1
VEGF	Vascular endothelial growth factor
VEGFR1	Vascular endothelial growth factor receptor 1

Introduction

Cancer is known to be a leading cause of death worldwide, accounting for 10 million deaths in 2020, or one in six deaths. The most common cancers are breast, lung, colorectal, and prostate. Among them, lung, colorectal, and liver remain the most common causes of cancer deaths accounting for 3.5 million deaths, which is about one-third of total cancer deaths in 2020 (World Health Organization 2022). Premature deaths, lost productivity costs, illness and therapy expenses, and the long-term impact on quality of life all contribute to cancer being a major public health threat. (National Cancer Institute). Many cancers can be cured if detected early and treated effectively. There are different conventional treatment modalities available to treat cancer. Chemotherapy is considered the most effective and extensively used approach. It targets the tumor cells and mainly produces reactive oxygen species, which destroy tumor cells through genotoxicity. However, it harms normal cells and leads to diverse dose-dependent side consequences such as fatigue, nausea, hair loss, vomiting, or even death in extreme cases (DeVita and Chu 2008; Aslam et al. 2014; Abbas and Rehman 2018).

Natural plants are excellent sources of bioactive components, such as flavonoids, tannins, alkaloids, and terpenoids that have been confirmed to possess anti-cancer activities. Moreover, these components, when used as nanoparticles, can exhibit more specific advantages, such as biocompatibility, reduced toxicity, excellent stability, enhanced permeability, and precise targeting (Abdalla et al. 2022).

Medicinal plants have been utilized as remedies since ancient times in Egypt. The ancient Egyptians possessed knowledge about numerous medicinal herbs and their effectiveness in treating various illnesses. Today, some of these same plants continue to be utilized (Metwaly et al. 2021).

This review aims to explore the existing research on plants grown in Egypt with anticancer activity. These plants are thoroughly discussed in terms of the part(s) used, active constituents, mechanism of action, and their effects on different cell lines. Clinical trials and the efficacy of nanoparticles derived from these plants have also been reviewed.

Methods

An independent literature survey was performed using PubMed and Scopus. The search process was limited to English-language peer-reviewed articles published

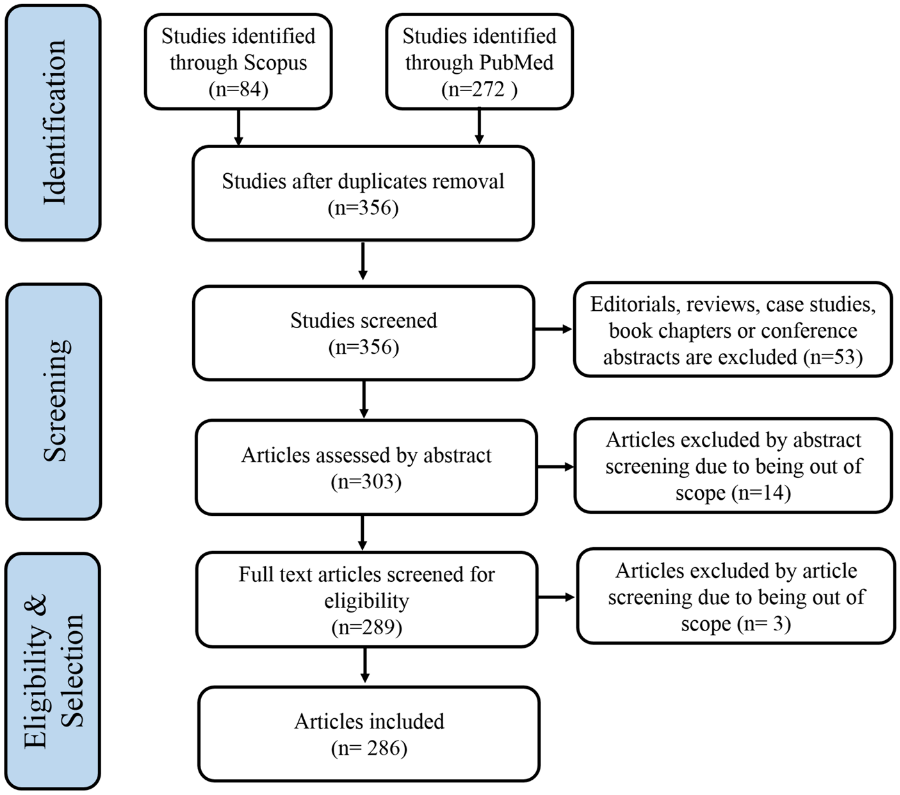

Fig. 1 PRISMA Flow Diagram, showing the number of screened and selected articles

since 1994 till February 2023. Scopus was searched for the following keywords: Medicinal plants, Egypt, and cancer. The same keywords were searched on PubMed using the "Grid Term" option. The data collection period was from November 15, 2022, to November 29, 2022. The inclusion criteria for this systematic review were original research articles peer-reviewed in English. The authors first screened the studies by title, followed by a second step of screening by abstract. The full-text screening step excluded reviews, duplicate articles, abstract-only and irrelevant studies. A total of 286 studies were included. Figure 1 shows the PRISMA flowchart, and the number of items screened.

Results

In this review, 97 medical plants were investigated including details on the parts used, active compounds, and their effects on different cell lines. Most of these plants contained flavonoids and phenols as their active ingredients. These extracts were most used against breast and colon cancer cell lines. Several in vivo and in vitro studies showed the cytotoxic effect of these Egyptian plants, shown in Table 1**.** Nanoparticles, of various sizes, of the extract of 28 plants were used against different cancer cell lines. As a more advanced approach, clinical trials were conducted to assess the effectiveness of 14 plant extracts. Promising results were observed for some extracts, as indicated in Table 2.

Discussion

From the findings, 97 Medicinal plants in Egypt have anticancer potential. These plants contain different active constituents that show different mechanisms of action and target several cancer types.

Table 1 Anticancer effects of various Egyptian medicinal plants

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Beta vulgaris	Root, leaves	Flavonoids (Apigenin), polyphenols, Saponins, glucoside (betanin)	Activation of the oxidative stress, apoptosis and inhibition of cell proliferation, migration	Prostate (DU-145 and PC-3), Cervix (HeLa cells) Breast (MCF-7)	Nowacki et al. (2015), Mancini et al. (2021), Romero et al. (2021)
Camellia sinensis	Leaves	Catechins phenolic compounds (epicatechin (EC), epigallocatechin (EGC), EC 3-gallate (ECG) and EGC 3-gallate (EGCG))	Inhibition of cancer cells proliferation	Prostate (DU145 and LNCaP), Breast (BT474,MCF-7) Skin (melanoma) (UACC-375), Colon (HT-29), Lung (A-427)	Valcic et al. (1996), Adhami et al. (2003), Ravindranath et al. (2009), Hosainzadegan et al. (2010), Shafqat et al. (2021)
		Cinnamomum verum	Bark	polyphenol (transcinnamic acid), cinnamic aldehyde and polyphenols (eugenol)	increase the anti-tumor activities of $CD8^{+}$ T cells
Melanoma (B16F10 and Clone M3) Colon (HCT-15 andHT-29)	Kwon et al. (2009),	Jaganathan et al. (2011), Sadeghi et al. (2019)			
Punica granatum	Fruit	Polyphenols (ellagic acid, punicic acid, ellagitannins, anthocyanins and anthocyanidins, flavones, flavonoids and estrogenic flavonols)	anti-estrogenic, anti-proliferative, anti-angiogenetic, and anti-metastatic	Colon Prostate Skin Lung (A549) Breast	Kim et al. (2002), Khan et al. (2007), Farrukh Afaq et al. (2008), Nuñez-Sánchez et al. (2015), Sharma et al. (2017), Jarrard et al. (2021), Moga et al. (2021)
Glycyrrhiza glabra	Root	Triterpene glycoside (Glycyrrhizin)	Inhibition of cancer cells proliferation and induction of apoptosis	Breast (4T1) Prostate (PC-3)	Harwansh et al. (2011), Hamta et al. (2014), Gioti et al. (2020)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Capsicum annuum	Fruit	Alkaloid (Capsaicin)	Activation of cell cycle arrest, inhibition of angiogenesis and metastasis	Bladder (5637, RT4, T24, MBT-2,TSGH8301,SD48), Prostate (C4-2, LNCaP,PC-3,RWPE-1,DU-145), Colon (colo 205,HT-29,Colo320DM, LoVo,HCT116) Stomach (AGS,HGC-27,SGC-7901, MGC-803, SW-480) Lung (H69, H82, DMS53, DMS114,A549,H1299) Breast (BT-474, SKBR-3, MDA-MB231,MCF-7, MCF-10A,BT-20) Nasopharyngeal (TW 03,TW 01) Cholangiocarcinoma (TFK-1, SZ-1,HuCCT1) Pancreatic (AsPC-1, BxPC-3) Osteosarcoma (MG63,U2OS) Melanoma (B16-F10 mouse melanoma cell line), Fibrosarcoma (HT-1080) Glioblastoma (A172)	Lee et al. (2000, 2004, 2014), Mori et al. (2006), Sánchez et al. (2006, 2008), Young et al. (2007), Chow et al. (2007), Jun et al. (2007), Shin et al. (2008), Amantini et al. (2009), Kyung et al. (2009), Kim et al. (2009), Brown et al. (2010), Lu et al. (2010), Thoennissen et al. (2010), Yang et al. (2010), Choi et al. (2010), Hwang et al. (2011), Chang et al. (2011), Ip et al. (2012), Chen et al. (2012), Pramanik and Srivastava (2012), D'Eliseo et al. (2013), Ying et al. (2013), Lau et al. (2014), Chakraborty et al. (2014), Meral et al. (2014), Wutka et al. (2014), Zheng et al. (2015), Lin et al. (2016, 2017), Ruth and Seong-HO (2016), Wang et al. (2016), Chapa-Oliver and Mejía-Teniente (2016), Jin et al. (2016), Garufi et al. (2016)
Ocimum basilicum	Leaves	phenolic and flavonoids (methyl cinnamate, linalool, eugenol, eucalyptol, hinesol, trans-α-bergamotene and γ-cadinene) triterpene (ursolic acid)	Induction of Apoptosis and oxidative stress	Breast (MCF-7,MDA-MB-231) Cervix (HeLa) laryngeal epithelial carcinoma (HEp-2) glioblastoma (U-87 MG)	Arshad Qamar et al. (2010), Kathirvel and Ravi (2012), Al-Ali et al. (2013), Behbahani (2014), Torres et al. (2018), Aburjai et al. (2020), Alkhateeb et al. (2021)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Zingiber officinale	Rhizome	Flavonoids (kaempferol, catechin, fisetin, and quercetin)	Induction of apoptosis	Breast (MCF-7) triple-negative breast cancer (MDA-MB-231) Liver (HePG2) Prostate(PC-3M)	(Rahman et al. (2012), Kurapati et al. (2012), Citronberg et al. (2013), El-Sayeh et al. (2018)
Curcuma longa	Rhizome	polyphenolic (Curcumin)	Inhibition of angiogenesis, induction of apoptosis	Lung (A549,QU-DB) Breast (T47D) Prostate (PC-3M) Cervix (HeLa) Larynx (Hep-2)	Anand et al. (2008), Pourhassan et al. (2010), Kurapati et al. (2012), Ayyadurai (2013), Hosseinimehr et al. (2014), Ranjbari et al. (2014)
Cassia italca	Aerial parts, leaves	phytosterols (β-sitosterol, stigmasterol), triterpenes (α-amyrin),,anthraquinone	Induction of apoptosis in cancer cells	Mouse lymphoma (L5178Y) Brain (PC12) Liver (HePG2) Cervix (Hela) Prostate (PC3) Breast (MCF-7) Leukemia (CCRF-CEM)	Aboul-Enein et al. (2014), Mohamed (2014), Madkour et al. (2017), Bayala et al. (2020)
Melia azedarach	Leaves, Fruits	steroid,triterpenoid,saponins, limonoids and flavonoids glycosides (quercetin glycosides)	Introduction of apoptosis to cancer cells	Breast cancer (T47D) Human myeloid leukemia (HL-60) Prostate (PC-3) Stomach (SGC-7901) Breast (MCF-7) Colorectal (HCT-116) Lung (A549)	Ervina et al. (2020, 2021), Mehreen Sadaf et al. (2021)
Ricinus communis	Leaves, Fruits, Seeds	Alkaloid (Ricinine), polyphenol (p-Coumaric acid), catechin (Epigallocatechin),fatty acid (Ricinoleic acid), glycoproteins (Lectin, ricin)	Inhibition of metastasis, induction of apoptosis	Breast (MCF-7), triple-negative breast cancer (MDA-MB-231) Ehrlich's ascites carcinoma in mice (EAC) Cervix (Hela) Liver (HepG2) Lung (A549)	Al-Mamun et al. (2016), Ghramh et al. (2019), Majumder et al. (2019), Mabasa et al. (2021), Herawati et al. (2022)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Sesamum indicum	Seeds, Leaves	phenolic (Sesamol), flavonoid o-glycosides (Pedaliin)	radical scavenger, induction of apoptosis	Pancreas (AR42J) Lung (SK-LU-1,H1299,A549) Breast (MCF-7) Triple-negative breast cancer (MDA-MB-231) Liver (HepG2) Colon (DLD-1) (HT29) and (HCT116) Prostate (PC-3) Cervix (HeLa) human lymphoid leukemia Molt (4B) Skin (SK-MEL2)	Miyahara et al. (2000), Galli et al. (2004), Yokota et al. (2007), Harikumar et al. (2010), Deng et al. (2013), Srisayam et al. (2017), Watanabe et al. (2017), Dou et al. (2018), Majdalawieh and Mansour 2019), Wu et al. (2019), Kim et al. (2021)
Melaleuca ericifolia	Leaves	Phenolic (ether methyl eugenol), monoterpenes (1,8-cineole, α-pinene, and α-terpineol)	Inhibition of metastasis	Breast (MCF-7) triple-negative breast cancer (MDA-MB-231) Melanoma	Bar et al. (2010), Chao et al. (2017)
Matthiola		*longipetala*	Aerial parts	Flavanoid glycosides (kaempferol glycosides)	Not reported
Cervix (HELA) Colon (HCT116)	Marzouk et al. (2008)				
Eucalyptus torquata	Leaves and stems	Monoterpenes (trans-myrtanol and myrtenol) and the apocarotene (E)-β-ionone	Induction of apoptosis	Breast (MCF7) triple-negative breast cancer (MDA-MB-231) Colorectal (SW620) Lymphoma (BJAB and Raji)	Ashour (2008), Bardaweel et al. (2015), Lahmadi et al. (2021)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Astragalus kahiricus	Aerial parts	glycosides (Kahiricosides)	Not reported	Ovary (A2780)	Radwan et al. (2004)
Tribulus		*parvispinus*	Aerial parts	Saponins and a Megastigmane Glucoside	Induction of apoptosis
Breast (MCF7) Liver (HepG2)	Perrone et al. (2005)				
Ambrosia maritime L	whole plant	Sesquiterpene Lactones (Neoambrosin and Damsin)	Inhibition of epidermal growth factor receptor (EGFR)	Multidrug-Resistant Cancer Cells	Saeed et al. (2015)
Nasturtium officinale R.Br	Seeds	ascorbic acid and phenethyl isothiocyanate	Chemopreventive	Liver (HepG2)	Palaniswamy et al. (2003), Lhoste et al. (2004)
Centaurea aegyptiaca L	Aerial parts	phenolic acids and their derivatives, flavonols, flavones, lignan and sesquiterpene	Not reported	Liver (Hep-G2) Breast (MCF-7) triple-negative breast cancer (MDA-MB-231) Colon (HCT-116) Cervix (HELA) Larynx (HEP2) Leukemia (CCRF-CEM)	Sary et al. (2016), Bakr et al. (2016), Mohamed et al. (2021)
Gingko biloba	Fruit (Exo carp), Leaves	Ginkgo biloba exocarp polysac charides (GBEP), Flavonoid (Kaempferol and quercetin) and terpenoid	Induction of apoptosis	Stomach (SGC-7901) Breast (MDA-231) Bladder (T-24) Pancreas (MIA PaCa-2) and (Panc-1) Mouth (SCC-1483), (SCC-25) and (SCC-QLL1) Lung (LLC)	DeFeudis et al. (2003), Xu et al. (2003), Zhang et al. (2008), Gohil et al. (2009), Kang et al. (2010a), Cao et al. (2017)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Ailanthus excelsa	Root	Flavones, flavonols	cell cycle arrest, induction of apoptosis inhibition of angiogenesis, antioxidation	Mouse melanoma (B16F10) Breast (MDA-MB-231) and (MCF-7) Prostate (PC3) Kidney (ACHN) Lung (COR-L23) and (A549) Melanoma (A375) and (C32)	Lavhale et al. (2009), Said et al. (2010)
Ammi majus	whole plant	furoquinoline alkaloids 8-methoxypsoralen protein (8-MOP)	Induction of apoptosis	Hepatic cancer (HepG2), neuroblastoma (SK-N-AS), metastatic colon cancer (SW620), breast cancer (MCF-7)	Mohammed and El-Sharkawy (2017), Bartnik et al. (2017), Issa et al. (2022)
trigonella foenum-graecum	Seed	galactomannan (GAL), flavonoid (Naringenin), tannin, steroids, alkaloid(trigonelline), saponins,phytate,steroids, saponin(Diosgenin)	Induction of apoptosis	Colorectal cancer (LS174-T) human breast MCF7, Pancreatic (AsPC-1), lung cancer A549, hepatic cancer (HepG2), squamous cell carcinoma (SCC) cells (A431, Hep2)	Corbiere et al. (2004), Das et al. (2012), Rahmati-Yamchi et al. (2014), Khalil et al. (2015), Abas and Naguib 2019), Ammar et al. (2022)
Nigella sativa	Black seed	Monoterpene (Thymoquinone (TQ)	Induction of apoptosis	Squamous cell carcinoma (SCC) cells (A431, Hep2), colon cancer cells (Caco-2, HCT-116, LoVo, DLD-1 and HT-29), Human osteosarcoma cells	Roepke et al. (2007), El-Najjar et al. (2010), Das et al. (2012)
Syzygium cumini	Fruit	Monoterpene compounds (α-pinene, β-pinene, β-(E)-ocimene, D-limonene, α-terpineol)	DNA damage	Hepatocellular carcinoma cells (HepG2), colorectal, cancer cell line (HT-29)	Khodavirdipour et al. (2021), El-Nashar et al. (2021)
Lawsonia inermis	Leaves	Ellagitannins	DNA damage	Oral squamous cell carcinoma cell lines (HSC-2, HSC-4, and Ca9–22)	Orabi et al. (2021)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Ceiba insignis	Leaves	Phenolic compounds naringenin, gallic acid, chlorogenic acid, syringic acid, rutin	-	Hepatocellular carcinoma cells (HepG2)	Abdel-Aziz et al. (2021)
Myrtus communis L	Aerial parts	Monoterpene (1,8-cineole, linalool, α-terpineol, Myrcene)	Antioxidant	Prostate PC3, human breast adenocarcinoma MCF-7, Lung cancer A549, hepatocellular carcinoma HepG-2, colon cancer HCT-116	Ibrahim et al. (2021)
Phlomis aurea Decne	Whole plant	sesquiterpene (germacrene D, trans-β-farnesene) Polyphenolic monoterpene (α-pinene & limonene)	Induce apoptosis through reduction of cell viability	Human colon adenocarcinoma (HCT-116), hepatocellular carcinoma (HepG2), human breast adenocarcinoma (MCF-7) cell lines	Torky et al. (2021)
Citrus sinensis	Leaves peels	monoterpenes hydrocarbons (Sabinene,2-carene and cis-β-ocimene),			Polymethoxyflavones,monodemethylated flavones
Induction of apoptosis	Human breast	adenocarcinoma MCF-7 hepatocellular carcinoma (HepG2), cervical cancer cells (HELA), lung cancer H1299	Xiao et al. (2009), Kammoun et al. (2021)		
Thymelaea hirsuta	Whole plant	Triflavanone, dicoumarinyl ethers (daphnoretin methyl ether, acetyldaphnoretin)	Induction of apoptosis	Hepatocellular carcinoma (HepG2), breast carcinoma (MCF-7) cell lines, colon (HCT 116) cancer cell lines	Elhady et al. (2021)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Callistemon citrinus	Leaves	Meroterpenoids), callistrilones O and P	Reduce the ability of cancer cells to tolerate nutrition starvation	PANC-1 human pancreatic cancer cells	Tawila et al. (2020)
					Callistemon macropunctatus and C. subulatus
Fresh leaves and flowers		Monoterpenes(1,8-cineole, α-pinene,α-terpineol,Limonene,α-phellandrene)	Topoisomerase IB and IIB inhibitor	Liver cancer cell line HepG2	Ibrahim and Moussa (2020)
Moringa peregrina	Seed leaves	Polyphenols and flavanoides (Syringic acid,Coumaric acid,Vanillin,Ferulic acid,Naringenin,Propyl			gallate,Daidzein,Quercetin,Cinnamic acid,Etinol,Thymol,ascorbic acid,myristic acid, palmitic acid,linoleic acid)
Induce apoptosis		Cervical cancer cells (HELA), prostate cancer cells (PC-3), hepatocellular carcinoma (HepG2), breast carcinoma (MCF-7) cell lines, colon (HCT 116) cancer cell lines	Ezzat et al. (2011), Mansour et al. (2019), Abou-Hashem et al. (2019)		
Ochrosia elliptica	Leaves	yohimbine alkaloid (N-methylarcinine,holeinine)	Induction of apop tosis by FOXO expression	K-562 leukemia cells	Labib et al. (2019)
Oryza sativa	Rice straw	phenolic acids (Vanillic, p-coumaric, Ferulic, sinapic acid,catechin),flavonoids aglycones (quercetin, apigenin, and kaempferol)	Reduction in Vascular endothelial growth factor (VEGF) expression and induction of apoptosis	The Ehrlich ascites carcinoma	Meselhy et al. (2019)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Withania obtusifolia	Leaves	Withanolides	Induction of apoptosis	Human melanoma (MDA-MB-435), human colon cancer (SW-620) , leukemia CCRF-CEM)cell lines	Alali et al. (2014), Hegazy et al. (2019)
Jasonia candicans	Aerial parts	terpenoids and flavonoids	Reduction of cell viability	CCRF-CEM leukemia cell line	Hegazy et al. (2019)
Centaurea lippii	Aerial parts	terpenoids and flavonoids	Reduction of cell viability	CCRF-CEM leukemia cell line	Hegazy et al. (2019)
Pulicaria undulata	aerial parts	terpenoids and flavonoids	Reduction of cell viability	CCRF-CEM leukemia cell line	Hegazy et al. (2019)
Acacia etbaica	NR	phenolics (Resorcinol), phenolic			ester,chromones,Noreugenin, Eugenin,cyclitol(pinitol)
	Mammary gland breast cancer (MCF-7),	Hepatocellular carcinoma (HEPG-2), Colorectal carcinoma (HCT-116) cell lines	Kayed et al. (2021)		
Artemisia annua	Dried leaves or flower	Sesquiterpene lactone; (Artemisinin), flavonoids (Casticin, chrysosplenol D, Artemetins,Quercetin, Isorhamnetin,Kaempferol), phytosterol (Stigmasterol, β-sitosterol)	Induction of ferroptosis, and reduction of oxidative stress	Osteosarcoma cell lines OSACA-8 and OSCA-40, non-small-cell lung cancer (NSCLC), colon cancer cell (HCT116), triple negative human breast cancer MDA-MB-231 cells ,Oral squamous cell carcinoma (OSCC)	Breuer and Efferth (2014), Zhao et al. (2016), Kim et al. (2017), Chou et al. (2018), Lang et al. (2019), Zhang et al. (2020), Fu et al. (2022), Salaroli et al. (2022)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Artemisia argyi	Aerial parts	Polyphenol (caffeoylquinic acids) Phytosterol (β-sitosterol,stigmasterol) Terpenes(α-amyrin,β-amyrin, α-pinene, α-myrcene,D-limonene), flavonoids (friedelin,naringenin, quercetin),Flavone glyco sides (Jaceosidin), Sesquiterpene lactone 3	Induction apoptosis, Inhibition of metastasis in vitro and in vivo, Induction of reactive oxygen species	Human lung cancer cells CL1-0 and CL1-0-GR, Colon Cancer HT-29,Hepatocellular carcinoma (HEPG-2), HPV positive cervical cancer cell lines, human osteosarcoma cell lines, HOS and MG63, Human gastric cancer cells), AGS and MGC803 cell lines	Lee et al. (2005), Li et al. (2008, 2021), Jeung-Min et al. (2010), Zhang et al. (2018), Tseng et al. (2020), Su et al. (2022)
Cassia angusti folia	Seed, leaf	Flavonoids (Quercimeritrin, scutellarein, rutin)	Induction of apoptosis	Laryngeal carcinoma (Hep2), Cervical cancer (HeLa), Breast cancer (MCF-7), Rat glioblastoma derived microglial C6 cells (ATCCCCL-107) triple-negative breast cancer (MDA-MB-231)	Ahmed et al. (2016), Abood 2022), Pang et al. (2022)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Schinus molle	Fruit, flower, Leaves	Monoterpene (p-cymene,α-phellandrene, myrcene, D-limonene, β-phellandrene, α-pinene and β -pinene),sesquiterpenes(β-eudesmol,b-elemene,juniper camphor, guaiyl acetate)	Antioxidant and induce apoptois	Human colon (HCT-116, Caco-2), hepatocellular (HepG-2), breast (MCF-7,T47D), human neuroblastoma (SH-SY5Y), human leukemia (HL60) cell lines Hepatoma Hep3B cell line, Bladder carcinoma ECV-304 cell line, Breast carcinoma EMT-6 cell line, leukemic cell line K56	Díaz et al. (2008), Hamdan et al. (2016), Aboalhaija et al. (2019), Ezzat et al. (2020), Ovidi et al. (2021)
Orig anum vulgare	Leaf	phenolic monoterpenes (carvacrol, thymol, limonene, pinene, ocimene, and caryophyllene)	Induction of apoptosis	human cancer cell lines (FaDu, K562, and A549) , leukemia (Molt-4), adrenocortical cancer SW13 and H295R cell lines	Rubin et al. (2019), Solouki et al. (2021), Fatima et al. (2022)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Onopordum alexandrinum	Aerial parts, Flowers	sesquiterpene–amino acid conjugate (onopornoids A–D), elemanes and germacrane, fl avonoidal gly coside(acacetin-7-O-galacturonide), fl avonoids (hispidulin, acacetin, apigenin, luteolin, kaempferol)	Cytoprotective	NR	Sugimoto et al. (2019), Ashaq et al. (2021)
Achillea fragrantissima	Flowers, leaves, and roots	Flavonoids (Cosmosiin, Centaureidin, Apressin, Eupatilin, Quercetin), fatty acid (Oleic acid),terpene(Bisabolol, lupeol)	Induction of apoptosis, inhibition of cell migration and invasiveness	Triple-negative breast cancer MDA-MB-231 cells breast cancer (MCF-7, SKBR3) pancreatic cancer (BxPC-3, MiaPaCa-2), prostate cancer (LNCaP, C4-2B, PC-3), lung cancer (A549), human colorectal cancer cell lines (SW480 and HCT-116)	Mansi et al. (2019), Ullah et al. (2022), Alshuail et al. (2022)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Ochrosia eliptica	Leaves	Terpenes(lupeol), triterpene (ursolic acid),β-sitosterol glucoside,flavonoids (Rutin),alkaloid), 9-methoxyellipticine	Cell cycle arrest	Human mammary adenocarcinoma (MCF7), multidrug-resistant (VCREMS), triple-negative breast cancer MDA-MB-231 cells, the non-cancerous, immortalized by telomerase human breast epithelial cell line (hTERT-HME1)	El-Shiekh et al. (2017)
Yucca aloifolia, Y. aloifolia variegata, Y.		*elephantipes and Y. fila mentosa*	leaves	Flavonoids(hesperidin), phenolic acids, (gallic acid)	NR
		Hepatocellular carcinoms HepG-2, breast cancer MCF-7	Hawary et al. (2018)		
Conocarpus erectus	Leaves	terpenoid (lupeol), phenolic acids (gallic acid), flavonoids (Catechin, Rutin, Myrecetin, Quercetin, Apigenine and Kaempferol)	NR	Pancreatic cancer AsPC-1, breast cancer MCF-7, Cervical cancer (Hela)	Faraj and Shawkat (2020), Tawfeeq et al. (2021)
Atriplex	Leaves	Phenolic acids and flavonoids	Antioxidant activity and cytotoxicity	Breast cancer cells lines MCF-7 triple-negative breast cancer MDA-MB-231 cells Lung cancer cells A549 human hepatocellular carcinoma (HepG2)	Al-Senosy et al. (2018), Hosny et al. (2021), Meng et al. (2021), Elbouzidi et al. (2022)
Euphorbia paralias	Stem	Di/triterpenoids	cycle arrest	Human prostate carcinoma cell line DU145,PNT2,human acute myeloid leukemia (THP1) and human colon epithelial (Caco2) cancer cell lines	Corea et al. (2009), Ben Jannet et al. (2017), He et al. (2021)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Cakile maritima Scop	Leaves	monoterpenoid (2-hydroxy-1,8-cineole, limonene, citronellal)	Cell cycle arrest and inducing apoptosis	Cancer breast cells MCF-7 Cancer colon cells HCT-116 human hepatocellular carcinoma (HepG2) Colorectal adenocarcinoma cells CaCo2 Cervical cancer cells HeLa	Omer et al. (2019), Tawfik et al. (2023)
Panax quin quefolius	Leaves and Stem	butanediamide glycoside, flavonoid glycoside, flavonone glycosides	Anti-proliferative	Human hepatocellular carcinoma (HepG2), Lung cancer cell line A549 Colorectal cancer cell line HCT116 Skin cancer in mice	Akhter et al. (2021), Zhang et al. (2021), Yu et al. (2023)
Rosmarinus officinalis	Leaves	flavonoids, phenolic acids, diterpenoids (carnosic acid, carnosol, and rosmanol derivatives), triterpenoid (betulinic acid), and lignans (medioresinol)	Induction of apoptosis and arrest cell cycle, Antioxidant and cytotoxic activity	Colorectal cancer HT-29 & HCT 116 cell lines, cervical cancer HeLa cell line	Alshahrani and Ibrahim (2022), Eid et al. (2022), Rizwana et al. (2022), Dolghi et al. (2022)
Zygophyllum album	Stem	Saponins, flavonoids and sterols	Antioxidant activity	Lung carcinoma (A-549) cell line, colon adenocarcinoma (DLD-1) cell line Hepatocellular carcinoma Huh-7 cell line, Lung adenocarcinoma A-549, Colon carcinoma Caco-2 cell line	Ksouri et al. (2013), Hawas et al. (2022)
Asparagus stipularis	Roots and rhizomes	Phenols Alkaloids	Antioxidant and Anti-proliferative	Human mammary gland adenocarcinoma cell line MCF-7	Maswada (2013), Galala et al. (2015), Adouni et al. (2022)
Retama raetam	leaves and seeds	polyphenolic compounds	Antioxidant and cytotoxic activities	Large cell carcinoma COR-L23 cell line	Conforti et al. (2004)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Olea europaea	Leaves	phenylethanoid glycoside (Verbascoside), flavonoids (Rutin), Luteolin_7_O_glucoside, Polyphenol	Antioxidant and cytoxic activity	Prostate DU145 cancer cells, pancreatic P ANC-1 cancer cells, acute human leukemia T cells (Jurkat and HL60)	Parra-Perez et al. (2022), Pacifico et al. (2022), Qais et al. (2022)
Pituranthos tortuosus	Aerial parts	Phenolics, flavanoids, terpenoids (B-myrcene, sabinene, trans-iso-elemicin, terpinen, α-pinene, limonene)	Cytotoxic Anti-oxidative	Hepatocellular carcinoma cell lines HepG2, human colon carcinoma cell lines HCT-116, melanoma cancer B16F10 cell line	Abdallah and Ezzat (2011), Krifa et al. (2015, 2016), Fatma et al. (2017), El-Moaty et al. (2021)
Capparis spinosa var.aegyptia (Lam.)	Leaves, Other Aerial parts	Phenolic acids, flavonoids (quercetin, kaempferol and isorhamnetin,myricetin, eriodictyol, cirsimaritin)and gallocatechin derivatives	Antioxidant and Cytotoxic activity	Breast adenocarcinoma cells (MCF-7), hepatocellular carcinoma cells(Hep-G2), colon carcinoma (HCT-116, HT29), pancreatic cancer(MIA PaCa2), Lung cancer A549 cell line, Cervical carcinoma HeLa cell line, Osteosarcoma Saos cell line, Fibroblast cancer cell lines, nontumorigenic fetal hepatic cell line WRL-68	Bakr and El Bishbishy (2016), Al-Marzook and Omran (2017), Moghadamnia et al. (2019), Salih et al. (2020), Osman et al. (2020), Xu et al. (2020), Al-Anazi et al. (2021)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Albizzia lebbeck	Fruit, Leaves, pods	alkaloids, anthraquinones, essential oils, flavonoids, glycosides, phenolics, phytosterol, saponins, steroids, and triterpenoids	Cytotoxic activity	Leukemia Raw 264.7 cancer cell line Lung cancer A549 cell line Cervical carcinoma HeLa8 cell line colon cancer HCT-116 cell line human breast cancer MCF-7 cells	Desai and Joshi (2019), Kavitha et al. (2021), Leutcha et al. (2022)
Bauhinia variegate	Aerial parts Leaves, Stem, flowers	flavones, flavonol glycoside, triterpene, phenan thraquinon	Cytotoxic activity	Breast cancer MCF-7 cell line Lung alveolar adenocar cinoma A549 cell line	Pandey and Agrawal (2010), Karamova et al. (2015), Mohammed et al. (2021)
Kigelia africana	Fruit, Root, Stem bark,	naphthoquinone (Lapachol), Phenolics and flavonoids	Cytotoxic activity, Antioxidant and anti-proliferative	Neuroblastoma stage 8 cell line, Human cervical cancer (Hela), mouse fibroblast (3T3) cell lines, hepatocellular carcinoma cells Hep-G2, Ovarian cancer (CHO-1) cell, human breast cancer cell line (HCC 1937	Mukavi et al. (2020), Nabatanzi et al. (2020), Atolani et al. (2021), Fagbohun et al. (2021), Ahrens et al. (2022)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Dovyalis caffra,	Fruit, Leaves	polyphenols (p-coumaric acid, caffeic acid, p-hydroxyphenylacetic acid, and protocatechuic acid)	Antioxidant activity	Prostate Cancer (PC-3) cell lines MCF7 breast cancer cell line Colon (HCT-116), hepatocellular (HepG 2) - lung (A-549)	Moustafa et al. (2014), Adeyemi et al. (2019, 2022), Al-Rajhi et al. (2022)
Origanum majorana L	Leaves	Phenolic and flavonoids	Anti-proliferative and antioxidant activity	Leukemia Jurkat cell line human breast cancer (MCF7) triple-negative breast cancer MDA-MB-231 cells colon (HT-29) cancer cells Lung cancer A549 cell line Cervical cancer HeLa human hepatocellular carcinoma (HepG2) cell line	Fathy et al. (2016), Jssim and Abdul-Halim (2020), Nezhad et al. (2020), Hamankoh and Shamaei (2021), Berdowska et al. (2022), Khaleghi et al. (2022)
Rumex vesicariu	Aerial part	Phenolics, flavonoids, tannins, and pigments (carotenoids and chlorophylls)	Antioxidant	NR	Beddou et al. (2014)
Eucalyptus cinerea	Juvenile leaves	acyl phloroglucinol (Sideroxylonal B and Macrocarpal A)	Cytotoxic activity	MCF7 (breast carcinoma cell line), HEP2 (laryngeal carcinoma), CaCo (colonic adenocarcinoma)	Soliman et al. (2014)
Calotropis procera	Aerial parts	Phenolics, flavonoids, glycosides and cardenolide	Antioxidant	Breast cancer(4T1) colorectal carcinoma (CRC) canine osteosarcoma cells (OST), canine mammary tumor (CMT)	Rabelo et al. (2021, 2022), Kumar et al. (2022)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Spergula fallax	Aerial parts	Glycosides	Growth inhibitory activity	Cervical carcinoma HeLa, colorectal adenocarcinoma DLD-1 cell line	Hamed et al. (2014)
Adenanthera pavonina	Stem, Leaves, seeds, and leaves	Methoxy flavonol glycoside	Antioxidant and antiproliferative activity	HeLa Cervical cancer cell line HCT116 colorectal adenocarcinoma cell line Laryngeal carcinoma HEp-2 cell line Bone cancer cell Liver cancer Hep G-2 cell line	Mohammed et al. (2014), Chauhan et al. (2015), Lindamulage and Soysa (2016), Bhadran et al. (2017)
Acacia saligna	Leaves	Polyphenols, flavnoids ,Spirostane saponin, Biflavonoid glycoside	Antioxidant cytotoxic activities	HEPG2 (liver cancer) cell line	Gedara and Galala (2014), Elansary et al. (2020)
Ferula hermonis	Root	Terpene (α -Bisabolol, α -pinene, β -pinene), and tetracyclic diterpenoid (Baccatin) I	Induction of apoptosis	Triple-negative breast cancer MDA-MB-231 cells colorectal cancer(LoVo) cells	Abutaha et al. (2019)
. *Leucenia leuco cephala Lam*	Aerial parts, seeds	Flavonoids (Caffeic acid, Isorhamnetin, Chrysoeriol, Kaempferol, Quercetin)	Cytoprotective	Human hepatocarcinoma (HepG2), breast carcinoma (MCF-7), lymphoblastic leukemia (1301)	Hassan et al. (2013), Gamal-Eldeen et al. (2007)
Ipomoea carnea	Leaves and flowers	Flavonoids (Caffeic acid) and Ipomoeflavoside and phytosterol(β-Sitosterol) and carotenoids (lycopene)	Inhibit growth and modify estrogen receptor and insulin like growth factor 1 receptor	Liver carcinoma (HEPG2), breast cancer (MCF7) colon cancer (HCT116)	Haddad et al. (2013), Rosendahl et al. (2015), Kamal et al. (2017)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Acacia nilotica pods	Pods seeds	gallocatechin	Cytotoxic effect	Human ovarian adenocarcinoma (SK-OV-3), Human glioblastoma–astrocytoma (U-87 MG) human cutaneous melanoma (SKMEL-28)	Salem et al. (2011)
Diceratella elliptica	Aerial parts	Coumarin Glycosides	Cytotoxic activity	Human carcinoma cell lines; liver (HEPG2), cervix (HELA) colon (HCT116)	Marzouk et al. (2012)
Gaillardia aristata	Leaves	sesquiterpene lactones ,(neopulchellin) , flavonoid (apigenin, quercitin, eupafolin, kaempferol)	Induction of apoptosis	Breast (MCF7) colon (HCT116)	Salama et al. (2012)
Mimusops laurifolia	Leaves	Myricetin, meamstrin, flavonoid(quercitin), silymarin	Cytoprotective	Liver (HEPG2) cells	Hifnawy et al. (2012)
Boswellia carteri	Resin	oleogum resin	Cytotoxic activity	Human hepatocarcinoma (HepG2), human breast adenocarcinoma (MCF-7) and raw murine macrophage (RAW 264.7) cell lines	Ali et al. (2013)
Plectranthus amboinicus	Leaves	phenolic monoterpenes (Carvacrol Thymol), phytocannabinoid (β-Caryophyllene)	Inhibition of cell growth	Human lung cancer A549 cell line	Arumugam et al. (2016)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Catha ranthus roseus	Leaves	indole alkaloids and mono-indole alkaloids vinblastine and vincristine	Cell cycle arrest	Pancreas (MIA PaCa-2), ovarian (A2780), lung (H460), skin (A431), prostate (Du145), colon (HT29), breast (MCF-7), neuroblastoma (BE2-C), glioblastoma(SJ-G2, U87, SMA) one nontumour derived normal breast cell line (MCF10A)	Salama et al. (2012)
Nerium oleander	Leaves	cardiac glycosides (oleandrin, oleandrigenin, digoxin, digitonin, digitoxigenin, nerizoside, neritaloside, odoroside	Induction of apoptosis	Pancreatic adenocarcinoma	Erdem et al. (2006), Roth et al. (2020)
Urginea maritima	Leaves	Bufadienolides (scillaridin A.and proscillaridn A)	Cytotoxic activity	Non-small cell lung cancer (NSCLC)(A549), glioblastoma (GBM) (U373), prostate cancer cell line(PC-3), breast MCF7, renal TK10 melanoma UACC62	Mohamed et al. (2014)
Lotas poly phylles	Whole plant	Kaempferol glycoside	Topoisomerase inhibitors	Breast cancer cells (MCF7) cervical cancer cells (HeLa), liver cancer cells(HepG2)	Tselepi et al. (2011), Aboul-Enein et al. (2012), El-Gazzar et al. (2022)
Cistanche phelypaea (L.)	Whole plant	Phenylethanoid Glycosides	Induction of apoptosis	HepG2 cell	Ye et al. (2019)

Table 1 continued

Scientific name	Part (s) Used	Important compounds	Mechanisms	Target organ/representing cell line	References
Moricandia nitens	Whole plant	glucosinolate compounds; Ethyl isothiocyanate	cytotoxic activity	Human hepatocellular carcinoma (HepG2)	Aboul-Enein et al. (2012), Ha et al. (2016), Soliman et al. (2018)
Zygophulum simplex L	Whole plant	Flavonoids (Isorhamnetin, myricitrin)	Cytotoxic activity	Human hepatocellular carcinoma (HepG2)	Aboul-Enein et al. (2012), Abdallah and Esmat 2017), El-Attar et al. (2019)
Arum palaes tinum	leaves	Flavonoids (luteolin, chrysoeriol, isoorientin)	Cytotoxic activity	Epidermal carcinoma of larynx (Hep2), cervix (HeLa), liver (HepG2) breast (MCF7)	Aboul-Enein et al. (2012), Farid et al. (2015)
Anabasis artiaulata	Whole plant	Saponins, oleanolic acid	Cytotoxic activity	Hepatic cancer	Gamal et al. (2022)
Thymelaea hirsute (L.) Endl	Whole plant	flavanone, dicoumarinyl ether	Induction of apoptosis	Hepatocellular carcinoma (HepG2)	Aboul-Enein et al. (2012), Badawy et al. (2021)
Astragalus pinosus	Root	spinocoumarin	Chemopreventive	Ovarian cancer cell line A2780	Radwan et al. (2007), Aboul-Enein et al. (2012)
Aspho delus micro carpus	Whole plant	spinocoumarin	Cytotoxic activity	Murine mammary carcinoma 4T1 human breast cancer MCF-7 triple-negative breast cancer MDA-MB-231 cells	Abdellatef et al. (2021)
Asclepias sinaica	Stem	cardenolide glycosides	Cell death	Lymphoma (U937) cells	El-Askary et al. (1995), El-Seedi et al. (2013)

Table 2 Clinical trials showing anticancer activities of medicinal plants cultivated in Egypt

Plant name	Clinical trials	Organ	References
Camellia sinensis	Results of a randomized clinical trial show that it regulates targeted biomarkers related to colorectal cancer oncogenesis. Another randomized controlled trial (RCT) was conducted on 2534 patients to compare green tea extract and placebo effect on prevention of CRC secondary to colorectal polyps in the elderly population	Colon	Hu et al. (2016), Stingl et al. (2011)
	Epigallocatechin-gallate (EGCG) has been shown in clinical research to have antitumor effects on hematologic malignancies such as chronic lymphocytic leukemia (CLL). It can modulate circulating Tregs in CLL patients with early stage of the disease	Chronic lymphocytic leukemia	D'Arena et al. (2013)
	Oral GSP increases bioavailability of EGCG, which is detectable in breast tumor tissue and is associated with antiproliferative effects on breast cancer tissue	Breast	Lazzeroni et al. (2017)
	Green tea carries limited antineoplastic activity, as defined by a decline in PSA levels, among patients with androgen independent prostate carcinoma	Prostate	Jatoi et al. (2003)
Punica granatum	Pomegranate appeared to affect specific colon tissue MicroRNAs but the components responsible for its effect require further research. Another RCT showed that pomegranate consumption decreases plasma lipopolysaccharide-binding protein levels which contributes to the onset and development of CRC	Colon	Nuñez-Sánchez et al. (2015), González-Sarrías et al. (2018)
	Pomegranate juice phytochemicals induce a delay in PSA doubling time, as well as apoptosis, and oxidative stress. Moreover, pomegranates slowed prostate cancer proliferation through prolonged PSA doubling times. It was expected that pomegranate extract taken orally would reduce tissue 8-hydroxy-2'-deoxyguanosine (8-OHdG) (a DNA damage marker). Pomegranate fruit extract (PFE) immunohistochemistry investigations indicated decreases from baseline in 8-OHdG and androgen receptor expression in prostate tumor-associated cells	Prostate	Pantuck et al. (2006), Freedland et al. (2013), Jarrard et al. (2021)
Zingiber officinale	Several clinical trials studied the effect of Zingiber officinale (Ginger) on CRC by different mechanisms. one RCT showed that ginger has anti-inflammatory activities with significant CRC preventive potential. (Another RCT showed that ginger may increase apoptosis and reduce proliferation in the normal-appearing colorectal epithelium, but further research is needed. Two studies showed contradictory results regarding ginger's potential to decrease eicosanoid levels, also one study said its safe and tolerable but the other did not agree	Colon	Jiang et al. (2013), Citronberg et al. (2013), Zick et al. (2011)
	Ginger supplementation alone or in combination with training play an important role in the pathogenesis of oxidative stress in obese women diagnosed with breast cancer	Breast	Karimi and Roshan (2013)
Curcuma longa	Use of the Curcuma extract can lower the PSA value after a 30-day intake period	Prostate	Fabiani et al. (2018)
Panax quinquefolius	Adjuvant to Reduce Respiratory Infection	Chronic Lymphocytic Leukemia	High et al. (2012)
Rosmarinus officinalis	Lower risk of developing prostate cancer in patients with High-grade prostatic intraepithelial neoplasia (HGPIN)	Prostate	Capodice et al. (2009)

Table 2 continued

Plant name	Clinical trials	Organ	References
Solanum nigrum	To ascertain the relative molecular targets in Stage IV lung adenocarcinoma patients	Lung	Liu et al. (2021)
Sesamum indicum	flaxseed-derived enterolignans may hinder cancer cell proliferation via VEGF-associated pathways	Prostate	Azrad et al. (2013)
Nasturtium officinale R.Br. (seeds)	PEITC inhibits the oxidative metabolism of NNK in humans, as seen in rodents, and support further development of PEITC as a chemopreventive agent against lung cancer	Lung	Hecht et al. (1995)
Gingko biloba	Ginkgo biloba exocarp polysaccharides can inhibit proliferation and induce apoptosis and differentiation of tumor cells	Stomach	Xu et al. (2003)
	Good benefit-risk ratio of the combined 5-FU and GBE 761 ONC therapy as second line treatment in metastatic colorectal cancer	Colon	Hauns et al. (2001)
Boswellia carteri (olibanum oleogum)	supplementation with Boswellia, betaine and myo-inositol reduce fibroadenoma dimension in young women. No relevant side effects have been recorded	Breast	Pasta et al. (2016)
Nigella sativa	N. sativa extract significantly decreases the severity of ARD and delays the onset of moist desquamation in breast cancer patients	Breast	Rafati et al. (2019)
	The chemo-preventive effect of Nigella sativa's methanolic extract on the development of liver cancer is due to its modulation of the energy metabolic pathways (such as glycolysists) that may be involved in hepatocarcinogenesis	Liver	Abdel-Hamid et al. (2013)
Oryza sativa	A non-randomized trial found that Oryza sativa extract contains anthocyanin, which may control microbiota composition and the NF-kb pathway, ultimately preserving the protective layer and tight junction of epithelial cells	Cytoprotective	Herman (2021)
Artemisia annua	Artemisia annua (Aa) coffee may have the potential to reduce rising PSA levels in patients with biochemical recurrence of prostate cancer	Prostate	Myint (2022)
	A phase I dose-escalation study of Artemisia annua (Aa) decaffeinated coffee in advanced ovarian cancer patients who have completed front-line carboplatin and paclitaxel chemotherapy	Ovarian	Jill (2021)
	The results showed that artesunate has anti proliferative effects and is well tolerated	Colon	Krishna et al. (2015)

Breast cancer

Breast cancer is a malignant tumor that arises in the lining epithelium of the ducts or lobules in the glandular tissue of the breast. It is the most prevalent cancer among women and the most common cancer overall. In 2020, there were 2.3 million women diagnosed with breast cancer and 685,000 deaths globally (Ferley et al. 2014; World Health Organization 2021). About 1 in 8 women are diagnosed with breast cancer during their lifetime (National Cancer Institute). Breast cancer is not a transmissible or infectious disease. Unlike some cancers that have infection-related causes, there are no known viral or bacterial infections linked to the development of breast cancer. Approximately half of breast cancers develop in women who have no identifiable breast cancer risk factor other than gender (female) and age (over 40 years). Breast cancer most commonly presents as a painless lump or thickening in the breast. Seeking medical attention at the first sign of a potential symptom allows for more successful treatment. Breast cancer treatment can be highly effective, achieving survival probabilities of 90% or higher, particularly when the disease is identified early. Scientific and research interest is drawing attention towards naturally derived compounds as they are considered less toxic, compared with current treatments (Greenwell and Rahman 2015). Egypt is well-known for its long-standing history of herbal medicine. Medicinal plants have been used as a source of remedies since ancient times in Egypt and the ancient Egyptians were familiar with many medicinal herbs and recognized their effectiveness in the treatment of various diseases (Azim 2011). The plant kingdom produces secondary metabolites that are investigated for anticancer activity and the development of new drugs (Greenwell and Rahman 2015). Regarding breast cancer, this review illustrates that 55 plants showed anti-cancer activities against 10 different breast cancer cell lines including MCF-7, BT-474, SKBR-3, MDA-MB231, MDA-MB-468, T-47D, EMT-6, hTERT-HME1, Hela and HCC-1937. It was also used against a murine mammary 4T1carcinoma and Ehrlich's ascites carcinoma in mice.

Many clinical trials were conducted to ascertain the cytotoxicity of Egyptian medicinal plant extracts or their adjuvant role with chemotherapeutic agents. Oral GSP (*Camellia sinensis* or Black tea) increased the bioavailability of EGCG, which was detectable in breast tumor tissue and was associated with anti-proliferative effects on breast cancer tissue (Lazzeroni et al. 2017). Ginger (*Zingiber officinale*) supplementation alone or in combination with training, also played an important role in the pathogenesis of oxidative stress in obese women diagnosed with breast cancer (Karimi and Roshan 2013). Supplementation with *Boswellia*, betaine,and myo-inositol reduced fibroadenoma dimension in young women with no relevant side effects recorded (Pasta et al. 2016). *N. sativa* extract significantly decreased the severity of ARD and delayed the onset of moist desquamation in breast cancer patients (Rafati et al. 2019). Oral ART was used in a phase I clinical trial as an add-on to the guideline-based oncological therapy in patients with metastatic breast cancer (von Hagens et al. 2017).

Many strategies have been developed for targeting natural anti-cancer compounds in cancerous breast cells including gold nanoparticles (AuNPs) of *Atriplex* (Hosny et al. 2021), ursolic acid from *Rosmarinus officinalis* extract using nano-drug delivery systems (Shao et al. 2020), Nickel-ferrite ($NiFe_2O_4$) and iron nanparticles of *Rosmarinus officinalis* (Farshchi et al. 2018; Alijani et al. 2020) copper oxide (CuO), zinc oxide (ZnO) nanoparticles (NPs) of extracts from the leaves *of Dovyalis caffra* (Adeyemi et al. 2022), extract from *Origanum majorana* and silicon nanoparticles (Jssim and Abdul-Halim 2020), silver nanoparticles (Ag-NPs) of *Beta vulgaris* extract (Venugopal et al. 2017), C. sinensis tea fraction nanoparticles (Kusmiyati et al. 2022), phytofabricated gold nanoparticles of *Plectranthus amboinicus* (Hasibuan and Sumaiyah 2019), silver and selenium nanoparticles of *trigonella foenum-graecum* (Ramamurthy et al. 2013; Pansare et al. 2016; Abdellatif et al. 2022), palladium-silver, palladium–platinum, gold and silver nanoparticles of *Nigella sativa* (Gulbagça et al. 2022), Gold nanoparticles (GNPs) of *Lawsonia inermis* (Firdhouse and Lalitha 2017; Alhomaidi et al. 2022), silver nanoparticles of *Phlomis aurea Decne* (Abdelhady et al. 2016), silver, Se-CuO and cerium oxide nanoparticles of *Cassia angustifolia* (Bharathi and Bhuvaneshwari 2019; Antony et al. 2022; Pavan Kumar et al. 2022), zinc oxide nanoparticles of *Catharanthus roseus* (Bangroo et al. 2022) and gold nanoparticles of *Nerium oleander* (Barai et al. 2018), Most of these nanoparticles were used against MCF human breast cancer cell line.

Leukemia

Leukemia is a malignant condition involving the excess production of immature or abnormal leukocytes, which eventually suppress the production of normal blood cells and results in symptoms related to cytopenia (Emadi and Law 2022). The incidence of leukemia is 14.1 per 100,000 men and women per year. The death rate is 6.0 per 100,000 men and women per year. Fortunately, the 5-year relative survival of leukemia is 65.7% (National Cancer Institute). Regarding leukemia, this study illustrates 14 Egyptian medicinal plants showed anti-cancer activities through various mechanisms against 8 different human leukemia cancer cell lines including CCRF-CEM, HL-60, MOLT-4, K-562, U-937, THP-1, 1301, and Jurkat. It was also used against a mice macrophage cell line which is RAW 264.7.

Patients with early-stage, untreated chronic lymphocytic leukemia (CLL) are at high risk for acute respiratory illness (ARI), according to a double-blind, placebo-controlled, randomized trial of 293 patients. This clinical trial evaluated the safety and efficacy of

Panax quinquefolius extract in reducing ARI. It was observed that lower rates of moderate-to-severe ARI and significantly lower rates of sore throat existed, implying that the increased rate of seroconversion (fourfold increases in antibody titer) towards 9 common viral pathogens. However, it did not decrease the number of ARI days or antibiotic use (High et al. 2012). Epigallocatechin-gallate (EGCG), an active constituent of green tea, has been shown in clinical research to have antitumor effects on hematologic malignancies such as chronic lymphocytic leukemia (CLL). It is interesting to note that during the green tea consumption phase, serum levels of IL-10 and TGF-beta decreased in both patients and controls. According to these findings, green tea may be able to control circulating T cells in CLL patients who are in the early stages of the disease. As a result, lymphocytosis and the prevention of disease progression may be under control (D'Arena et al. 2013).

Laryngeal cancer

Laryngeal cancers represent one-third of head and neck cancers and are often diagnosed in patients with a significant smoking history (Koroulakis and Agarwal 2022). The rate of new cases of laryngeal cancer is 2.8 per 100,000 men and women per year and the death rate is 0.9 per 100,000 men and women per year (National Cancer Institute). Regarding Laryngeal cancer, this review illustrates 6 Egyptian medicinal plants that showed anti-cancer activities through various mechanisms against Hep-2 which is a human Laryngeal cancer cell line.

Glioblastoma

Glioblastoma (GBM) is the most aggressive primary malignant brain tumor. It has an incidence rate of 3.19 per 100,000 persons in the United States and a median age of 64 years. Survival from GBM is poor; only a few patients survive 2.5 years and less than 5% of patients survive 5 years following diagnosis (Tamimi and Juweid 2017). This review illustrates 6 Egyptian medicinal plants that showed anti-cancer activities through various mechanisms against 8 different Human glioblastoma cancer cell lines including A-172, U-87 MG, SHG-44, GBM-8901, GBM-8401, SJ-G2, SMA and U-373. It was also used against rat glioblastoma-derived microglial C6 cells (ATCC-CCL-107).

The polyphenol content of *Calotropis procera* leaf has anti-cancer properties. Electrochemical methods were used to test *Calotropis procera* aqueous extract against glioblastoma cell lines (LN-18) as a cytosensor, and its possible mechanism for DNA binding was investigated using a graphite/poly(allylaminehydrochloride)/nanotube-graphene composite/polypyrrole/deoxyribonucleic acid modified electrode (Nalini et al. 2016).

Gastric cancer

Gastric cancer is a tumor of the stomach. The rate of new cases of gastric cancer is 7.1 per 100,000 men and women per year and the death rate is 2.8 per 100,000 men and women per year. Its 5-year relative survival is 33.3% (National Cancer Institute). Regarding gastric cancer, this review illustrates 5 plants cultivated in Egypt with anti-cancer activities through various mechanisms against 3 different Human gastric cancer cell lines including AGS, SGC-790, and MGC-803.

Ginkgo biloba exocarp polysaccharides (GBEP) were studied for their anticancer activity against human gastric cancer SGC-7901 cells in 30 patients with gastric cancer. It was found that GBEP can inhibit and induce differentiation and apoptosis of tumor cells by its effects on the expression of c-myc, bcl-2, and c-fos genes (Xu et al. 2003).

Gold nanoparticle (AuNP) synthesized from *Nigella sativa* seed extract exhibited significant cytotoxic activity against human gastric adenocarcinoma (AGS) cells by significantly upregulating intracellular apoptotic signaling molecules, such as Caspase 9/Caspase 3, p53, and Bcl-associated X protein (Bax) (Dhandapani et al. 2021).

Lymphoma

Lymphomas are a type of cancer that begins in the lymphatic system. Lymphomas are the sixth most common form of cancer overall. There are two main types of lymphoma: non-Hodgkin and Hodgkin lymphoma. The incidence of non-Hodgkin lymphoma is 19.0 per 100,000 men and women per year while in Hodgkin lymphoma, it is 2.6 per 100,000 men and women per year (National Cancer Institute). This review illustrates 3 Egyptian medicinal plants that showed anti-cancer activities through various mechanisms against 2 different human lymphoma cancer cell lines including U-937, BJAB, and Raji. It was also used against L5178Y, a mouse lymphoma cell line.

Neuroblastoma

Neuroblastoma is the most common extracranial solid tumor in childhood. It arises from immature nerve tissue in the adrenal glands, neck, chest, or spinal cord. The incidence is 10.54 cases per 1 million per year in children younger than 15 years (Smith et al. 2014). Regarding neuroblastoma, this review illustrates 3 Egyptian plants that showed anti-cancer activities through various mechanisms against 2 cell lines including SK-N-AS, SH-SY5Y, and a stage 8 neuroblastoma cell line.

Gallbladder cancer

Gallbladder cancer is a rare cancer that is usually diagnosed late due a to lack of early signs and symptoms (National Cancer Institute). The incidence of gallbladder cancer in the US is 1.4 per 100,000 among women and 0.8 among men (Rawla et al. 2019b). This review illustrates one plant cultivated in Egypt with anti-cancer activities against GBC-SD, a human Gallbladder cancer cell line.

Liver cancer

Liver cancer is the 6th most common cancer worldwide (WCRF 2018). In Egypt, Hepatocellular carcinoma (HCC) represents about 70% of all liver tumors (Ezzat et al. 2021). In this review, we found that 45 plants in Egypt have cytotoxic effects on human hepatocellular carcinoma (HePG2) and (Huh7), hepatoma (Hep3B), (Bel-7402), (SMMC-7721), and nontumorigenic fetal hepatic cell line (WRL-68).

Several plant extracts showed promising results for the prevention of liver cancer. Methanolic extract of *Nigella sativa* showed a chemo-preventive effect on the development of liver cancer due to its modulation of the energy metabolic pathways (such as glycolysis) that may be involved in hepatocarcinogenesis (Abdel-Hamid et al. 2013). Also, ethanolic *Moringa peregrina* leaf (MPLE) and bark extract (MPBE) anti-obesity and hepatoprotective effects in rats fed a high-fat diet (HFD) (Alkhudhayri et al. 2021). A non-randomized trial found that *Oryza sativa* extract contains anthocyanin, which may control microbiota composition and the NF-kb pathway, ultimately preserving the protective layer and tight junction of epithelial cells (Herman 2021).

Ursolic acid from *Rosmarinus officinalis* extract with nano-drug delivery systems was tested against hepatic carcinoma cell lines (Shao et al. 2020). Turmeric rhizome extract nanoparticles (TE-NPs) from fractions of dried turmeric (*Curcuma longa Linn.*) rhizome was used as anticancer agents against human hepatoma cells, HepG2, and remarkably exhibited higher cytotoxic effect when compared with free curcumin (Auychaipornlert et al. 2022). Silver nanoparticles of *Myrtus communis*, *Phlomis aurea Decne*, *Citrus sinensis*, *Callistemon citrinus, Schinus mole, and Catharanthus roseus* were used on HepG2 liver carcinoma cell line showing anticancer activities with variable levels (Abdelhady et al. 2016; Satsangi and Preet 2016; Ali Abuderman et al. 2019; Azhar et al. 2020; Dutta et al. 2020; Hailan et al. 2022).

Lung cancer

Lung cancer is the second most common cancer worldwide. It is the most common cancer in men and the second most common cancer in women. In Egypt, lung cancer causes 1.06% of total deaths according to the data published by WHO in 2020 (Insights10 2023). There are 25 Egyptian plants studied for their anticancer effect on Lung cancer (A549, A-427, H69, H82, DMS53, DMS114, H1299, QU-DB, SK-LU-1, LLC, COR-L23, CL1-0, CL1-0-GR, H460) cell lines.

The survival benefits of *Solanum Nigrum Linn* (SNL), *Curcumae Rhizoma* (CR), and other 16 herbs were evaluated. Patients given these herbs had a longer median survival time (31 months) than the control group (19 months; *P* 0.001). According to bioinformatics analysis, the 18 herbs exerted anti-lung-adenocarcinoma activity primarily by (1) downregulation of some growth factor receptors, such as HGFR, EGFR, and IGFR, (2) reduction of angiogenesis not only via VEGFR and PDGFR but also via neurotransmitter functions such as dopamine and serotonin, and (3) directly inhibiting the Ras signaling pathway via Ras as well as ALK and FNTA/FNTB (Liu et al. 2021). Epidemiological studies showed that eating vegetables reduces the risk of lung cancer in humans. The chemopreventive agent phenethyl isothiocyanate (PEITC), which is released when watercress (*nasturtium officinale*) is chewed, is a chemopreventive agent against tobacco-induced lung cancer (Hecht et al. 1995).

Many studies have proven the efficacy of Egyptian plant nanoparticles in lung cancer. The green synthesis of silver nanoparticles (AgNPs) by Beta vulgaris extract has been demonstrated to have a cytotoxic effect on the lung cancer cell line A549 (Venugopal et al. 2017). Moreover, Ag NPs were synthesized by an aqueous extract of *Citrus sinensis* without the use of any toxic chemical reagents. Eco-synthesized Ag NPs was revealed as a new chemotherapeutic drug for lung carcinoma cell lines. Ag NPs had IC50 values of 82, 139, 170, 66, 62, and 50 g/mL against the cell lines NCI-H661, HLC-1, NCI-H1563, LC-2/ad, NCI-H1299, and PC-14, respectively (Chen et al. 2022). The aqueous extract of *Origanum vulgare* (Oregano) green synthesized Ag NPs showed a dose-dependent response against human lung cancer A549 cell line (LD50—100g/ml) (Sankar et al. 2013). The self-nanoemulsifying drug delivery system (SNEDDS) has been identified as an ideal method for increasing Curcumin oral absorption and bioavailability. In vitro cytotoxic activities against cervical cancer (Hela), liver cancer (HepG2), and large cell lung cancer (H460) cell lines revealed that the prepared curcumin nanoemulsion effectively inhibited the growth of all three cell lines with IC50 values of 8.6 μM, 14.5 μM, and 5.3 μM, respectively (Nguyen et al. 2020). *Plectranthus amboinicus* extracts phyto-fabricated Au NPs in vitro against lung adenocarcinoma (LAC) cells (A549 cell line). The eco-synthesized Au NPs had radical scavenger properties with cytotoxic characteristics towards the A549 cell line and an IC50 of 16.3 μg/mL in 48 h (Suresh et al. 2020). Furthermore, the synthesis of gold nanoparticles using *Nigella sativa* essential oil (NsEO-AuNPs) demonstrated in-vitro anti-lung cancer activity, The IC50 value revealed that NsEO-AuNPs 28.37 μg ml(-1) were significantly more effective than bulk Au 87.2 μg ml(-1) and *Nigella sativa* essential oil 64.15 μg ml(-1) in inhibiting A549 lung cancer cells (Manju et al. 2016). *Syzygium cumini* seed extract (SCSE) is used as a natural reducing and stabilizing agent for the simultaneous reduction of chloroauric acid and graphene oxide in a phytofabricated gold nanoparticles decorated with reduced graphene oxide nanocomposite (GO). MTT assay results indicated that Au NPs-rGO-NC had an inhibitory effect on A549 (IC50 = 51.99 μgL^{-1}) cell lines (Kadiyala et al. 2018).

Prostate cancer

Prostate cancer is the 4th most common cancer and the second most common cancer in men (World Cancer Research Fund International 2020). In Egypt, prostate cancer is the 7th most common cancer in males with an incidence rate of about 7.2% (Ibrahim and Shash 2022). Twenty Egyptian plants were found to have cytotoxic effects on different prostate cancer cell lines (DU-145, PC-3, LNCaP, C4-2, RWPE-1, PC-3M, C4-2B, PNT2, and CA-HPV-10).

Prostate-specific antigen (PSA) levels can be elevated because of prostate cancer, benign prostatic hyperplasia, prostatic infection, or inflammation. Curcuma extract can lower PSA levels in a short period (a 30-day intake). Fifty individuals were committed to the clinical trial for a first PSA level of more than 4ng/ml. This Curcuma extract may help to prevent prostate cancer, but more research is required to assess that (Fabiani et al. 2018). Prostate cancer (CaP) risk is increased in individuals with high-grade prostatic intraepithelial neoplasia (HGPIN), which makes HGPIN a prime target for herbal chemoprotective supplements such as Zyflamend, which was formed of ten botanical extracts: Bakil's skullcap, knotweed, turmeric, ginger, holy basil, green tea, and oregano. After 18 months, 48% of the individuals showed a 25–50% reduction in PSA. There was a decline in serum C-reactive protein. Immunoreactive staining showed that the 18-month samples had less NF-B. Since 13.3% (2 of 15) of the individuals in these studies had CaP at 18 months, more research is necessary to assess these medications in patients who are at risk for the condition (Capodice et al. 2009). Green tea's antineoplastic benefits in patients with androgen-independent prostate cancer were investigated in a phase II experiment. Green tea had minimal antineoplastic effects in individuals with androgen-independent prostate cancer, as measured by the decrease in PSA values (Jatoi et al. 2003). Enterolactone and enterodiol, mammalian lignans produced from flaxseed, sesame seeds, kale, broccoli, and apricots, may inhibit prostate cancer progression via VEGF-associated mechanisms (Azrad et al. 2013). A phase II trial using *Artemisia annua* (AA) decaf coffee demonstrated a reduction in rising PSA levels in men with biochemical recurrence of prostate cancer (Myint 2022). A phase II clinical study was done for males with increasing PSA following surgery or radiation. Pomegranate juice phytochemicals induce a considerable delay in PSA doubling time, as well as apoptosis, and oxidative stress (Pantuck et al. 2006). Moreover, another clinical trial proved that pomegranates slowed prostate cancer proliferation through prolonged prostate-specific antigen (PSA) doubling times. It was expected that pomegranate extract taken orally would reduce tissue 8-hydroxy-2'-deoxyguanosine (8-OHdG) (a DNA damage marker), an oxidative stress biomarker (Freedland et al. 2013). Pomegranate fruit extract (PFE) immunohistochemistry investigations indicated decreases from baseline in 8-OHdG and androgen receptor expression in prostate tumor-associated cells (Jarrard et al. 2021). Curcumin nanoparticles by wet-milling approach were tested in vitro against prostate cancer cell line 3 (PC3) (E% = 59.66%). The long term use and the safety of nanoparticle-based therapeutics are still questionable.

Skin cancer (Melanoma)

Skin cancers are the most common group of cancers worldwide. More than 1.5 million new cases were estimated in 2020 (Arnold et al. 2022). In Egypt, skin cancer is uncommon as it represents only 5% of the malignant tumors of the body (Hussein 2005). In this review, we found that 11 Egyptian plants were studied for their anti-cancerous effect on skin cancer cell lines (UACC-375, B16F10, A375, C32, MDA-MB-435, A431, UACC62). *Capsicum annuum, Ailanthus excelsa, Panax quinquefolius,* and *Bauhinia variegate* were tried on skin cancer in mice. AgNPs from Trigonella foenum-graecum (TFG) seed extract were assessed for their anticancer activity against skin cancer cell line A431. The results showed more than 50% reduction in the cancerous cells growth confirming its anticancer and antioxidant activity. Also, it was observed that the anticancer activity increases with the increase in TFG-AgNPs concentration (Goyal et al. 2018).

Thymoquinone (TQ), the active compound from *Nigella sativa* was formulated as TQ-Loaded PLGA nanoparticles and was evaluated for its anticancer activity against human melanoma cancer cells. High cell toxicity was observed in melanoma cells due to the rapid and sustained release of TQ from the NPs. However, further investigation is needed as stability problems of the active ingredient were addressed in this study (Ibrahim et al. 2020).

Mouth cancer

The risk of developing oral and oropharyngeal cancer is about 1.7% in males and 0.71% in females (American Cancer Society 2021). Oral cancer deaths present 0.15% of all deaths in Egypt according to data published by WHO. We found that three Egyptian plants (*Gingko biloba, Lawsonia inermis, and Artemisia annua*) were tried for their anti-cancerous effect on oral squamous cell carcinoma cell lines (HSC-2, HSC-4, Ca9–22, SCC-1483, SCC-25, and SCC-QLL1).

Considering nanotechnology application in oral cavity cancers, essential oils as active ingredients of lipid nanocarriers were used as chemo-therapeutic agents against oral cavity cell line (UMSCC1) (Sertel et al. 2011; Severino et al. 2015). Also, a novel strategy of nanosized herbal *Plectranthus amboinicus, Phyllanthus niruri,* and *Euphorbia hirta* treated TiO_2 nanoparticles for anticancer activities on KB oral cancer cells (Maheswari et al. 2021).

Colon\ colorectal cancer

Colorectal cancer (CRC) is now the world's third greatest cause of cancer mortality. Its prevalence is gradually increasing in developing countries. CRC is a kind of colorectal adenocarcinoma that develops from the glandular, epithelial cells of the large intestine. Cancer develops when specific epithelial cells acquire a succession of genetic or epigenetic alterations that give them a selective advantage (Rawla et al. 2019a). CRC is more frequent in males than women and is three to four times more common in industrialized countries than in underdeveloped countries. The age-standardized (global) incidence rates per 100,000 CRC in both sexes are 19.7, 23.6, and 16.3, respectively. Colon cancer is the fifth most lethal malignancy, with 551,000 fatalities expected in 2018, accounting for 5.8% of all cancer deaths. Meanwhile, rectal cancer is the tenth most lethal, accounting for 310,000 fatalities (3.2% of all cancer deaths). At 0–74 years, the cumulative chance of dying from colon cancer is 0.66% for males and 0.44% for women. The risk of rectal cancer is 0.46% in males and 0.26% in women. The age-standardized (global) mortality rate of CRC in both sexes is 8.9 per 100,000 by testing on the Colon cell cancer (HCT-15 andHT-29) (HCT116) (Bray et al. 2018).

There are many clinical trials conducted to study the effect of Egyptian plants on colorectal cancer (CRC). A randomized clinical trial was conducted on 32 volunteers to explore the effect of nuts and green tea extract on CRC and the results showed that those plants regulate targeted biomarkers related to colorectal cancer oncogenesis (Hu et al. 2016). Another randomized controlled trial (RCT) was conducted on 2534 patients to compare between green tea extract and placebo effect on the prevention of CRC secondary to colorectal polyps in the elderly population (Stingl et al. 2011). A randomized, double-blind, controlled trial was conducted on Thirty-five CRC patients to study the effect of *pomegranate* extract consumption on microRNAs expression in normal and malignant colon tissues and it appeared to affect specific colon tissue MicroRNAs but the components responsible for its effect require further research (Nuñez-Sánchez et al. 2015). Another RCT showed that pomegranate consumption decreases plasma lipopolysaccharide-binding protein levels which contributes to the onset and development of CRC (González-Sarrías et al. 2018).

Several clinical trials studied the effect of *Zingiber officinale* (Ginger) on CRC by different mechanisms, an RCT conducted on 30 individuals at normal and 20 individuals at increased risk for CRC for 28 days, showed that ginger had anti-inflammatory activities with significant CRC preventive potential (Jiang et al. 2013). Another RCT on 20 people at increased risk for CRC showed that ginger may increase apoptosis and reduce proliferation in the normal-appearing colorectal epithelium, but further research is needed to support these results (Citronberg et al. 2013). Two studies showed contradictory results regarding ginger's potential to decrease eicosanoid levels by inhibiting their synthesis from arachidonic acid, one study said it was safe and tolerable but the other did not support these findings (Zick et al. 2011). More investigations are required to make a solid conclusion about these effects.

A phase II clinical trial studied the effect of combination of 5-fluorouracil/ *Ginkgo biloba* extract (GBE 761 ONC) in patients with advanced CRC pretreated with 5-fluorouracil only. Forty-four patients (32 evaluable for response) participated in the study and only 2 patients showed partial response after the first cycle of treatment (Hauns et al. 2001). Another randomized, double-blind, placebo-controlled Phase II trial of *Artemisia annua* for CRC was conducted on 20 patients, 9 taking oral artesunate and 11 taking placebo. The results showed that artesunate has anti-proliferative effects and is well tolerated (Krishna et al. 2015; von Hagens et al. 2017; Jill 2021; Myint 2022).

Two studies showed the effect of *C. citrinus* leaves extract on CRC in rats. Results indicated that this extract may have a chemo-preventive effect against colon cancer by inducing antioxidant enzymes and reducing damage of oxidative stress. The extract reduced the size of the tumor, the number of aberrant crypt foci, and the crypt multiplicity (López-Mejia et al. 2019; López-Mejía et al. 2021).

Several studies have been conducted to explore the effect of nanoparticles of Egyptian plants on colorectal cancer cells. One study found that iron nanoparticles from rosemary extract could be more toxic on 4T1 and C26 cancer cell lines than total extract (Farshchi et al. 2018). Another study showed that Nano-liquid chromatography-orbitrap ms-based quantitative proteomics of carnosol and carnosic acid from rosemary herb can protect against HT-29 colon cancer cells (Valdés et al. 2017). Capsaicin-loaded self-nano emulsifying drug delivery system (SNEDDS) was found to inhibit the proliferation of HT-29 colorectal cancer cells 3.6 fold more than plain capsaicin (Bhagwat et al. 2021). Also, silver nano-spheres using zingiber officinale root extract were tested against colon cancer (HCT116) cells and showed anti-cancerous properties (Ramya et al. 2020). One study found that curcuminoids loaded poloxamer 188-based nano emulsion induces apoptosis in five colorectal cancer cell lines (CP1–CP5) (Chen et al. 2011). Another study found that polymer-encapsulated curcumin nanoparticles have anti-tumor activity on cancer cells (HT29) and (HeLa) (Kyung et al. 2009). Selenium nanoparticles from the *Trigonella foenumgraecum* plant cause $>$ 50% inhibition of COLO-205 cell proliferation and could be a promising material for biomedical applications (Pansare et al. 2016). Silver nanoparticles from Phlomis species growing in Egypt showed cytotoxic activity against HCT-116 cancer cell line (Abdelhady et al. 2016). Also, gold nanoparticles from *Citrus sinensis* showed cytotoxicity against colon cancer cell lines (colo 320DM and Ht29) (Randive et al. 2020; Dutta et al. 2020; Chen et al. 2022).

Cervical cancer

Cervical cancer is the fourth most frequent female cancer worldwide, and it poses a significant global health concern (Bray et al. 2018). The most prevalent histological subtypes are squamous cell carcinoma and adenocarcinoma, which account for roughly 70% and 25% of all cervical malignancies, respectively (Small et al. 2017).

There are applications for nanotechnology for targeting cervical cancer as one of these studies mentioned that the nano-formulation of curcumin could reduce the expression of E6 and E7 oncogenes and increase P53 and Rb tumors. Under the influence of nano curcumin treatment, Gene and protein expression analysis showed the up-regulation of P53 and Rb factors and the downregulation of E6 and E7 (Sadeghi et al. 2022). Pd–Ag bimetallic nanoparticles were also successfully prepared by the green method by using Nigella sativa extract as a reducing and stabilizing agent. Pd–Ag NPs showed high toxic effects against MDA-MB-231, ISH, and HeLa cancer cells. Pd–Ag NPs have the potential for use in medicine (Gulbagça et al. 2022). Photosynthesized gold nanoparticles are another application which is from *Catharanthus roseus* -by in vitro model- induce mitochondrial-mediated apoptotic signaling pathways via reactive oxygen species (ROS) induced cytotoxicity in a cervical cancer cell line (HeLa). Exposure to *Catharanthus roseus* Photosynthesized gold nanoparticles CR-AuNPs for 24 h induced cleavage of caspase-3. These findings suggest that CR-AuNPs contribute to apoptotic cell death in human cervical cancer (HeLa) cells (Ke et al. 2019).

Pancreatic cancer

Pancreatic cancer is the 14th most frequent malignancy and the 7th leading cause of cancer death worldwide (McGuigan et al. 2018). Worldwide incidence and mortality rates of pancreatic cancer correlate with increasing age and are slightly more common in men than in women (Bray et al. 2018). Although the causation of pancreatic cancer is complicated and multifaceted, cigarette smoking (Bosetti et al. 2012) and a family history of the disease are the most common (Klein et al. 2004). Pancreatic cancer is classified into two types: pancreatic adenocarcinoma, which is the most prevalent (85% of cases) and develops in the pancreatic exocrine glands, and pancreatic neuroendocrine tumor (PanNET), which is less common (less than 5%) and arises in the pancreatic endocrine tissue (Hidalgo et al. 2015). Some Egyptian medicinal plants are showing anti-cancer effects against MIA PaCa2, AsPC-1, PANC-1, PANC28, BxPC-3, and HUVECs pancreatic cell lines.

Ovarian cancer

Ovarian cancer is the third-ranked gynecologic cancer (Bray et al. 2018). It has the worst prognosis and the highest mortality rate (Coburn et al. 2017). Ovarian cancer mortality rate is caused by asymptomatic growth of the tumor, delayed symptoms appearance, and lack of screening that results in its diagnosis in the advanced stages. Thus, ovarian cancer is called the silent killer (Caan and Thomson 2007). Non-Hispanic white women had the greatest ovarian cancer prevalence (12.0 per 100,000), followed by Hispanic (10.3 per 100,000), non-Hispanic black (9.4 per 100,000), and Asian/Pacific Islander women (9.2 per 100,000) (Torre et al. 2018). However, due to disparities in access to diagnostic and treatment services, ovarian cancer mortality follows a distinct pattern, with African people having the greatest death rate (Chornokur et al. 2013). Our study illustrates plants that showed anti-cancer activities through various mechanisms against SK-OV-3 (human ovarian, (CHO-1) cells ovarian cell line. In a phase I dose-escalation study, *Artemisia annua* (Aa) decaffeinated coffee is used in advanced ovarian cancer patients who have completed front-line carboplatin and paclitaxel chemotherapy. Biomarkers of tumor progression or recurrence are to be followed (Jill 2021). Gold nanoparticles (AuNPs) of Artemisia annua were used against the human ovarian cancer cell line (A2780) and the findings suggest that AuNP-loaded niosomal formulation is considered a promising and suitable targeted system for improving anti-tumor activity against A2780 cells (Amale et al. 2021).

Osteosarcoma

Osteosarcoma OS is the most common primary malignancy of bone in children and a high-grade primary skeletal malignancy characterized by spindle cells of mesenchymal origin depositing immature osteoid matrix (Sissons 1976). The rates of occurrence vary according to age, race, gender, and a variety of other characteristics. Male mortality rates range from 3–5 per million to 2–4 per million worldwide. Showing plants have toxic effect against bone cancer cells lines:(OST), (MG63), OSACA-8 and OSCA-40, HOS and MG63.

Renal cancer

Renal cancer is the world's 13th most frequent cancer, accounting for 2.4% of all malignancies, with over 330,000 new cases identified each year. Men have a two-fold greater incidence of kidney cancer than women (Oeyen et al. 2019). Table 1 presents some plants which show anti-cancer effects on renal cell lines A498, Caki-2, ACHN,786-0, Caki-1, and TK10.

Bladder cancer

Bladder cancer is the fourth most frequent disease in males and the eighth most common cancer in women. Ovarian cancer is the fifth most prevalent malignancy in males worldwide. It affects men four times more than women. We illustrate Egyptian medicinal plants with anti-cancer effect against (T-24) and Bladder carcinoma ECV-304 cell line.

Brain cancer

Brain cancer is a mass of tissue in which cells proliferate and replicate uncontrollably, unregulated by normal cell processes. There are several types of brain illnesses, and it is believed that one in every six persons is affected by these disorders (Roda and Bottone 2022). The common pathways of neuroinflammation, tumor microenvironment, and BBB leakage status that have been found to promote tumor initiation, invasion, and progression are frequently mediated by the dysregulation of a variety of channel proteins and ion pumps by testing on brain cell line (PC12) (Brandalise et al. 2020).

Fibrosarcoma

Fibrosarcoma are malignant tumors made out of fibroblasts with varied quantities of collagen synthesis and a "herringbone" architecture (Davis et al. 2022). Our study illustrates Egyptian plants that showed anti-cancer activities against Fibrosarcoma (HT-1080) and mouse fibroblast (3T3) cell lines.

Pharynx cancer

Silver nanoparticles (Ag-NPs) from Beta vulgaris extract showed anticancer activity against pharynx (Hep-2) cancer cell line by inducing apoptosis. The results of the study proposed that Ag-NPs can be used as an anticancer agent for various cancer types. However, in vivo examination is needed to explore the effect of these nanoparticles inside human bodies (Venugopal et al. 2017).

Adrenal gland cancer

Copper nanoparticles green synthesized from *Nigella sativa L.* seed aqueous extract were studied for their cytotoxic activity against the adrenal phaeochromocytoma (PC12) cell line. It was found that these nanoparticles suppressed methadone-induced cell death in phaeochromocytoma PC12 cells (Yan et al. 2020).

Endometrial cancer

Palladium-silver nanoparticles (Pd–Ag NPs) using the extract of *Nigella sativa* seeds were used against human endometrial carcinoma cells and it promises that Pd–Ag NPs may play a therapeutic role in complications related to cancer (Gulbagça et al. 2022).

Mechanisms of anticancer medicinal plants, which are growing in Egypt

Cell cycle checkpoint inhibitors

The cell cycle refers to the process by which a cell duplicates its whole cellular content during interphase (SubG1, G0/G1, S, and G2) and divides during the M

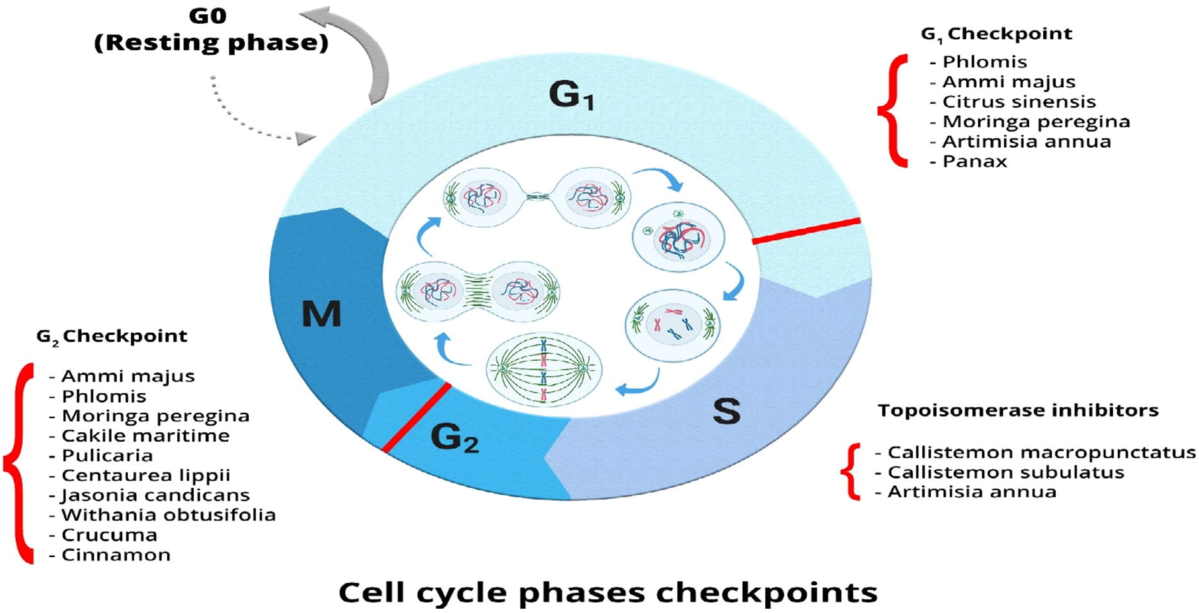

Fig. 2 Mechanisms of medicinal plants cultivated in Egyptian, acting on specific cell cycle phases

phase (Matthews et al. 2022). Cell cycle checkpoints act as DNA surveillance mechanisms, preventing the accumulation and spread of genetic errors during cell division (Barnum and O'Connell 2014). Many medicinal plants play a critical role as checkpoint inhibitors in cancerous cells. The main active constituent of *Ammi majus*, xanthotoxin, inhibited HepG2 cell proliferation via cell cycle arrest at the G2/M phase and induction of apoptosis (Issa et al. 2022). *Phlomis* essential oil induced apoptosis in HepG2 cells by increasing cell accumulation in the sub G1 and G2/M phases of the cell cycle, decreasing the S and G0/G1 phases, activating caspases-3 and-9, and inhibiting cyclin-dependent kinase-2 (CDK2), which play critical roles in the regulation of cell cycle progression and are negatively regulated by CDK inhibitors. By using a colorimetric assay, *P. aurea* oil significantly reduced CDK2 activity in HepG2 cells. Docking was executed on the major chemical constituents of *P. aurea* oil, which were germacrene-D, trans—farnesene, limonene, and -pinene. Germacrene-D demonstrated good binding to the CDK2 receptor pocket via hydrophobic interactions of its alkyl side chains (Torky et al. 2021). *Citrus sinensis* active constituents 5HPMF and 5HHMF, which are monomethylated PMFs, suppress lung cancer cell growth by accumulating cell populations in the sub-G0/G1 phase.

The increased sub G0/G1 cell population revealed DNA fragmentation caused by Poly (ADP-ribose) polymerase (PARP) cleavage (Xiao et al. 2009). The ethanolic extract of *Moringa peregrina* revealed a high proportion of cells in the sub-G0 phase due to nuclear DNA fragmentation caused by decreased poly-ADP-ribose polymerase-1 protein expression (PARP-1). In addition, compared to the control, the proportion of cells in the G0/G1, S, and G2/M phases was significantly decreased. This outcome revealed that Moringa peregrina extract induced apoptosis in cervical and prostate cells by increasing caspase-3 mRNA expression, decreasing Bcl-2 mRNA expression, and decreasing ATP levels (Abou-Hashem et al. 2019). In CCRF-CEM leukemia cells, *Withania obtusifolia, Jasonia candicans, Centaurea lippii,* and *Pulicaria undulata* were identified as promising cytotoxic agents, which cause cell cycle arrest in the G2/M phase. *Withania obtusifolia* methanol extract demonstrated significant cytotoxic activity, with a low IC50 value of 0.79 μg/ml. Furthermore, it inhibited cell proliferation, increased the G2/M cell cycle phase, and decreased the S-phase. The cytotoxic mode of action was illustrated by Western blot analysis, which used increased PARP cleavage as an apoptosis marker (Hegazy et al. 2019). Treatments with *Artemisia annua* extract and artemisinin impair cellular distribution in different

Osteosarcoma cell cycle phases. Pure artemisinin, but not *Artemisia annua* extract, caused a significant decrease in G0/G1 cells, followed by a significant increase in sub-G0/G1 cells in the OSCA-8 cell line. Both treatments had a significant influence on cell distribution in OSCA-40, with a significant decrease in G0/G1 cells and a significant increase in sub G0/G1 cells. The hydroalcoholic extract of *Artemisia annua* is cytotoxic, causing an increase in total iron, accumulation of lipid peroxides, and a "ballooning" death phenotype, indicating ferroptosis activation in osteosarcoma cell lines (Salaroli et al. 2022). *Panax quinquefolius* Saponins inhibited (PQS) prostate cancer cell line (DU145) and caused cell cycle arrest in the G1 phase. PQS treatment for 24 h reduced DU145 cell invasion and migration significantly. PQS increased the expression of p21, p53, TMEM79, ACOXL, ETV5, and SPINT1 while decreasing the expression of bcl2, STAT3, FANCD2, DRD2, and TMPRSS2 (He et al. 2021). Cakile maritima According to the Annexin-V assay, cytotoxicity involved the induction of G2/M phase arrest in targeted human colon cancer (HCT-116), human breast cancer (MCF-7) cells, as well as the induction of apoptosis in both cell lines. Apoptosis was investigated in MCF-7 and HCT-116 cells treated with ethanolic extracts using RT-PCR, which revealed an increase in proapoptotic genes P53, BAX, Capase-3,6,7,8,9 and a decrease in the antiapoptotic gene (BCL-2) after treatment (Tawfik et al. 2023). Curcumin caused melanoma cell cycle arrest at the G2/M phase, through downregulation of NF-B activation, nitric oxide synthase, and upregulation of tumor suppressor gene as p53, p21, p27 (Zheng et al. 2004). Cinnamon induced a cytotoxic effect through stimulation of cyclin B1 expression, suppression of Cdc25B phosphatase, and caused G2/M cell cycle arrest (Jeong et al. 2003; Shin et al. 2006). Figure 2 illustrates the medicinal plants cultivated in Egyptian, acting on specific cell cycle phases.

Immune checkpoint inhibitors

Immune checkpoint inhibitors function by inhibiting regulatory proteins. Checkpoint proteins, such as PD-L1 on tumor cells and (PD-1, and CTLA-4) on T cells, aid in the regulation of immune responses. By preventing PD-L1 from binding to PD-1 with an immune checkpoint inhibitor (anti-PD-L1 or anti-PD-1) T cells can eradicate cancer cells. Terpenes as cannabidiol decreased the expression of PD-L1 by either pancreatic cancer or pancreatic stellate cells through a PAK1-dependent pathway (Yang et al. 2020). Human studies have shown that green tea catechin has cancer-preventive properties by inhibiting PD-L1 expression in non–small-cell lung cancer cells and suppressing both interferon (IFN) -γ- and epidermal growth factor (EGF) by epigallocatechin gallate (EGCG) (Rawangkan et al. 2018).

Curcumin and apigenin inhibited tumor growth and promoted apoptosis in melanoma cells (A375 cell line). Flavonoids, particularly apigenin, dramatically suppressed IFN-γ-induced PD-L1 induction, with corresponding decreases in STAT1 phosphorylation (Xu et al. 2018). Furthermore, apigenin reduced IFN-γ-induced PD-L1 expression in triple-negative MDA-MB-468 BC cells (Coombs et al. 2016). Luteolin has be tested in vitro and in vivo as an anticancer vaccination adjuvant in melanoma. Luteolin was reported to stimulate the PI3K-Akt pathways in APCs (Antigen Presenting cells), stimulate APC activation, promote CTL (Cytotoxic T Lymphocyte) responses, and suppress regulatory T cells (Tian et al. 2021). Luteolin also inhibits HIF-1 expression levels in breast and colon cancer (Monti et al. 2020). Apigenin and luteolin both dramatically inhibited lung cancer growth in KRAS mutants through downregulation of IFN-γ induced PD-L1 expression through inhibiting STAT3 phosphorylation. In vivo experiments revealed that apigenin/luteolin has a synergistic effect with PD-1 antibodies in the treatment of NSCLC with KRAS mutation (Jiang et al. 2021). Curcumin cytotoxicity is caused by decreased PD-L1 expression through inhibition of STAT3 phosphorylation in tongue squamous cell carcinoma (Liao et al. 2018). Furthermore, curcumin combined with total ginsenosides inhibited TLR4/ NF-κB signaling pathway angiogenesis and decreased PD-L1 protein expression in HepG2 hepatocellular cells (Deng et al. 2020). Anthocyanins such as cyanidin-3-O-glucoside, delphinidin-3-O-glucoside, delphinidin chloride, and gallic acid have been shown in silico experiments to reduce the binding of PD-L1 to PD-1, leading in T cell stimulation in the tumor microenvironment (Mazewski et al. 2019). In crizotinib-resistant cells, silibinin-induced STAT3 suppression worked synergistically with crizotinib to reverse its resistance. Furthermore, silibinin suppressed PD-L1 expression as well as EMT regulators (e.g., SLUG, VIM, and

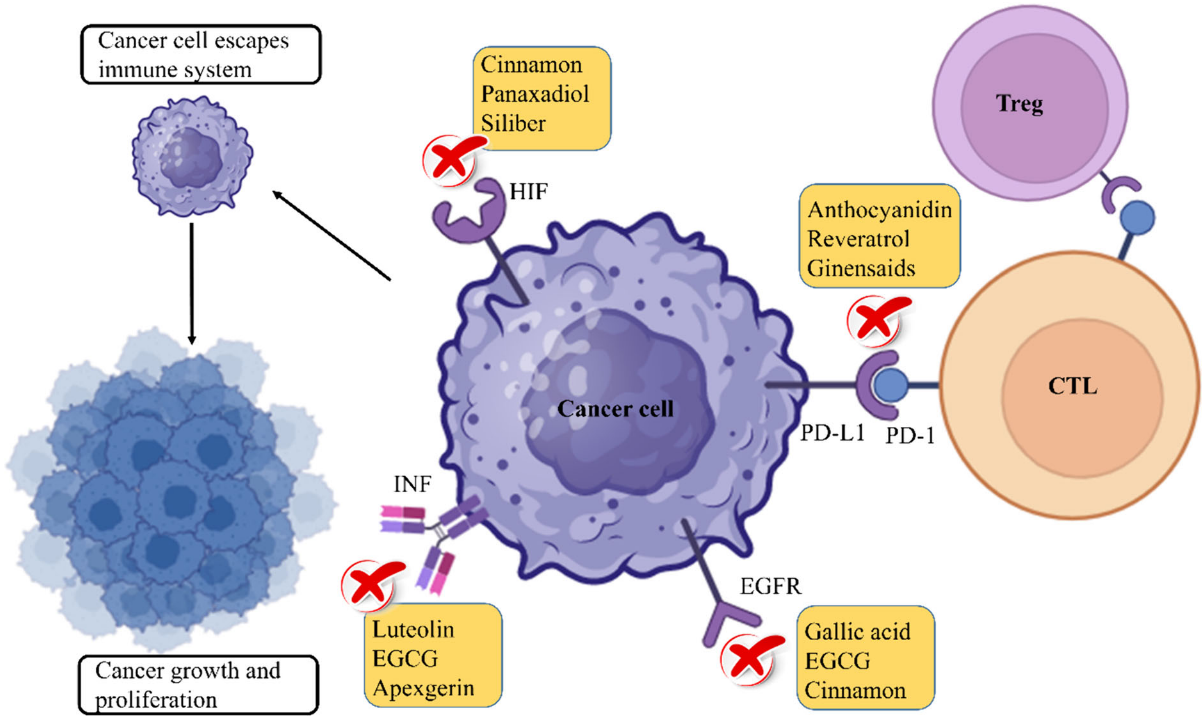

Fig. 3 Mechanisms of medicinal plants cultivated in Egyptian, acting on the immune checkpoints

CD44) in crizotinib-resistant cells (Cuyàs et al. 2016). In nasopharyngeal cancer, silibinin can decrease PD-L1 expression by disrupting the hypoxia-inducible transcription factor HIF-1/LDH-A-mediated cell metabolism (Sellam et al. 2020).

In MDA-MB231 cells, hesperidin decreased cell proliferation. Furthermore, hesperidin suppressed the overexpression of PD-L1 in cancer cells via suppressing Akt and NF-κB signaling (Kongtawelert et al. 2020). In oral cancer cells, hesperidin inhibited PD-L1 expression by suppressing STAT1 and STAT3 phosphorylation (Wudtiwai et al. 2021).

Gallic acid (GA) inhibits colorectal cancer (CRC) growth and improves PD-1 antibody by suppressing the PD-L1 expression via STAT3 phosphorylation (Deng et al. 2022). In non-small-cell lung cancer cells, GA blocked EGFR and inhibited EGF binding, inhibiting PI3K/AKT pathway, and decreasing PD-L1 expression (Kang et al. 2020). Resveratrol (RSV) alters N-linked glycosylation and inhibits the cell membrane translocation of PD-L1. Furthermore, in silico experiments suggested that RSV might cause PD-L1 dimerization, which could directly disrupt the PD-1/PD-L1 interaction (Verdura et al. 2020). In the mouse lung cancer model, lycopene can potentiate anti-PD-1 antibodies to alter PD-L1 expression. Lycopene also inhibited IFN-induced PD-L1 expression in lung cancer cells by activating JAK2/STAT3 signaling, while suppressing AKT signaling (Jiang et al. 2019). Ginsenosides, a triterpenoid saponin, is reported to be a potential anti-PD-L1 drug for the treatment of chemotherapy-resistant NSCLC. Furthermore, PD-L1 deficiency was linked to Akt and NF-B signaling pathway deficiency (Jiang et al. 2017). Panaxadiol, a triterpenoid sapogenin isolated from *Panax ginseng* roots, suppressed PD-L1 expression in colon cancer through blocking HIF-1 and STAT3 signals (Wang et al. 2020b). Cinnamon extract inhibited tumor progression by downregulating tumor-associated growth factors such as EGF, VEGF-, TGF-, Cox-2, HIF-1, and neo-vascularization, while enhancing CD8 + T cell cytolytic activity (Kwon et al. 2009). The mechanisms of medicinal plants cultivated in Egyptian, acting on the immune checkpoints are summarized in Fig. 3.

Apoptosis

Glycyrrhiza glabra L chloroform and methanol fractions had potent antioxidant and cytotoxic effects in HeLa and HepG2 cancer cells via up-regulating pro-apoptotic proteins caspase-8, caspase-3, and down-regulating anti-apoptotic proteins (Bcl-2). Rutin and gallic acid are the flavonoid and phenolic contents of the methanol fraction (Hejazi et al. 2017). Rutin had anti-neuroblastoma activity via inducing G2/M arrest in the cell cycle by suppressing BCL2 expression and the BCL2/BAX ratio (Chen et al. 2013). Furthermore, rutin induced apoptosis through upregulation of caspase-3, caspase-9, and BAX (Pandey et al. 2021). Glabridin, a prenylated isoflavonoid derived from the roots of *Glycyrrhiza glabra* L., suppressed cell growth in acute myelogenous leukemia cell lines. Moreover, glabridin caused apoptosis by activating caspases-3, -8, and -9 and cleaving PARP (Huang et al. 2014). Glycyrrhizic acid-induced G1 phase cell cycle arrest by decreasing proteins such as cyclin D1, D2, D3, E1, and E2. Glycyrrhizic acid increased the levels of Bax, cleaved PARP, and pro-caspase-3, -8, and -9, but didn't affect their cleavage patterns. Furthermore, Glycyrrhizic acid would inhibit PI3K/AKT phosphorylation (Wang et al. 2020a). Gallic acid-induced apoptosis of non-small-cell lung cancer NCI-H460 cells at the G2/M phase through activation of caspase-8, -9, and -3 increases the mitochondrial release of cytochrome c and AIF. Furthermore, Gallic acid suppressed BCL2 and increased BAX (Ji et al. 2009). Two isomers of pregnane steroids isolated from Melia azedarach L. induced apoptosis in breast cancer by increasing the ratio of BAX/bcl-2 (Ervina et al. 2021). *Ricinus communis L.* fruit extract (RCFE) contained ricinine, p-coumaric acid, epigallocatechin, and ricinoleic acid, which showed cytotoxic activities in breast cancer. RCFE-induced apoptosis by decreasing Bcl-2 and increasing pro-apoptotic Bax and caspase-7 expressions, as well as PARP cleavage (Majumder et al. 2019). Apoptosis induced by ricin, a protein isolated from Ricinus communis seeds, was caused by upregulation of caspase-9 and caspase-3 (Herawati et al. 2022). *Ginkgo biloba* exocarp polysaccharides (GBEP) induced apoptosis of human gastric cancer through attenuation of the expression of c-myc, bcl-2, and c-fos genes (Xu et al. 2003). Kaempferol and quercetin isolated from Ginkgo biloba leaves have been reported to induce apoptosis via activation of caspase-3 in oral cavity cancer cells (Kang et al. 2010b). 8-Methoxypsoralen (8-MOP) is a furanocoumarin isolated from *Ammi majus L.* that induces apoptosis in several human cancer cell lines, including neuroblastoma (SK-N-AS) and metastatic colon cancer (SW620), by suppressing AKT, downregulating Bcl-2, increasing Bax, and activating caspases -8, -9, and -3 (Bartnik et al. 2017). Ellagitannins isolated from *Lawsonia inermis* leaves showed a cytotoxic effect on human oral squamous cell carcinoma cell lines. Tellimagrandin II exhibited the greatest cytotoxicity by increasing the amount of cleaved poly (ADP-ribose) polymerase 1 (Orabi et al. 2021). Thymoquinone (TQ) isolated from *Nigella sativa* significantly increased the number of pre-G1 (apoptotic) cells; G2/M arrest in osteosarcoma was associated with p21 upregulation. TQ showed the activation of caspases 8, 9, and 3. TQ revealed a three-fold increase in the Bax/Bcl-2 ratio and the induction of p53 (Roepke et al. 2007). New triflavanone and dicoumarinyl ethers isolated from *Thymelaea hirsuta* daphnoretin methyl ether, and acetyldaphnoretin stimulated apoptosis of breast cancer, resulting in the Pre-G1 stage of the cell cycle arrest by stimulation of BAX and caspase-9, and attenuation of BCL2 (Elhady et al. 2021). Diosgenin isolated from fenugreek caused HEp-2 cells' deaths in S phase and G2/M phase by increasing the apoptotic ratio (Bax/Bcl-2) by 1.6-fold and activating caspase-3 and -9 by 1.6- and 1.2-fold, respectively. PARP cleavage is aided by diosgenin (Corbiere et al. 2004). The rosemary extract and diterpenes suppressed cell viability and caused apoptosis and cell cycle arrest in the G2/M phase (Chan et al. 2021). Rosemary diterpenes: 1. carnosic acid causes apoptosis by inhibiting Bcl-2, increasing Bax protein expression and cytochrome c release, and activating caspase-8, -9, -3, -7, and PARP cleavage. 2. Carnosol induces apoptosis through attenuation of Bcl-2 expression, activation of caspase-8, -9, and -3, PARP cleavage, upregulation of Bax levels, and mitochondrial membrane depolarization. 3. Rosmanol causes apoptosis by increasing Fas and FasL, cytochrome c release, and PARP cleavage (Petiwala and Johnson 2015). Carvacrol isolated from thyme, black cumin, and oregano caused colon cancer cell cycle arrest at the G2/M phase and suppressed cyclin B1 expression. Moreover, carvacrol induced apoptosis by downregulating Bcl-2 and upregulating the expression

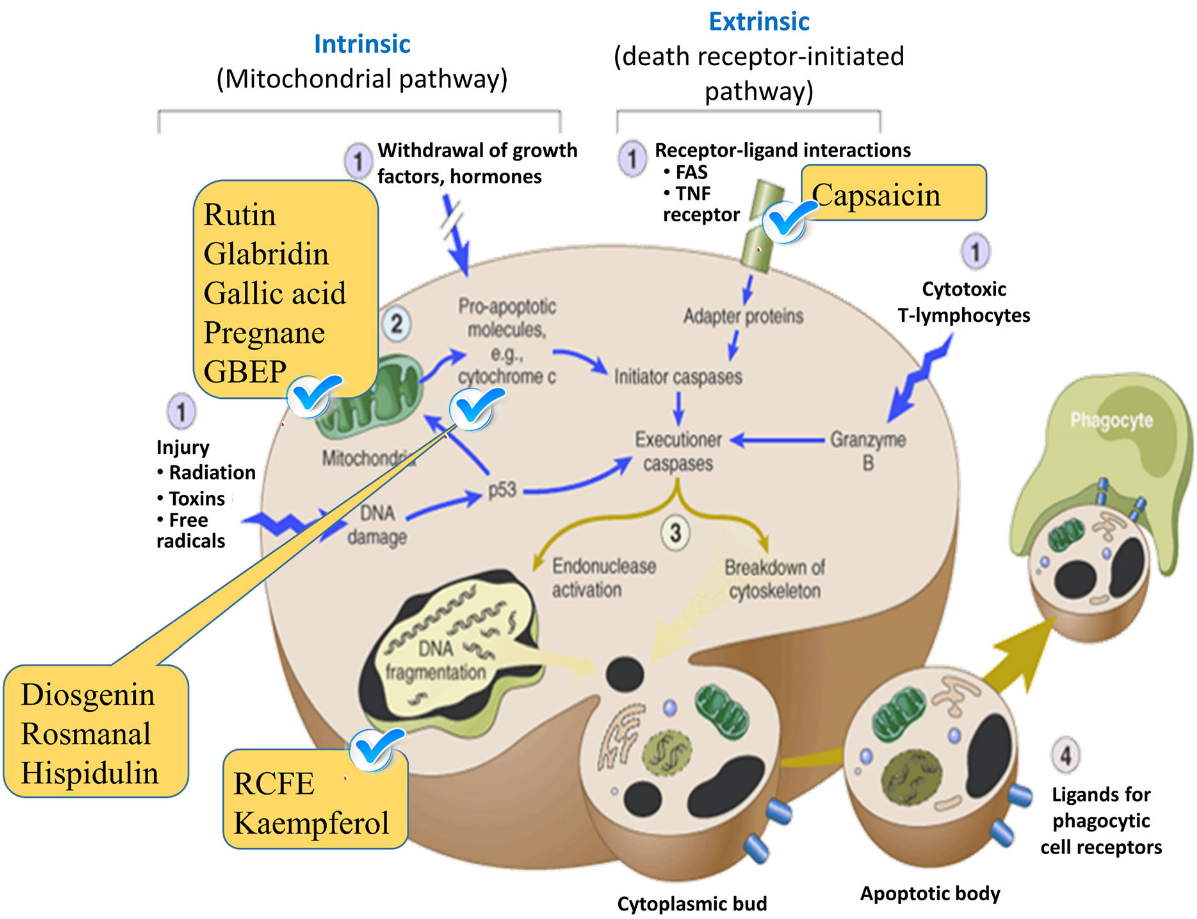

Fig. 4 Medicinal plants cultivated in Egyptian, with apoptotic effects. From Azzwali and Azab (2019), under the terms of the Creative Commons Attribution License

of Bax (Fan et al. 2015). Hispidulin isolated from *Onopordum alexandrinum* induced apoptosis by activating the mitochondria-mediated pathway via an increased ratio of Bax/Bcl-2, cytochrome c release, and caspase-3 sequential increase (Gao et al. 2014; Ashaq et al. 2021). Naringenin, isolated from *Artemisia argyi*, activates caspase-3, caspase-9, caspase-8, and Bax expression in cancer cells (Li et al. 2008; Faramarzi et al. 2022). Jaceosidin, a flavonoid isolated from *Artemisia vestita and Artemisia argyi,* causes apoptosis in renal carcinoma cells by activation of Bax and caspase-3, cleavage of PARP, the release of cytochrome c, and attenuation of Mcl-1 and c-FLIP expression (Lee et al. 2005; Woo and Kwon 2016). Apigenin-induced apoptosis in human lung cancer cells by activating caspases 3, 8, and 9, as well as Bax, and inhibiting BCL-2 (Xu et al. 2018). Eugenol is isolated from nutmeg, basil, cinnamon, and clove. Eugenol activated caspase-9, -3 PARP cleavage, and Bax, decreased Bcl2, and released cytochrome C. Further, eugenol suppressed the expression of MMP-2 and MMP-9, VEGF, and VEGFR1, and increased the expression of TIMP-2 and RECK (Jaganathan and Supriyanto 2012). Sesamol in sesame seeds exerts cytotoxic activity towards human non-small cell lung adenocarcinoma (SK-LU-1) by activation of caspases 8, 9, 3, and 7 and cleavage of PARP (Siriwarin and Weerapreeyakul 2016). Capsaicin (CPS), isolated from green and red peppers, induces apoptosis in renal carcinoma by activating c-myc, FADD, and Bax expression while suppressing Bcl2 expression, finally activating the caspase-3, -8, and -9 cascades (Liu et al. 2016). Emodin increased the expression of p53, p21, Bax, cyclin E, caspases 3, 8, and 9, as well as cleaved poly (ADPribose) polymerase (PARP). However, the protein expression of Bcl2, cyclin A, and CDK2 was suppressed. Emodin promotes apoptosis in hepatocellular carcinoma via the mitochondrial apoptosis cascade (Dong et al. 2018). Figure 4 shows the apoptosis cascade and the mechanism of each of the Egyptian medicinal plants.

Conclusion

In recent years, there has been a shift towards researching the medicinal properties and anticancer potential of various plant compounds, including flavonoids, phenolics, terpenoids, alkaloids, and other constituents. Our review delved into the potential of medicinal plants in Egypt to act as effective anticancer agents. These plants underwent in vivo and in vitro studies, as well as clinical trials in various stages. The data were gathered from Scopus, and PubMed databases through literature survey. We found that the most promising plants were *Capsicum annuum, Camellia sinensis, Zingiber officinale, Punica granatum, and Nerium oleander* as these plants showed anticancer activity in several clinical trials targeting different organs. Also, the development of nanoparticles (NPs) of these plants as a part of cancer therapeutics was investigated. The most promising plants were *Rosmarinus officinalis, Curcuma longa, and Nigella sativa*. Other plants' NPs such as *Beta vulgaris, Plectranthus amboinicus, Citrus sinensis, Cassia angustifolia, and Catharanthus roseus* showed cytotoxic activity. Several in vivo and in vitro studies showed that gold, silver, zinc oxide, copper, iron, and platinum nanoparticles of these plants exhibited cytotoxicity as monotherapy or in combination with other cytotoxic drugs. Additional studies are necessary to investigate the efficacy and the safety of plants-based therapeutic regimens in human subjects. It is also important to further investigate the active compounds found in these plants and their mechanism of action, as this could potentially lead to a new approach to cancer prevention and treatment.

Funding Open access funding provided by The Science, Technology & Innovation Funding Authority (STDF) in cooperation with The Egyptian Knowledge Bank (EKB). No funding was received for this project.

Declarations

Competing interests The authors declare no competing interest.

References

Abas A-SM, Naguib DM (2019) Effect of germination on anticancer activity of *Trigonella foenum* seeds extract. Biocatal Agric Biotechnol 18:101067. https://doi.org/10.1016/j.bcab.2019.101067

Abbas Z, Rehman S (2018) An overview of cancer treatment modalities. Neoplasm. https://doi.org/10.5772/intechopen.76558

Abdalla YOA, Subramaniam B, Nyamathulla S et al (2022) Natural products for cancer therapy: a review of their mechanism of actions and toxicity in the past decade. J Trop Med 2022:1–20. https://doi.org/10.1155/2022/5794350

Abdallah HM, Esmat A (2017) Antioxidant and anti-inflammatory activities of the major phenolics from *Zygophyllum simplex* L. J Ethnopharmacol 205:51–56. https://doi.org/10.1016/j.jep.2017.04.022

Abdallah HM, Ezzat SM (2011) Effect of the method of preparation on the composition and cytotoxic activity of the essential oil of pituranthos tortuosus. Zeitschrift Für Naturforsch C 66:143–148. https://doi.org/10.1515/znc-2011-3-408

Abdel-Aziz A-W, Abdel-Motagaly M, Abdallah MA et al (2021) In vitro cytotoxicity, antimicrobial, antioxidant activities and HPLC finger print analyses of the extracts of ceiba insignis leaves growing in Egypt. Egypt J Chem 5:10–110. https://doi.org/10.21608/ejchem.2021.73023.3618

Abdelhady NM, Badr KA, Nevein Abdelhady CM (2016) Comparative study of phenolic content, antioxidant potentials and cytotoxic activity of the crude and green synthesized silver nanoparticles′ extracts of two Phlomis species growing in Egypt. ∼ 377 ∼. J Pharmacogn Phytochem 5:377–38396

Abdel-Hamid NM, Abdel-Ghany MI, Nazmy MH, Amgad SW (2013) Can methanolic extract of Nigella sativa seed affect glyco-regulatory enzymes in experimental hepatocellular

carcinoma? Environ Health Prev Med 18:49–56. https://doi.org/10.1007/s12199-012-0292-8
Abdellatef AA, Fathy M, Mohammed AE-SI et al (2021) Inhibition of cell-intrinsic NF-κB activity and metastatic abilities of breast cancer by aloe-emodin and emodic-acid isolated from Asphodelus microcarpus. J Nat Med 75:840–853. https://doi.org/10.1007/s11418-021-01526-w
Abdellatif AAH, Osman SK, Alsharidah M et al (2022) Green synthesis of silver nanoparticles reduced with Trigonella foenum-graecum and their effect on tumor necrosis factor-α in MCF7 cells. Eur Rev Med Pharmacol Sci 26:5529–5539. https://doi.org/10.26355/eurrev_202208_29424
Aboalhaija NH, Awwad O, Khalil E et al (2019) Chemodiversity and antiproliferative activity of the essential oil of schinus molle growing in jordan. Chem Biodivers. https://doi.org/10.1002/cbdv.201900388
Abood W (2022) Anti-proliferative activity of Cassia angustifolia in breast cancer cell line. Azerbaijan Med Assoc J 62:763–774
Abou-Hashem MMM, Abo-elmatty DM, Mesbah NM, Abd EL-Mawgoud AM (2019) Induction of sub-G0 arrest and apoptosis by seed extract of Moringa peregrina (Forssk.) Fiori in cervical and prostate cancer cell lines. J Integr Med 17:410–422. https://doi.org/10.1016/j.joim.2019.09.004
Aboul-Enein AM, Abu El-Ela F, Shalaby EA, El-Shemy HA (2012) Traditional medicinal plants research in Egypt: studies of antioxidant and anticancer activities. J Med Plants Res 6:689–703
Aboul-Enein AM, El-Ela A, Shalaby E, El-Shemy H (2014) Potent Anticancer and Antioxidant Activities of Active Ingredients Separated from Solanum nigrum and Cassia ital... faten abouelella Potent Anticancer and Antioxidant Activities of Active Ingredients Separated from Solanum nigrum and Cassia italica Extrac. J Arid L Stud 24:145–152
Aburjai TA, Mansi K, Azzam H et al (2020) Chemical compositions and anticancer potential of'essential oil from greenhouse-cultivated ocimum basilicum leaves. Indian J Pharm Sci 82:179–84. https://doi.org/10.36468/pharmaceutical-sciences.637
Abutaha N, Nasr FA, Al-zharani M et al (2019) Effects of hexane root extract of Ferula hermonis Boiss. on human breast and colon cancer cells: an in vitro and in vivo study. Biomed Res Int 2019:1–12. https://doi.org/10.1155/2019/3079895
Adeyemi JO, Elemike EE, Onwudiwe DC, Singh M (2019) Bioinspired synthesis and cytotoxic evaluation of silver-gold bimetallic nanoparticles using Kei-Apple (Dovyalis caffra) fruits. Inorg Chem Commun 109:107569. https://doi.org/10.1016/j.inoche.2019.107569
Adeyemi JO, Onwudiwe DC, Oyedeji AO (2022) Biogenic synthesis of CuO, ZnO, and CuO–ZnO nanoparticles using leaf extracts of Dovyalis caffra and their biological properties. Molecules 27:3206. https://doi.org/10.3390/molecules27103206
Adhami VM, Ahmad N, Mukhtar H (2003) Molecular targets for green tea in prostate cancer prevention. J Nutr 133:2417S-2424S. https://doi.org/10.1093/jn/133.7.2417S
Adouni K, Bendif H, Zouaoui O et al (2022) Antioxidant activity of extracts obtained by high-pressure extraction procedures from *Asparagus stipularis* Forssk. S Afr J Bot 146:789–793. https://doi.org/10.1016/j.sajb.2021.12.027
Afaq F, Zaid M, Khan N et al (2008) Inhibitory effect of oral feeding of pomegranate fruit extract on UVB-induced skin carcinogenesis in SKH-1 hairless mice. Cancer Res 68:1246
Ahmed SI, Hayat MQ, Tahir M et al (2016) Pharmacologically active flavonoids from the anticancer, antioxidant and antimicrobial extracts of *Cassia angustifolia* Vahl. BMC Complement Altern Med 16:460. https://doi.org/10.1186/s12906-016-1443-z
Ahrens S, Appl B, Trochimiuk M et al (2022) Kigelia africana inhibits proliferation and induces cell death in stage 4 Neuroblastoma cell lines. Biomed Pharmacother 154:113584. https://doi.org/10.1016/j.biopha.2022.113584
Akhter KF, Mumin MA, Lui EMK, Charpentier PA (2021) Transdermal nanotherapeutics: *Panax quinquefolium* polysaccharide nanoparticles attenuate UVB-induced skin cancer. Int J Biol Macromol 181:221–231
Al-Ali KH, El-Beshbishy HA, El-Badry AA, Alkhalaf M (2013) Cytotoxic activity of methanolic extract of *Mentha longifolia* and *Ocimum basilicum* against human breast cancer. Pak J Biol Sci PJBS 16:1744–1750. https://doi.org/10.3923/PJBS.2013.1744.1750
Alali FQ, Amrine CSM, El-Elimat T et al (2014) Bioactive withanolides from *Withania obtusifolia*. Phytochem Lett 9:96–101. https://doi.org/10.1016/j.phytol.2014.05.002
Al-Anazi KM, Al-Mareed AA, Farah MA et al (2021) Protective effect of *Capparis spinosa* extract against potassium bromate induced oxidative stress and genotoxicity in mice. Evid-Based Complement Altern Med 2021:1–15. https://doi.org/10.1155/2021/8875238
Alhomaidi E, Jasim SA, Amin HIM et al (2022) Biosynthesis of silver nanoparticles using *Lawsonia inermis* and their biomedical application. IET Nanobiotechnol 16:284–294. https://doi.org/10.1049/nbt2.12096
Ali SI, Zhang C-R, Mohamed AA et al (2013) Major constituents of *Boswellia carteri* resin exhibit cyclooxygenase enzyme inhibition and antiproliferative activity. Nat Prod Commun 8:1365–1366
Ali Abuderman A, Syed R, Alyousef AA et al (2019) Green synthesized silver nanoparticles of *Myrtus communis* L. (AgMC) extract inhibits cancer hallmarks via targeting aldose reductase (AR) and associated signaling network. Processes 7:860. https://doi.org/10.3390/pr7110860
Alijani HQ, Pourseyedi S, Torkzadeh-Mahani M et al (2020) Bimetallic nickel-ferrite nanorod particles: greener synthesis using rosemary and its biomedical efficiency. Artif Cells Nanomed Biotechnol 48:242–251. https://doi.org/10.1080/21691401.2019.1699830
Alkhateeb MA, Al-Otaibi WR, AlGabbani Q et al (2021) Low-temperature extracts of Purple blossoms of basil (*Ocimum basilicum* L.) intervened mitochondrial translocation contributes prompted apoptosis in human breast cancer cells. Biol Res. https://doi.org/10.1186/s40659-020-00324-0
Alkhudhayri DA, Osman MA, Alshammari GM et al (2021) Moringa peregrina leaf extracts produce anti-obesity, hypoglycemic, anti-hyperlipidemic, and hepatoprotective effects on high-fat diet fed rats. Saudi J Biol Sci 28:3333–3342. https://doi.org/10.1016/j.sjbs.2021.02.078

Al-Mamun MA, Akter Z, Uddin MJ et al (2016) Characterization and evaluation of antibacterial and antiproliferative activities of crude protein extracts isolated from the seed of *Ricinus communis* in Bangladesh. BMC Complement Altern Med 16:1–10. https://doi.org/10.1186/S12906-016-1185-Y/FIGURES/4

Al-Marzook F, Omran R (2017) Cytotoxic activity of alkaloids extracted from three Iraqi plants against breast cancer cell line. Asian J Pharm Clin Res 10:78–81

Al-Rajhi AMH, Salem SS, Alharbi AA, Abdelghany TM (2022) Ecofriendly synthesis of silver nanoparticles using Kei-apple (Dovyalis caffra) fruit and their efficacy against cancer cells and clinical pathogenic microorganisms. Arab J Chem. https://doi.org/10.1016/j.arabjc.2022.103927

Al-Senosy NK, Abou-Eisha A, Ahmad ES (2018) Cytotoxic effects of Atriplex halimus extract on human cancer cell lines. Biosci Res 15:1718–1728

Alshahrani MY, Ibrahim EH (2022) Gold nanoparticles (AuNPs) and Rosmarinus officinalis extract and their potentials to prompt apoptosis and arrest cell cycle in HT-29 colon cancer cells. J King Saud Univ - Sci. https://doi.org/10.1016/j.jksus.2022.102304

Alshuail N, Alehaideb Z, Alghamdi S et al (2022) Achillea fragrantissima (Forssk.) Sch.Bip flower dichloromethane extract exerts anti-proliferative and pro-apoptotic properties in human triple-negative breast cancer (MDA-MB-231) cells: in vitro and in silico studies. Pharmaceuticals 15:1060. https://doi.org/10.3390/ph15091060

Amale FR, Ferdowsian S, Hajrasouliha S et al (2021) Gold nanoparticles loaded into niosomes: a novel approach for enhanced antitumor activity against human ovarian cancer. Adv Powder Technol 32:4711–4722. https://doi.org/10.1016/j.apt.2021.10.019

Amantini C, Ballarini P, Caprodossi S et al (2009) Triggering of transient receptor potential vanilloid type 1 (TRPV1) by capsaicin induces Fas/CD95-mediated apoptosis of urothelial cancer cells in an ATM-dependent manner. Carcinogenesis 30:1320–1329. https://doi.org/10.1093/carcin/bgp138

American Cancer Society (2021) Key statistics for oral cavity and oropharyngeal cancers. https://www.cancer.org/content/dam/CRC/PDF/Public/8763.00.pdf. Accessed 18 Mar 2023

Ammar MK, Handoussa H, Hanafi RS et al (2022) Multivariate approach for optimization of galactomannan extraction from seeds of Egyptian *Trigonella foenum-graecum* with insights on its pharmacological activities. Nat Prod Res 36:2125–2128. https://doi.org/10.1080/14786419.2020.1837817

Anand P, Sundaram C, Jhurani S et al (2008) Curcumin and cancer: an "old-age" disease with an "age-old" solution. Cancer Lett 267:133–164. https://doi.org/10.1016/J.CANLET.2008.03.025

Antony D, Balasubramanian K, Yadav R (2022) Experimental and computational studies of phytomediated selenium-CuO and ZnO nanoparticles-potential drugs for breast cancer. J Mol Struct. https://doi.org/10.1016/j.molstruc.2022.133113

Arnold M, Singh D, Laversanne M et al (2022) Global burden of cutaneous melanoma in 2020 and projections to 2040. JAMA Dermatol 158:495. https://doi.org/10.1001/jamadermatol.2022.0160

Arshadqamar K, Dar A, Siddiqui BS et al (2010) Anticancer activity of *Ocimum basilicum* and the effect of ursolic acid on the cytoskeleton of MCF-7 human breast cancer cells. Ingenta Connect 7:726–736

Arumugam G, Swamy M, Sinniah U (2016) *Plectranthus amboinicus* (Lour.) Spreng: botanical, phytochemical, pharmacological and nutritional significance. Molecules 21:369. https://doi.org/10.3390/molecules21040369

Ashaq A, Maqbool MF, Maryam A et al (2021) Hispidulin: A novel natural compound with therapeutic potential against human cancers. Phyther Res 35:771–789. https://doi.org/10.1002/ptr.6862

Ashour HM (2008) Antibacterial, antifungal, and anticancer activities of volatile oils and extracts from stems, leaves, and flowers of *Eucalyptus sideroxylon* and *Eucalyptus torquata*. Cancer Biol Ther 7:399–403. https://doi.org/10.4161/cbt.7.3.5367

Aslam MS, Naveed S, Ahmed A et al (2014) Side effects of chemotherapy in cancer patients and evaluation of patients opinion about starvation based differential chemotherapy. J Cancer Ther 05:817–822. https://doi.org/10.4236/jct.2014.58089

Atolani O, Olatunji GA, Adeyemi OS (2021) Cytotoxicity of lapachol and derivatized analogues from *Kigelia africana* (Lam.) Benth. on cancer cell lines. Arab J Sci Eng 46:5307–5312. https://doi.org/10.1007/s13369-020-05113-1

Auychaipornlert S, Lawanprasert PP, Piriyaprasarth S et al (2022) Design of turmeric rhizome extract nano-formula for delivery to cancer cells. Molecules 27:896. https://doi.org/10.3390/molecules27030896

Ayyadurai N (2013) Evaluation of cytotoxic properties of curcuma longa and tagetes erecta on cancer cell line (Hep2). Afr J Pharm Pharmacol 7:736–739. https://doi.org/10.5897/ajpp12.031

Azhar NA, Ghozali SZ, Abu Bakar SA et al (2020) Suppressing growth, migration, and invasion of human hepatocellular carcinoma HepG2 cells by Catharanthus roseus-silver nanoparticles. Toxicol Vitr 67:104910. https://doi.org/10.1016/j.tiv.2020.104910

Azim NSA (2011) Egyptian herbal drug industry: challenges for the future. Planta Med. https://doi.org/10.1055/s-0031-1282154

Azrad M, Vollmer RT, Madden J et al (2013) Flaxseed-derived enterolactone is inversely associated with tumor cell proliferation in men with localized prostate cancer. J Med Food 16:357–360. https://doi.org/10.1089/jmf.2012.0159

Azzwali A-AA, Azab AE (2019) Mechanisms of programmed cell death. J Appl Biotechnol Bioeng 6:156–158. https://doi.org/10.15406/jabb.2019.06.00188

Badawy A, Hassanean H, Ibrahim AK et al (2021) Isolates from *Thymelaea Hirsuta* inhibit progression of hepatocellular carcinoma in vitro and in vivo. Nat Prod Res 35:1799–1807. https://doi.org/10.1080/14786419.2019.1643859

Bakr RO, El Bishbishy MH (2016) Profile of bioactive compounds of *Capparis spinosa* var. *aegyptiaca* growing in Egypt. Rev Bras Farmacogn 26:514–520. https://doi.org/10.1016/j.bjp.2016.04.001

Bakr RO, Mohamed SAEH, Ayoub N (2016) Phenolic profile of *Centaurea aegyptiaca* L. Growing in Egypt and its cytotoxic and antiviral activities. Afr J Tradit Complement Altern Med 13:135–143. https://doi.org/10.21010/ajtcam.v13i6.19
Bangroo A, Malhotra A, Sharma U et al (2022) Biosynthesis of zinc oxide nanoparticles using *Catharanthus Roseus* leaves and their therapeutic response in breast cancer (MDA-MB-231) cells. Nutr Cancer 74:1489–1496. https://doi.org/10.1080/01635581.2021.1952622
Bar FMA, Khanfar MA, Elnagar AY et al (2010) Design and pharmacophore modeling of biaryl methyl eugenol analogs as breast cancer invasion inhibitors. Bioorg Med Chem 18:496–507. https://doi.org/10.1016/j.bmc.2009.12.019
Barai AC, Paul K, Dey A et al (2018) Green synthesis of Nerium oleander-conjugated gold nanoparticles and study of its in vitro anticancer activity on MCF-7 cell lines and catalytic activity. Nano Converg. https://doi.org/10.1186/s40580-018-0142-5
Bardaweel S, Hudaib M, Tawaha K (2015) Evaluation of antibacterial, antifungal, and anticancer activities of essential oils from six species of eucalyptus. J Essent Oil Bear Plants 17:1165–1174. https://doi.org/10.1080/0972060X.2014.963169
Barnum KJ, O'Connell MJ (2014) Cell cycle regulation by checkpoints. In: Methods in molecular biology, pp 29–40
Bartnik M, Sławińska-Brych A, Żurek A et al (2017) 8-methoxypsoralen reduces AKT phosphorylation, induces intrinsic and extrinsic apoptotic pathways, and suppresses cell growth of SK-N-AS neuroblastoma and SW620 metastatic colon cancer cells. J Ethnopharmacol 207:19–29. https://doi.org/10.1016/j.jep.2017.06.010
Bayala B, Zohoncon TM, Djigma FW et al (2020) Antioxidant and antiproliferative activities on prostate and cervical cultured cancer cells of five medicinal plant extracts from Burkina Faso. Int J Biol Chem Sci 14:652–663. https://doi.org/10.4314/ijbcs.v14i3.1
Beddou F, Bekhechi C, Ksouri R et al (2014) Potential assessment of *Rumex vesicarius* L. as a source of natural antioxidants and bioactive compounds. J Food Sci Technol 52:3549–3560. https://doi.org/10.1007/s13197-014-1420-9
Behbahani M (2014) Evaluation of in vitro anticancer activity of Ocimum basilicum, Alhagi maurorum, Calendula officinalis and their parasite Cuscuta campestris. PLoS One. https://doi.org/10.1371/journal.pone.0116049
Ben Jannet S, Hymery N, Bourgou S et al (2017) Antioxidant and selective anticancer activities of two Euphorbia species in human acute myeloid leukemia. Biomed Pharmacother 90:375–385. https://doi.org/10.1016/j.biopha.2017.03.072
Berdowska I, Zieliński B, Matusiewicz M, Fecka I (2022) Modulatory impact of lamiaceae metabolites on apoptosis of human leukemia cells. Front Pharmacol 13:867709
Bhadran S, George SA, Malla S, Harini BP (2017) Screening of bioprotective properties of various plant extracts and gas chromatography-mass spectrometry profiling of adenanthera pavonina stem extract. Asian J Pharm Clin Res 10:188–194
Bhagwat DA, Swami PA, Nadaf SJ et al (2021) Capsaicin loaded solid SNEDDS for enhanced bioavailability and anticancer activity: in-vitro, in-silico, and in-vivo characterization. J Pharm Sci 110:280–291. https://doi.org/10.1016/j.xphs.2020.10.020
Bharathi D, Bhuvaneshwari V (2019) Evaluation of the cytotoxic and antioxidant activity of phyto-synthesized silver nanoparticles using cassia angustifolia flowers. Bionanoscience 9:155–163. https://doi.org/10.1007/s12668-018-0577-5
Bosetti C, Lucenteforte E, Silverman DT et al (2012) Cigarette smoking and pancreatic cancer: an analysis from the international pancreatic cancer case-control consortium (Panc4). Ann Oncol 23:1880–1888. https://doi.org/10.1093/annonc/mdr541
Brandalise F, Ratto D, Leone R et al (2020) Deeper and deeper on the role of BK and Kir4.1 channels in glioblastoma invasiveness: a novel summative mechanism? Front Neurosci. https://doi.org/10.3389/fnins.2020.595664
Bray F, Ferlay J, Soerjomataram I et al (2018) Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 68:394–424. https://doi.org/10.3322/caac.21492
Breuer E, Efferth T (2014) Treatment of iron-loaded veterinary sarcoma by *Artemisia annua*. Nat Prod Bioprospect 4:113–118. https://doi.org/10.1007/s13659-014-0013-7
Brown KC, Witte TR, Hardman WE et al (2010) Capsaicin displays anti-proliferative activity against human small cell lung cancer in cell culture and nude mice models via the E2F pathway. PLoS One. https://doi.org/10.1371/journal.pone.0010243
Caan BJ, Thomson CA (2007) 10 Breast and ovarian cancer. Optim Women's Heal through Nutr 230–257
Cao C, Su Y, Han D et al (2017) Ginkgo biloba exocarp extracts induces apoptosis in Lewis lung cancer cells involving MAPK signaling pathways. J Ethnopharmacol 198:379–388. https://doi.org/10.1016/J.JEP.2017.01.009
Capodice JL, Gorroochurn P, Cammack AS et al (2009) Zyflamend in men with high-grade prostatic intraepithelial neoplasia: results of a phase I clinical trial. J Soc Integr Oncol 7:43–51
Chakraborty S, Adhikary A, Mazumdar M et al (2014) Capsaicin-induced activation of p53-SMAR1 auto-regulatory loop down-regulates VEGF in non-small cell lung cancer to restrain angiogenesis. PLoS One. https://doi.org/10.1371/journal.pone.0099743
Chan EWC, Wong SK, Chan HT (2021) An overview of the chemistry and anticancer properties of rosemary extract and its diterpenes. J Herbmed Pharmacol 11:10–19. https://doi.org/10.34172/jhp.2022.02
Chang H, Chen S, Chien S et al (2011) Capsaicin may induce breast cancer cell death through apoptosis-inducing factor involving mitochondrial dysfunction. Hum Exp Toxicol 30:1657–1665. https://doi.org/10.1177/0960327110396530
Chao WW, Su CC, Peng HY, Chou ST (2017) Melaleuca quinquenervia essential oil inhibits α-melanocyte-stimulating hormone-induced melanin production and oxidative stress in B16 melanoma cells. Phytomedicine 34:191–201. https://doi.org/10.1016/J.PHYMED.2017.08.024
Chapa-Oliver A, Mejía-Teniente L (2016) Capsaicin: from plants to a cancer-suppressing agent. Molecules 21:931. https://doi.org/10.3390/molecules21080931

Chauhan R, D'Souza HL, Shabnam R, Abraham J (2015) Phytochemical and cytotoxicity analysis of seeds and leaves of *Adenanthera pavonina*. Res J Pharm Technol 8:198. https://doi.org/10.5958/0974-360X.2015.00036.0

Chen MJ, Chu YY, Lai PH et al (2011) Experimental results of colorectal cancer chemoprevention by curcuminoids loaded nano-carrier drug delivery system increased in vitro biocompatibility. Dig J Nanomater Biostruct 6:1187–1197

Chen D, Yang Z, Wang Y et al (2012) Capsaicin induces cycle arrest by inhibiting cyclin-dependent-kinase in bladder carcinoma cells. Int J Urol 19:662–668. https://doi.org/10.1111/j.1442-2042.2012.02981.x

Chen H, Miao Q, Geng M et al (2013) Anti-tumor effect of rutin on human neuroblastoma cell lines through inducing G2/M cell cycle arrest and promoting apoptosis. Sci World J 2013:1–8. https://doi.org/10.1155/2013/269165

Chen F, Zheng Q, Li X, Xiong J (2022) *Citrus sinensis* leaf aqueous extract green-synthesized silver nanoparticles: characterization and cytotoxicity, antioxidant, and anti-human lung carcinoma effects. Arab J Chem 15:103845. https://doi.org/10.1016/j.arabjc.2022.103845

Choi CH, Jung YK, Oh SH (2010) Autophagy induction by capsaicin in malignant human breast cells is modulated by p38 and extracellular signal-regulated mitogen-activated protein kinases and retards cell death by suppressing endoplasmic reticulum stress-mediated apoptosis. Mol Pharmacol 78:114–125. https://doi.org/10.1124/mol.110.063495

Chornokur G, Amankwah EK, Schildkraut JM, Phelan CM (2013) Global ovarian cancer health disparities. Gynecol Oncol 129:258–264. https://doi.org/10.1016/j.ygyno.2012.12.016

Chou G-L, Peng S-F, Liao C-L et al (2018) Casticin impairs cell growth and induces cell apoptosis via cell cycle arrest in human oral cancer SCC-4 cells. Environ Toxicol 33:127–141. https://doi.org/10.1002/tox.22497

Chow J, Norng M, Zhang J, Chai J (2007) TRPV6 mediates capsaicin-induced apoptosis in gastric cancer cells—mechanisms behind a possible new "hot" cancer treatment. Biochim Biophys Acta - Mol Cell Res 1773:565–576. https://doi.org/10.1016/j.bbamcr.2007.01.001

Citronberg J, Bostick R, Ahearn T et al (2013) Effects of ginger supplementation on cell-cycle biomarkers in the normal-appearing colonic mucosa of patients at increased risk for colorectal cancer: results from a pilot, randomized, and controlled trial. Cancer Prev Res 6:271–281. https://doi.org/10.1158/1940-6207.CAPR-12-0327

Coburn SB, Bray F, Sherman ME, Trabert B (2017) International patterns and trends in ovarian cancer incidence, overall and by histologic subtype. Int J Cancer 140:2451–2460. https://doi.org/10.1002/ijc.30676

Conforti F, Statti G, Tundis R et al (2004) Antioxidant and cytotoxic activities of *Retama raetam* subsp. *Gussonei*. Phyther Res 18:585–587. https://doi.org/10.1002/ptr.1496

Coombs MRP, Harrison ME, Hoskin DW (2016) Apigenin inhibits the inducible expression of programmed death ligand 1 by human and mouse mammary carcinoma cells. Cancer Lett 380:424–433. https://doi.org/10.1016/j.canlet.2016.06.023

Corbiere C, Liagre B, Terro F, Beneytout J-L (2004) Induction of antiproliferative effect by diosgenin through activation of p53, release of apoptosis-inducing factor (AIF) and modulation of caspase-3 activity in different human cancer cells. Cell Res 14:188–196. https://doi.org/10.1038/sj.cr.7290219

Corea G, Di Pietro A, Dumontet C et al (2009) Jatrophane diterpenes from Euphorbia spp. as modulators of multidrug resistance in cancer therapy. Phytochem Rev 8:431–447. https://doi.org/10.1007/s11101-009-9126-8

Cuyàs E, Pérez-Sánchez A, Micol V et al (2016) STAT3-targeted treatment with silibinin overcomes the acquired resistance to crizotinib in ALK-rearranged lung cancer. Cell Cycle 15:3413–3418. https://doi.org/10.1080/15384101.2016.1245249

D'Arena G, Simeon V, Martino L et al (2013) Regulatory T-cell modulation by green tea in chronic lymphocytic leukemia. Int J Immunopathol Pharmacol 26:117–125

D'Eliseo D, Manzi L, Velotti F (2013) Capsaicin as an inducer of damage-associated molecular patterns (DAMPs) of immunogenic cell death (ICD) in human bladder cancer cells. Cell Stress Chaperones 18:801–808. https://doi.org/10.1007/s12192-013-0422-2

Das S, Dey KK, Dey G et al (2012) Antineoplastic and apoptotic potential of traditional medicines thymoquinone and diosgenin in squamous cell carcinoma. PLoS One 7:e46641. https://doi.org/10.1371/journal.pone.0046641

Davis DD, Shah SJ, Kane S M (2022) Fibrosarcoma. StatPearls [Internet] StatPearls Publ

DeFeudis FV, Papadopoulos V, Drieu K (2003) Ginkgo biloba extracts and cancer: a research area in its infancy. Fundam Clin Pharmacol 17:405–417

Deng P, Wang C, Chen L et al (2013) Sesamin induces cell cycle arrest and apoptosis through the inhibition of signal transducer and activator of transcription 3 signalling in human hepatocellular carcinoma cell line HepG2. Biol Pharm Bull 36:1540–1548. https://doi.org/10.1248/bpb.b13-00235

Deng Z, Xu X-Y, Yunita F et al (2020) Synergistic anti-liver cancer effects of curcumin and total ginsenosides. World J Gastrointest Oncol 12:1091–1103. https://doi.org/10.4251/wjgo.v12.i10.1091

Deng B, Yang B, Chen J et al (2022) Gallic acid induces T-helper-1-like T_{reg} cells and strengthens immune checkpoint blockade efficacy. J Immunother Cancer 10:e004037. https://doi.org/10.1136/jitc-2021-004037

Desai TH, Joshi SV (2019) Anticancer activity of saponin isolated from Albizia lebbeck using various in vitro models. J Ethnopharmacol 231:494–502. https://doi.org/10.1016/j.jep.2018.11.004

DeVita VT, Chu E (2008) A history of cancer chemotherapy. Cancer Res 68:8643–8653. https://doi.org/10.1158/0008-5472.CAN-07-6611

Dhandapani S, Xu X, Wang R et al (2021) Biosynthesis of gold nanoparticles using *Nigella sativa* and *Curtobacterium proimmune* K3 and evaluation of their anticancer activity. Mater Sci Eng C 127:112214. https://doi.org/10.1016/j.msec.2021.112214

Díaz C, Quesada S, Brenes O et al (2008) Chemical composition of Schinus molle essential oil and its cytotoxic activity on tumour cell lines. Nat Prod Res 22:1521–1534. https://doi.org/10.1080/14786410701848154

Dolghi A, Coricovac D, Dinu S et al (2022) Chemical and antimicrobial characterization of *Mentha piperita* L. and *Rosmarinus officinalis* L. essential oils and in vitro potential cytotoxic effect in human colorectal carcinoma cells. Molecules 27:6106. https://doi.org/10.3390/molecules27186106

Dong X, Ni B, Fu J et al (2018) Emodin induces apoptosis in human hepatocellular carcinoma HepaRG cells via the mitochondrial caspase-dependent pathway. Oncol Rep. https://doi.org/10.3892/or.2018.6620

Dou H, Yang S, Hu Y et al (2018) Sesamin induces ER stress-mediated apoptosis and activates autophagy in cervical cancer cells. Life Sci 200:87–93. https://doi.org/10.1016/J.LFS.2018.03.003

Dutta T, Chattopadhyay AP, Ghosh NN et al (2020) Biogenic silver nanoparticle synthesis and stabilization for apoptotic activity; insights from experimental and theoretical studies. Chem Pap 74:4089–4101. https://doi.org/10.1007/s11696-020-01216-z

Eid AM, Jaradat N, Issa L et al (2022) Evaluation of anticancer, antimicrobial, and antioxidant activities of rosemary (Rosmarinus Officinalis) essential oil and its Nanoemulgel. Eur J Integr Med. https://doi.org/10.1016/j.eujim.2022.102175

El Hawary S, El SA, Helmy MW et al (2018) DNA fingerprinting, biological and chemical investigation of certain Yucca species. Nat Prod Res 32:2617–2620. https://doi.org/10.1080/14786419.2017.1423311

Elansary HO, Szopa A, Kubica P et al (2020) Antioxidant and biological activities of *Acacia saligna* and *Lawsonia inermis* natural populations. Plants 9:908. https://doi.org/10.3390/plants9070908

El-Askary H, Hölzl J, Hilal S, El-Kashoury E-S (1995) Cardenolide glycosides from *Gomphocarpus sinaicus*. Phytochemistry 38:943–946. https://doi.org/10.1016/0031-9422(94)00606-T

El-Attar M, Awad A, Abdel-Tawab F et al (2019) Assessment of cytotoxic and anticancer activity of zygophyllum album and suaeda palastina extracts on human liver cancer cell lines. Arab Univ J Agric Sci 27:539–544. https://doi.org/10.21608/ajs.2019.43663

Elbouzidi A, Ouassou H, Aherkou M et al (2022) LC–MS/MS phytochemical profiling, antioxidant activity, and cytotoxicity of the ethanolic extract of *Atriplex halimus* L. against breast cancer cell lines: computational studies and experimental validation. Pharmaceuticals 15:1156. https://doi.org/10.3390/ph15091156

El-Gazzar N, Abdallah R, Hammoda H, Sallam S (2022) Chemical constituents and biological activities of genus Lotus: An updated review. Rec Pharm Biomed Sci 6:147–162. https://doi.org/10.21608/rpbs.2022.150727.1157

Elhady SS, Abdelhameed RFA, El-Ayouty MM et al (2021) New Antiproliferative Triflavanone from *Thymelaea hirsuta*—isolation, structure elucidation and molecular docking studies. Molecules 26:739. https://doi.org/10.3390/molecules26030739

El-Moaty HIA, Soliman NA, Hamad RS et al (2021) Comparative therapeutic effects of *Pituranthos tortuosus* aqueous extract and phyto-synthesized gold nanoparticles on *Helicobacter pylori*, diabetic and cancer proliferation. S Afr J Bot 139:167–174. https://doi.org/10.1016/j.sajb.2021.02.009

El-Najjar N, Chatila M, Moukadem H et al (2010) Reactive oxygen species mediate thymoquinone-induced apoptosis and activate ERK and JNK signaling. Apoptosis 15:183–195. https://doi.org/10.1007/s10495-009-0421-z

El-Nashar HAS, Eldehna WM, Al-Rashood ST et al (2021) GC/MS analysis of essential oil and enzyme inhibitory activities of *Syzygium cumini* (Pamposia) grown in Egypt: chemical characterization and molecular docking studies. Molecules 26:6984. https://doi.org/10.3390/molecules26226984

El-Sayeh NEM, Elsaadany SS, Elmassry RA, Hefnawy HTM (2018) Cytotoxic effect of ginger root (Zingiber officinale) on liver and breast cancer. Zagazig J Agric Res 45:995–1001. https://doi.org/10.21608/zjar.2018.49149

El-Seedi HR, Burman R, Mansour A et al (2013) The traditional medical uses and cytotoxic activities of sixty-one Egyptian plants: discovery of an active cardiac glycoside from *Urginea maritima*. J Ethnopharmacol 145:746–757. https://doi.org/10.1016/j.jep.2012.12.007

El-Shiekh RA, Al-Mahdy DA, Hifnawy MS et al (2017) Chemical and biological investigation of *Ochrosia elliptica* Labill. Rec Nat Prod 11:552–557

Emadi A, Law JY (2022) Overview of leukemia - hematology and oncology. In: MSD Man. Prof. Ed. https://www.msdmanuals.com/professional/hematology-and-oncology/leukemias/overview-of-leukemia.

Erdem S, Seyhan V, Arslan BA, Mericli F (2006) Cytotoxic effects of leaf, stem and root extracts of Nerium oleander on leukemia cell lines and role of the p-glycoprotein in this effect the patient is mine. View project anxiety disorder view project. J Exp Ther Oncol 6:31–38

Ervina M, Poerwono H, Widyowati R et al (2020) Bio-selective hormonal breast cancer cytotoxic and antioxidant potencies of *Melia azedarach* L. wild type leaves. Biotechnol Rep 25:e00437. https://doi.org/10.1016/j.btre.2020.e00437

Ervina M, Poerwono H, Widyowati R et al (2021) Pregnane steroids from the leaves of Melia Azedarach and apoptotic activity against T47D Cells. Asian Pac J Cancer Prev 22:1967–1973. https://doi.org/10.31557/APJCP.2021.22.6.1967

Ezzat S, Hegazy A, Amer AM et al (2011) Isolation of biologically active constituents from *Moringa peregrina* (Forssk.) Fiori. (family: Moringaceae) growing in Egypt. Pharmacogn Mag 7:109. https://doi.org/10.4103/0973-1296.80667

Ezzat EAO, Eman AM, Mortada ME-S et al (2020) Identification of the volatile and nonvolatile constituents of *Schinus molle* (L.) fruit extracts and estimation of their activities as anticancer agents. J Appl Pharm Sci. https://doi.org/10.7324/JAPS.2021.110719

Ezzat R, Eltabbakh M, El Kassas M (2021) Unique situation of hepatocellular carcinoma in Egypt: a review of epidemiology and control measures. World J Gastrointest Oncol 13:1919–1938. https://doi.org/10.4251/wjgo.v13.i12.1919

Fabiani A, Morosetti C, Filosa A et al (2018) Effect on prostatic specific antigen by a short time treatment with a Curcuma extract: a real life experience and implications for prostate

biopsy. Arch Ital Di Urol e Androl 90:107. https://doi.org/10.4081/aiua.2018.2.107
Fagbohun OF, Olawoye B, Ademakinwa AN et al (2021) UHPLC/GC-TOF-MS metabolomics, MTT assay, and molecular docking studies reveal physostigmine as a new anticancer agent from the ethyl acetate and butanol fractions of *Kigelia africana* (Lam.) Benth. fruit extracts. Biomed Chromatogr. https://doi.org/10.1002/bmc.4979
Fan K, Li X, Cao Y et al (2015) Carvacrol inhibits proliferation and induces apoptosis in human colon cancer cells. Anticancer Drugs 26:813–823. https://doi.org/10.1097/CAD.0000000000000263
Faraj AK, Shawkat MS (2020) Cytotoxic effect of flavonoids extracted from *conocarpus erectus* leaves on Hela cell and ref. Plant Arch 20:3476–3480
Faramarzi F, Alimohammadi M, Rahimi A et al (2022) Naringenin induces intrinsic and extrinsic apoptotic signaling pathways in cancer cells: a systematic review and meta-analysis of in vitro and in vivo data. Nutr Res 105:33–52. https://doi.org/10.1016/j.nutres.2022.05.003
Farid MM, Hussein SR, Ibrahim LF et al (2015) Cytotoxic activity and phytochemical analysis of *Arum palaestinum* Boiss. Asian Pac J Trop Biomed 5:944–947. https://doi.org/10.1016/j.apjtb.2015.07.019
Farshchi HK, Azizi M, Jaafari MR et al (2018) Green synthesis of iron nanoparticles by Rosemary extract and cytotoxicity effect evaluation on cancer cell lines. Biocatal Agric Biotechnol 16:54–62. https://doi.org/10.1016/j.bcab.2018.07.017
Fathy SA, Emam MA, Abo Agwa SH et al (2016) The antiproliferative effect of Origanum majorana on human hepatocarcinoma cell line: suppression of NF-κB. Cell Mol Biol 62:80–84
Fatima K, Luqman S, Meena A (2022) Carvacrol arrests the proliferation of hypopharyngeal carcinoma cells by suppressing ornithine decarboxylase and hyaluronidase activities. Front Nutr. https://doi.org/10.3389/fnut.2022.857256
Fatma G, Sami BHA, Ahmed L (2017) Investigation of extracts from tunisian ethnomedicinal plants as antioxidants, cytotoxins, and antimicrobials. Biomed Environ Sci 30:811–824. https://doi.org/10.3967/bes2017.109
Ferley J, Soerjomataram I, Ervik M, et al (2014) Breast cancer statistics | World Cancer Research Fund International. Int. Agency Res. Cancer http://globocan.iarc.fr
Firdhouse MJ, Lalitha P (2017) Cytotoxicity of spherical gold nanoparticles synthesised using aqueous extracts of aerial roots of Rhaphidophora aurea (Linden ex Andre) intertwined over Lawsonia inermis and Areca catechu on MCF-7 cell line. IET Nanobiotechnol 11:2–11
Freedland SJ, Carducci M, Kroeger N et al (2013) A double-blind, randomized, neoadjuvant study of the tissue effects of POMx pills in men with prostate cancer before radical prostatectomy. Cancer Prev Res 6:1120–1127. https://doi.org/10.1158/1940-6207.CAPR-12-0423
Fu C, Zhang K, Wang M, Qiu F (2022) Casticin and chrysosplenol D from *Artemisia annua* L. induce apoptosis by inhibiting topoisomerase IIα in human non-small-cell lung cancer cells. Phytomedicine. https://doi.org/10.1016/j.phymed.2022.154095
Galala AA, Ahmad KFM, Zaghloul MG, Mansour ESSA (2015) Two new alkaloids from *Asparagus stipularis* Forssk. roots. Phytochem Lett 12:220–223. https://doi.org/10.1016/j.phytol.2015.04.004
Galli F, Stabile AM, Betti M et al (2004) The effect of α- And γ-tocopherol and their carboxyethyl hydroxychroman metabolites on prostate cancer cell proliferation. Arch Biochem Biophys 423:97–102. https://doi.org/10.1016/j.abb.2003.11.014
Gamal G, Abo-El-Seoud KA, Attia G (2022) Triterpenoids from the aerial parts of *Anabasis articulata* (Forssk) Moq: gastroprotective effect in vivo with in silico studies, cytotoxic and antimicrobial activities. Nat Prod Res 36:4076–4084. https://doi.org/10.1080/14786419.2021.1961769
Gamal-Eldeen A, Amer H, Helmy W et al (2007) Antiproliferative and cancer-chemopreventive properties of sulfated glycosylated extract derived from *Leucaena leucocephala*. Indian J Pharm Sci 69:805. https://doi.org/10.4103/0250-474X.39438
Gao H, Wang H, Peng J (2014) Hispidulin induces apoptosis through mitochondrial dysfunction and inhibition of P13k/Akt signalling pathway in HepG2 cancer cells. Cell Biochem Biophys 69:27–34. https://doi.org/10.1007/s12013-013-9762-x
Garufi A, Pistritto G, Cirone M, D'Orazi G (2016) Reactivation of mutant p53 by capsaicin, the major constituent of peppers. J Exp Clin Cancer Res 35:136. https://doi.org/10.1186/s13046-016-0417-9
Gedara SR, Galala AA (2014) New cytotoxic spirostane saponin and biflavonoid glycoside from the leaves of *Acacia saligna* (Labill.) H.L. Wendl Nat Prod Res 28:324–329. https://doi.org/10.1080/14786419.2013.863200
Ghramh HA, Khan KA, Ibrahim EH, Setzer WN (2019) Synthesis of gold nanoparticles (AuNPs) using ricinus communis leaf ethanol extract, their characterization, and biological applications. Nanomaterials. https://doi.org/10.3390/nano9050765
Gioti K, Papachristodoulou A, Benaki D et al (2020) Glycyrrhiza glabra-enhanced extract and adriamycin antiproliferative effect on PC-3 prostate cancer cells. Nutr Cancer 72:320–332. https://doi.org/10.1080/01635581.2019.1632357
Gohil K, Moy RK, Farzin S et al (2009) mRNA expression profile of a human cancer cell line in response to Ginkgo biloba extract: Induction of antioxidant response and the golgi system. Free Radic Res 33:831–849. https://doi.org/10.1080/10715760000301351
González-Sarrías A, Núñez-Sánchez MA, Ávila-Gálvez MA et al (2018) Consumption of pomegranate decreases plasma lipopolysaccharide-binding protein levels, a marker of metabolic endotoxemia, in patients with newly diagnosed colorectal cancer: a randomized controlled clinical trial. Food Funct 9:2617–2622. https://doi.org/10.1039/C8FO00264A
Goyal S, Gupta N, Kumar A et al (2018) Antibacterial, anticancer and antioxidant potential of silver nanoparticles engineered using *Trigonella foenum-graecum* seed extract. IET Nanobiotechnol 12:526–533. https://doi.org/10.1049/iet-nbt.2017.0089

Greenwell M, Rahman PKSM (2015) Medicinal plants: their use in anticancer treatment. Int J Pharm Sci Res 6:4103–4112. https://doi.org/10.13040/IJPSR.0975-8232.6(10).4103-12

Gulbagça F, Aygun A, Altuner EE et al (2022) Facile bio-fabrication of Pd-Ag bimetallic nanoparticles and its performance in catalytic and pharmaceutical applications: hydrogen production and in-vitro antibacterial, anticancer activities, and model development. Chem Eng Res Des 180:254–264. https://doi.org/10.1016/j.cherd.2022.02.024

Ha PP, Ibrahim H, El-Moaty A (2016) Bioactive compounds of moricandia nitens and its anticancer effect. IAJPS 3:1283–1290

Haddad NF, Teodoro AJ, Leite de Oliveira F et al (2013) Lycopene and beta-carotene induce growth inhibition and proapoptotic effects on ACTH-secreting pituitary adenoma cells. PLoS One 8:e62773. https://doi.org/10.1371/journal.pone.0062773

Hailan WA, Al-Anazi KM, Farah MA et al (2022) Reactive oxygen species-mediated cytotoxicity in liver carcinoma cells induced by silver nanoparticles biosynthesized using *Schinus* molle extract. Nanomaterials 12:161. https://doi.org/10.3390/nano12010161

Hamankoh RS, Shamaei S (2021) Evaluation of anticancer and anti-bacterial effects of silver nanoparticles synthesized by origanum majoranal. Extract on cancer cells MCF-7, HeLa and A549. J Chem Heal Risks 11:457–467. https://doi.org/10.22034/JCHR.2021.1937062.1373

Hamdan D, Al-Gendy A, Sahzly A (2016) Chemical composition and cytotoxic activity of the essential oils of *Schinus molle* growing in Egypt. J Pharm Sci Res 8:779–793

Hamed AI, Masullo M, Pecio L et al (2014) Unusual fernane and gammacerane glycosides from the aerial parts of *Spergula fallax*. J Nat Prod 77:657–662. https://doi.org/10.1021/np4008415

Hamta A, Shariatzadeh SMA, Soleimani Mehranjani M et al (2014) The cytotoxic effects of *Glycyrrhiza glabra* L. root extract on 4T1 cell line derived from BALB/c mice mammary tumors. J Med Plants 13:92–103

Harikumar KB, Sung B, Tharakan ST et al (2010) Sesamin manifests chemopreventive effects through the suppression of NF-κB–regulated cell survival, proliferation, invasion, and angiogenic gene products. Mol Cancer Res 8:751–761. https://doi.org/10.1158/1541-7786.MCR-09-0565

Harwansh RK, Patra KC, Pareta SK, et al (2011) Pharmacological studies on Glycyrrhiza glabra pharmacological studies oo glycyrrhiza glabra: a review. Pharmacologyonline 2:1032–1038

Hasibuan PAZ, Sumaiyah S (2019) The anti-proliferative and pro-apoptotic properties of Ethanol *Plectranthus amboinicus* (Lour.) Spreng. Leaves ethanolic extract nanoparticles on T47D cell lines. Asian Pac J Cancer Prev 20:897–901. https://doi.org/10.31557/APJCP.2019.20.3.897

Hassan RA, Tawfik WA, Abou-Setta LM (2013) The flavonoid constituents of Leucaena leucocephala. Growing in Egypt, and their biological activity. Afr J Tradit Complement Altern Med 11:67–72

Hauns B, Haring B, Kohler S et al (2001) Phase II study of combined 5-fluorouracil/Ginkgo biloba extract (GBE 761 ONC) therapy in 5-fluorouracil pretreated patients with advanced colorectal cancer. Phyther Res 15:34–38. https://doi.org/10.1002/1099-1573(200102)15:1%3c34::AID-PTR755%3e3.0.CO;2-2

Hawas UW, El-Kassem LTA, Shaher FM et al (2022) Phytochemical compositions of some red sea halophyte plants with antioxidant and anticancer potentials. Molecules. https://doi.org/10.3390/molecules27113415

He S, Lyu F, Lou L et al (2021) Anti-tumor activities of *Panax quinquefolius* saponins and potential biomarkers in prostate cancer. J Ginseng Res 45:273–286. https://doi.org/10.1016/j.jgr.2019.12.007

Hecht SS, Chung FL, Richie JP et al (1995) Effects of watercress consumption on metabolism of a tobacco-specific lung carcinogen in smokers. Cancer Epidemiol Biomark Prev 4:877–884

Hegazy M-EF, Abdelfatah S, Hamed AR et al (2019) Cytotoxicity of 40 Egyptian plant extracts targeting mechanisms of drug-resistant cancer cells. Phytomedicine 59:152771. https://doi.org/10.1016/j.phymed.2018.11.031

Hejazi II, Khanam R, Mehdi SH et al (2017) New insights into the antioxidant and apoptotic potential of *Glycyrrhiza glabra* L. during hydrogen peroxide mediated oxidative stress: an in vitro and in silico evaluation. Biomed Pharmacother 94:265–279. https://doi.org/10.1016/j.biopha.2017.06.108

Herawati IE, Lesmana R, Levita J, Subarnas A (2022) Cytotoxicity, apoptosis, migration inhibition, and autophagy-induced by crude ricin from ricinus communis seeds in A549 lung cancer cell lines. Med Sci Monit Basic Res 28:e936683. https://doi.org/10.12659/MSMBR.936683

Herman B (2021) Effect of Oryza Sativa l extract to LPS, ZO-1, and intestinal microbiota in obese individuals. https://ichgcp.net/fr/clinical-trials-registry/NCT04827628. Accessed 18 Mar 2023

Hidalgo M, Cascinu S, Kleeff J et al (2015) Addressing the challenges of pancreatic cancer: future directions for improving outcomes. Pancreatology 15:8–18. https://doi.org/10.1016/j.pan.2014.10.001

Hifnawy M, Sokkar N, Ezzat S et al (2012) Cytotoxicity and suppressive effect of leaves of *Mimusops laurifolia* on carbon tetrachloride-induced liver injury in rats and its bioactive constituents. Asian J Plant Sci 11:124–130. https://doi.org/10.3923/ajps.2012.124.130

High KP, Case D, Hurd D et al (2012) A randomized, controlled trial of *Panax quinquefolius* extract (CVT-E002) to reduce respiratory infection in patients with chronic lymphocytic leukemia. J Support Oncol 10:195–201. https://doi.org/10.1016/j.suponc.2011.10.005

Hosainzadegan H, Ezzetpor B, Abdollahpor F et al (2010) Study of cytotoxic activity of olive and green tea extracts on breast tumor cell line. J Ardabil Univ Med Sci 10:287–294

Hosny M, Fawzy M, Abdelfatah AM et al (2021) Comparative study on the potentialities of two halophytic species in the green synthesis of gold nanoparticles and their anticancer, antioxidant and catalytic efficiencies. Adv Powder Technol 32:3220–3233. https://doi.org/10.1016/j.apt.2021.07.008

Hosseinimehr S, Shafaghati N, Hedayati M (2014) Protective effects of curcumin against genotoxicity induced by 131-iodine in human cultured lymphocyte cells. Pharmacogn Mag 10:106. https://doi.org/10.4103/0973-1296.131020

Hu Y, McIntosh GH, Le Leu RK et al (2016) Supplementation with Brazil nuts and green tea extract regulates targeted biomarkers related to colorectal cancer risk in humans. Br J Nutr 116:1901–1911. https://doi.org/10.1017/S0007114516003937

Huang H-L, Hsieh M-J, Chien M-H et al (2014) Glabridin mediate caspases activation and induces apoptosis through JNK1/2 and p38 MAPK pathway in human promyelocytic leukemia cells. PLoS One 9:e98943. https://doi.org/10.1371/journal.pone.0098943

Hussein MR (2005) Skin cancer in Egypt: a word in your ear. Cancer Biol Ther 4:593–595. https://doi.org/10.4161/cbt.4.5.1730

Hwang YP, Yun HJ, Choi JH et al (2011) Suppression of EGF-induced tumor cell migration and matrix metalloproteinase-9 expression by capsaicin via the inhibition of EGFR-mediated FAK/Akt, PKC/Raf/ERK, p38 MAPK, and AP-1 signaling. Mol Nutr Food Res 55:594–605. https://doi.org/10.1002/mnfr.201000292

Ibrahim N, Moussa AY (2020) Comparative metabolite profiling of *Callistemon macropunctatus* and *Callistemon subulatus* volatiles from different geographical origins. Ind Crops Prod 147:112222. https://doi.org/10.1016/j.indcrop.2020.112222

Ibrahim WN, Rosli LMBM, Doolaanea AA (2020) Formulation, cellular uptake and cytotoxicity of thymoquinone-loaded PLGA nanoparticles in malignant melanoma cancer cells. Int J Nanomed 15:8059–8074

Ibrahim FM, Fouad R, EL-Hallouty S et al (2021) Egyptian *Myrtus communis* L. essential oil potential role as in vitro antioxidant, cytotoxic and α-amylase inhibitor. Egypt J Chem 64:3005–3017. https://doi.org/10.21608/ejchem.2021.57354.3245

Ibrahim AH, Shash E (2022) General oncology care in Egypt. Cancer Arab World 41–61. https://doi.org/10.1007/978-981-16-7945-2_4

Insights10 (2023) Egypt lung cancer therapeutics market analysis. https://www.insights10.com/report/egypt-lung-cancer-therapeutics-market-analysis/#: ~ :text=According to the latest WHO,115th in the world.

Ip SW, Lan SH, Lu HF et al (2012) Capsaicin mediates apoptosis in human nasopharyngeal carcinoma NPC-TW 039 cells through mitochondrial depolarization and endoplasmic reticulum stress. Hum Exp Toxicol 31:539–549. https://doi.org/10.1177/0960327111417269

Issa MY, Elshal MF, Fathallah N et al (2022) Potential anticancer activity of the furanocoumarin derivative xanthotoxin isolated from *Ammi majus* L. fruits: in vitro and in silico studies. Molecules 27:943. https://doi.org/10.3390/molecules27030943

Jaganathan SK, Supriyanto E (2012) Antiproliferative and molecular mechanism of eugenol-induced apoptosis in cancer cells. Molecules 17:6290–6304. https://doi.org/10.3390/molecules17066290

Jaganathan SK, Mazumdar A, Mondhe D, Mandal M (2011) Apoptotic effect of eugenol in human colon cancer cell lines. Cell Biol Int 35:607–615. https://doi.org/10.1042/cbi20100118

Jarrard D, Filon M, Huang W et al (2021) A phase II randomized placebo-controlled trial of pomegranate fruit extract in men with localized prostate cancer undergoing active surveillance. Prostate 81:41–49. https://doi.org/10.1002/pros.24076

Jatoi A, Ellison N, Burch PA et al (2003) A phase II trial of green tea in the treatment of patients with androgen independent metastatic prostate carcinoma. Cancer 97:1442–1446. https://doi.org/10.1002/cncr.11200

Jeong H-W, Han DC, Son K-H et al (2003) Antitumor effect of the cinnamaldehyde derivative CB403 through the arrest of cell cycle progression in the G2/M phase. Biochem Pharmacol 65:1343–1350. https://doi.org/10.1016/S0006-2952(03)00038-8

Jeung-Min L, Hyun-Jung K, Seong-Hee M, Hae-Ryong P (2010) Anticancer activity of *Artemisia argyi* extracts on HT-29 human colon cancer cells. Cancer Prev Res 15:76–82

Ji B-C, Hsu W-H, Yang J-S et al (2009) Gallic acid induces apoptosis via caspase-3 and mitochondrion-dependent pathways in vitro and suppresses lung xenograft tumor growth in vivo. J Agric Food Chem 57:7596–7604. https://doi.org/10.1021/jf901308p

Jiang Y, Turgeon DK, Wright BD et al (2013) Effect of ginger root on cyclooxygenase-1 and 15-hydroxyprostaglandin dehydrogenase expression in colonic mucosa of humans at normal and increased risk for colorectal cancer. Eur J Cancer Prev 22:455–460. https://doi.org/10.1097/CEJ.0b013e32835c829b

Jiang Z, Yang Y, Yang Y et al (2017) Ginsenoside Rg3 attenuates cisplatin resistance in lung cancer by downregulating PD-L1 and resuming immune. Biomed Pharmacother 96:378–383. https://doi.org/10.1016/j.biopha.2017.09.129

Jiang X, Wu H, Zhao W et al (2019) Lycopene improves the efficiency of anti-PD-1 therapy via activating IFN signaling of lung cancer cells. Cancer Cell Int 19:68. https://doi.org/10.1186/s12935-019-0789-y

Jiang Z-B, Wang W-J, Xu C et al (2021) Luteolin and its derivative apigenin suppress the inducible PD-L1 expression to improve anti-tumor immunity in KRAS-mutant lung cancer. Cancer Lett 515:36–48. https://doi.org/10.1016/j.canlet.2021.05.019

Jill KM (2021) Phase 1 dose escalation of ArtemiCoffee. ClinicalTrials.gov

Jin T, Wu H, Wang Y, Peng H (2016) Capsaicin induces immunogenic cell death in human osteosarcoma cells. Exp Ther Med 12:765–770. https://doi.org/10.3892/etm.2016.3368

Jssim QANK, Abdul-Halim AG (2020) Cytotoxic effect of synergism relationship of oil extract from origanum majorana l. and silicon nano particles on MCF-7. Plant Arch 20:817–821

Jun HS, Park T, Lee CK et al (2007) Capsaicin induced apoptosis of B16–F10 melanoma cells through down-regulation of Bcl-2. Food Chem Toxicol 45:708–715. https://doi.org/10.1016/J.FCT.2006.10.011

Kadiyala NK, Mandal BK, Ranjan S, Dasgupta N (2018) Bioinspired gold nanoparticles decorated reduced graphene oxide nanocomposite using *Syzygium cumini* seed extract: evaluation of its biological applications. Mater Sci Eng C 93:191–205. https://doi.org/10.1016/j.msec.2018.07.075

Kamal AM, Abdel Shakour ZT, All SA et al (2017) Phytochemical and biological investigation of Ipomoea carnea

Jacq. grown in Egypt. Int J Pharmacogn Phytochem Res 9:266–281
Kammoun AK, Altyar AE, Gad HA (2021) Comparative metabolic study of *Citrus sinensis* leaves cultivars based on GC–MS and their cytotoxic activity. J Pharm Biomed Anal 198:113991. https://doi.org/10.1016/j.jpba.2021.113991
Kang JW, Kim JH, Song K et al (2010a) Kaempferol and quercetin, components of *Ginkgo biloba* extract (EGb 761), induce caspase-3-dependent apoptosis in oral cavity cancer cells. Phyther Res 24:S77–S82. https://doi.org/10.1002/ptr.2913
Kang JW, Kim JH, Song K et al (2010) Kaempferol and quercetin, components of Ginkgo biloba extract (EGb 761), induce caspase-3-dependent apoptosis in oral cavity cancer cells. Phyther. Res. 24:632
Kang DY, Sp N, Jo ES et al (2020) the inhibitory mechanisms of tumor PD-l1 expression by natural bioactive gallic acid in non-small-cell lung cancer (NSCLC) cells. Cancers (Basel) 12:727. https://doi.org/10.3390/cancers12030727
Karamova NS, Zelenikhin PV, Miroshnik NB et al (2015) Apoptosis-inducing activity of *Bacillus pumilus* ribonuclease and some egyptian medicinal plants extracts on human alveolar adenocarcinoma cells. Genes Cells 10:62–67
Karimi N, Roshan VD (2013) Change in adiponectin and oxidative stress after modifiable lifestyle interventions in breast cancer cases. Asian Pac J Cancer Prev 14:2845–2850. https://doi.org/10.7314/APJCP.2013.14.5.2845
Kathirvel P, Ravi S (2012) Chemical composition of the essential oil from basil (*Ocimum basilicum* Linn.) and its in vitro cytotoxicity against HeLa and HEp-2 human cancer cell lines and NIH 3T3 mouse embryonic fibroblasts. Nat Prod Res 26:1112–1118. https://doi.org/10.1080/14786419.2010.545357
Kavitha C, Raja Kd, Sk Rao (2021) Antitumor activity of *Albizia lebbeck* L. against Ehrlich ascites carcinoma in vivo and HeLa and A549 cell lines in vitro. J Cancer Res Ther 17:491. https://doi.org/10.4103/jcrt.JCRT_454_19
Kayed AM, Genady EAM, Kadry HA, Elghaly E-SM (2021) New phytoconstituents, anti-microbial and cytotoxic activities of *Acacia etbaica* Schweinf. Nat Prod Res 35:5571–5580. https://doi.org/10.1080/14786419.2020.1797725
Ke Y, Al Aboody MS, Alturaiki W et al (2019) Photosynthesized gold nanoparticles from *Catharanthus roseus* induces caspase-mediated apoptosis in cervical cancer cells (HeLa). Artif Cells Nanomed Biotechnol 47:1938–1946. https://doi.org/10.1080/21691401.2019.1614017
Khaleghi S, Khayatzadeh J, Neamati A (2022) Biosynthesis of zinc oxide nanoparticles using *Origanum majorana* L. leaf extract, its antioxidant and cytotoxic activities. Mater Technol 37:2522–2531. https://doi.org/10.1080/10667857.2022.2044218
Khalil MIM, Ibrahim MM, El-Gaaly GA, Sultan AS (2015) *Trigonella foenum* (Fenugreek) induced apoptosis in hepatocellular carcinoma cell line, HepG2, mediated by upregulation of p53 and proliferating cell nuclear antigen. Biomed Res Int 2015:1–11. https://doi.org/10.1155/2015/914645
Khan N, Hadi N, Afaq F et al (2007) Pomegranate fruit extract inhibits prosurvival pathways in human A549 lung carcinoma cells and tumor growth in athymic nude mice. Carcinogenesis 28:163–173. https://doi.org/10.1093/carcin/bgl145
Khodavirdipour A, Zarean R, Safaralizadeh R (2021) Evaluation of the anti-cancer effect of *Syzygium cumini* ethanolic extract on HT-29 colorectal cell line. J Gastrointest Cancer 52:575–581. https://doi.org/10.1007/s12029-020-00439-3
Kim ND, Mehta R, Yu W et al (2002) Chemopreventive and adjuvant therapeutic potential of pomegranate (*Punica granatum*) for human breast cancer. Breast Cancer Res Treat 71:203–217. https://doi.org/10.1023/A:1014405730585
Kim MY, Trudel LJ, Wogan GN (2009) Apoptosis induced by capsaicin and resveratrol in colon carcinoma cells requires nitric oxide production and caspase activation. Anticancer Res 29:3733–3740
Kim EJ, Kim GT, Kim BM et al (2017) Apoptosis-induced effects of extract from *Artemisia annua* Linné by modulating PTEN/p53/PDK1/Akt/ signal pathways through PTEN/p53-independent manner in HCT116 colon cancer cells. BMC Complement Altern Med 17:236. https://doi.org/10.1186/s12906-017-1702-7
Kim S, Yang HY, Lee HJ, Ju J (2021) In vitro antioxidant and anti-colon cancer activities of *Sesamum indicum* L. leaf extract and its major component, Pedaliin. Foods 10:1216. https://doi.org/10.3390/foods10061216
Klein AP, Brune KA, Petersen GM et al (2004) Prospective risk of pancreatic cancer in familial pancreatic cancer kindreds. Cancer Res 64:2634–2638. https://doi.org/10.1158/0008-5472.CAN-03-3823
Kongtawelert P, Wudtiwai B, Shwe TH et al (2020) Inhibitory effect of hesperidin on the expression of programmed death ligand (PD-L1) in breast cancer. Molecules 25:252. https://doi.org/10.3390/molecules25020252
Koroulakis A, Agarwal M (2022) Laryngeal cancer. In: StatPearls. http://www.ncbi.nlm.nih.gov/pubmed/28618252
Krifa M, El Mekdad H, Bentouati N et al (2015) Immunomodulatory and anticancer effects of *Pituranthos tortuosus* essential oil. Tumor Biol 36:5165–5170. https://doi.org/10.1007/s13277-015-3170-3
Krifa M, El Meshri SE, Bentouati N et al (2016) In vitro and in vivo anti-melanoma effects of *Pituranthos tortuosus* essential oil via inhibition of FAK and Src activities. J Cell Biochem 117:1167–1175. https://doi.org/10.1002/jcb.25400
Krishna S, Ganapathi S, Ster IC et al (2015) A randomised, double blind, placebo-controlled pilot study of oral artesunate therapy for colorectal cancer. EBioMedicine 2:82–90. https://doi.org/10.1016/j.ebiom.2014.11.010
Ksouri WM, Medini F, Mkadmini K et al (2013) LC–ESI-TOF–MS identification of bioactive secondary metabolites involved in the antioxidant, anti-inflammatory and anticancer activities of the edible halophyte Zygophyllum album Desf. Food Chem 139:1073–1080. https://doi.org/10.1016/j.foodchem.2013.01.047
Kumar VL, Verma S, Das P (2022) Anti-inflammatory and antioxidant effect of methanol extract of latex of *Calotropis procera* in rat model of colorectal cancer.

J Ethnopharmacol 296:115503. https://doi.org/10.1016/j.jep.2022.115503

Kurapati KRV, Samikkannu T, Kadiyala DB et al (2012) Combinatorial cytotoxic effects of *Curcuma longa* and *Zingiber officinale* on the PC-3M prostate cancer cell line. J Basic Clin Physiol Pharmacol 23:139–146. https://doi.org/10.1515/jbcpp-2012-0021

Kusmiyati M, Rusdin A, Trinovani E et al (2022) Cytotoxicity and antiproliferative activity of ethanol and ethyl acetate fractions from polymeric nanoparticles of green tea leaves (*Camellia sinensis*) in breast cancer cell line MDA-MB-132. J Adv Pharm Technol Res 13:301. https://doi.org/10.4103/JAPTR.JAPTR_422_22

Kwon HK, Jeon WK, Hwang JS et al (2009) Cinnamon extract suppresses tumor progression by modulating angiogenesis and the effector function of CD8+ T cells. Cancer Lett 278:174–182. https://doi.org/10.1016/j.canlet.2009.01.015

Kyung MY, Jong OP, Kim GY et al (2009) Capsaicin induces apoptosis by generating reactive oxygen species and disrupting mitochondrial transmembrane potential in human colon cancer cell lines. Cell Mol Biol Lett 14:497–510. https://doi.org/10.2478/s11658-009-0016-2

Labib RM, Zulfiqar F, Ibrahim MA et al (2019) FOXO signal activating alkaloids isolated from *Ochrosia elliptica* leaf cultivated in Egypt. Med Chem Res 28:1628–1632. https://doi.org/10.1007/s00044-019-02399-1

Lahmadi G, Lahmar A, Znati M et al (2021) Chemical composition and cytotoxic activity of *Eucalyptus torquata* Luehm. and *Eucalyptus salmonophloia* F. Muell Trunk bark essential oils against human SW620 and MDA-MB-231 cancer cell lines. Chem Biodivers. https://doi.org/10.1002/cbdv.202100315

Lang SJ, Schmiech M, Hafner S et al (2019) Antitumor activity of an *Artemisia annua* herbal preparation and identification of active ingredients. Phytomedicine 62:152962. https://doi.org/10.1016/j.phymed.2019.152962

Lau JK, Brown KC, Dom AM et al (2014) Capsaicin induces apoptosis in human small cell lung cancer via the TRPV6 receptor and the calpain pathway. Apoptosis 19:1190–1201. https://doi.org/10.1007/S10495-014-1007-Y

Lavhale MS, Kumar S, Mishra SH, Sitasawad SL (2009) A novel triterpenoid isolated from the root bark of *Ailanthus excelsa* Roxb (Tree of Heaven), AECHL-1 as a potential anti-cancer agent. PLoS One 4:e5365. https://doi.org/10.1371/JOURNAL.PONE.0005365

Lazzeroni M, Guerrieri-Gonzaga A, Gandini S et al (2017) A presurgical study of Lecithin formulation of green tea extract in women with early breast cancer. Cancer Prev Res 10:363–370. https://doi.org/10.1158/1940-6207.CAPR-16-0298

Lee YS, Nam DH, Kim JA (2000) Induction of apoptosis by capsaicin in A172 human glioblastoma cells. Cancer Lett 161:121–130. https://doi.org/10.1016/S0304-3835(00)00608-X

Lee JS, Chang JS, Lee JY, Kim JA (2004) Capsaicin-induced apoptosis and reduced release of reactive oxygen species in MBT-2 murine bladder tumor cells. Arch Pharm Res 27:1147–1153. https://doi.org/10.1007/BF02975121

Lee HG, Yu KA, Oh WK et al (2005) Inhibitory effect of jaceosidin isolated from *Artemisia argyi* on the function of E6 and E7 oncoproteins of HPV 16. J Ethnopharmacol 98:339–343. https://doi.org/10.1016/j.jep.2005.01.054

Leutcha BP, Dzoyem JP, Jouda J-B et al (2022) Antimicrobial and cytotoxic activities of constituents from the fruit of *Albizia lebbeck* L. Benth (Fabaceae). Molecules 27:4823. https://doi.org/10.3390/molecules27154823

Lhoste EF, Gloux K, De Waziers I et al (2004) The activities of several detoxication enzymes are differentially induced by juices of garden cress, water cress and mustard in human HepG2 cells. Chem Biol Interact 150:211–219. https://doi.org/10.1016/J.CBI.2004.08.007

Li N, Mao Y, Zhang X (2008) Separation and Identification of volatile constituents in *Artemisia argyi* flowers by GC–MS with SPME and steam distillation. J Chromatogr Sci 46:401–405. https://doi.org/10.1093/chromsci/46.5.401

Li Y, Tian Y, Zhong W et al (2021) *Artemisia argyi* essential oil inhibits hepatocellular carcinoma metastasis via suppression of DEPDC1 dependent Wnt/β-catenin signaling pathway. Front Cell Dev Biol. https://doi.org/10.3389/fcell.2021.664791

Liao F, Liu L, Luo E, Hu J (2018) Curcumin enhances anti-tumor immune response in tongue squamous cell carcinoma. Arch Oral Biol 92:32–37. https://doi.org/10.1016/j.archoralbio.2018.04.015

Lin MH, Lee YH, Cheng HL et al (2016) Capsaicin inhibits multiple bladder cancer cell phenotypes by inhibiting tumor-associated NADH oxidase (tNOX) and sirtuin1 (SIRT1). Molecules. https://doi.org/10.3390/molecules21070849

Lin Y-T, Wang H-C, Hsu Y-C et al (2017) Capsaicin induces autophagy and apoptosis in human nasopharyngeal carcinoma cells by downregulating the PI3K/AKT/mTOR pathway. Int J Mol Sci 18:1343. https://doi.org/10.3390/ijms18071343

Lindamulage IKS, Soysa P (2016) Evaluation of anticancer properties of a decoction containing *Adenanthera pavonina* L. and *Thespesia populnea* L. BMC Complement Altern Med 16:55. https://doi.org/10.1186/s12906-016-1053-9

Liu T, Wang G, Tao H et al (2016) Capsaicin mediates caspases activation and induces apoptosis through P38 and JNK MAPK pathways in human renal carcinoma. BMC Cancer 16:790. https://doi.org/10.1186/s12885-016-2831-y

Liu J, Hao J, Niu Y, Wu X (2021) Network pharmacology-based and clinically relevant prediction of active ingredients and potential targets of Chinese herbs on stage IV lung adenocarcinoma patients. J Cancer Res Clin Oncol 147:2079–2092. https://doi.org/10.1007/s00432-020-03488-0

López-Mejia A, Ortega-Pérez LG, Godinez-Hernández D et al (2019) Chemopreventive effect of *Callistemon citrinus* (Curtis) Skeels against colon cancer induced by 1,2-dimethylhydrazine in rats. J Cancer Res Clin Oncol 145:1417–1426. https://doi.org/10.1007/s00432-019-02905-3

López-Mejía A, Ortega-Pérez LG, Magaña-Rodríguez OR et al (2021) Protective effect of *Callistemon citrinus* on oxidative stress in rats with 1,2-dimethylhydrazine-induced colon cancer. Biomed Pharmacother 142:112070. https://doi.org/10.1016/j.biopha.2021.112070

Lu HF, Chen YL, Yang JS et al (2010) Antitumor activity of capsaicin on human colon cancer cells in vitro and colo 205 tumor xenografts in vivo. J Agric Food Chem 58:12999–13005. https://doi.org/10.1021/jf103335w

Mabasa R, Malemela K, Serala K et al (2021) *Ricinus communis* butanol fraction inhibits MCF-7 breast cancer cell migration, adhesion, and invasiveness. Integr Cancer Ther 20:153473542097768. https://doi.org/10.1177/1534735420977684

Madkour HMF, Ghareeb MA, Abdel-Aziz MS et al (2017) Gas chromatography-mass spectrometry analysis, antimicrobial, anticancer and antioxidant activities of n-hexane and methylene chloride extracts of *Senna italica*. J Appl Pharm Sci 7:023–032. https://doi.org/10.7324/JAPS.2017.70604

Maheswari P, Harish S, Ponnusamy S, Muthamizhchelvan C (2021) A novel strategy of nanosized herbal *Plectranthus amboinicus*, *Phyllanthus niruri* and *Euphorbia hirta* treated TiO2 nanoparticles for antibacterial and anticancer activities. Bioprocess Biosyst Eng 44:1593–1616. https://doi.org/10.1007/s00449-020-02491-6

Majdalawieh AF, Mansour ZR (2019) Sesamol, a major lignan in sesame seeds (*Sesamum indicum*): anti-cancer properties and mechanisms of action. Eur J Pharmacol 855:75–89. https://doi.org/10.1016/J.EJPHAR.2019.05.008

Majumder M, Debnath S, Gajbhiye RL et al (2019) *Ricinus communis* L. fruit extract inhibits migration/invasion, induces apoptosis in breast cancer cells and arrests tumor progression in vivo. Sci Rep 9:14493. https://doi.org/10.1038/s41598-019-50769-x

Mancini MCS, Ponte LGS, Silva CHR et al (2021) Beetroot and leaf extracts present protective effects against prostate cancer cells, inhibiting cell proliferation, migration, and growth signaling pathways. Phyther Res 35:5241–5258. https://doi.org/10.1002/ptr.7197

Manju S, Malaikozhundan B, Vijayakumar S et al (2016) Antibacterial, antibiofilm and cytotoxic effects of *Nigella sativa* essential oil coated gold nanoparticles. Microb Pathog 91:129–135. https://doi.org/10.1016/j.micpath.2015.11.021

Mansi I, Awadh Ali NA, Mhaidat NM et al (2019) Chemical composition and biological activity of the essential oil isolated from the leaves of *Achillea fragrantissima* growing wild in Yemen. Pharmacogn J 11:1077–1081. https://doi.org/10.5530/pj.2019.11.168

Mansour M, Mohamed MF, Elhalwagi A et al (2019) *Moringa peregrina* leaves extracts induce apoptosis and cell cycle arrest of hepatocellular carcinoma. Biomed Res Int. https://doi.org/10.1155/2019/2698570

Marzouk MM, Kawashty SA, Ibrahium LF et al (2008) Two new Kaempferol glycosides from *Matthiola Longipetala* (subsp. livida) (Delile) maire and carcinogenic evaluation of its extract. Maire Carcinog Eval Its Extr Pharmacol Pathol Toxicol 3:1325–1328

Marzouk MM, Elkhateeb A, Ibrahim LF et al (2012) Two cytotoxic coumarin glycosides from the aerial parts of *Diceratella elliptica* (DC.) Jonsell growing in Egypt. Rec Nat Prod 6:237

Maswada HF (2013) Assessment of total antioxidant capacity and antiradical scavenging activity of three Egyptian wild plants. J Med Sci 13:546–554

Matthews HK, Bertoli C, de Bruin RAM (2022) Cell cycle control in cancer. Nat Rev Mol Cell Biol 23:74–88. https://doi.org/10.1038/s41580-021-00404-3

Mazewski C, Kim MS, Gonzalez de Mejia E (2019) Anthocyanins, delphinidin-3-O-glucoside and cyanidin-3-O-glucoside, inhibit immune checkpoints in human colorectal cancer cells in vitro and in silico. Sci Rep 9:11560. https://doi.org/10.1038/s41598-019-47903-0

McGuigan A, Kelly P, Turkington RC et al (2018) Pancreatic cancer: a review of clinical diagnosis, epidemiology, treatment and outcomes. World J Gastroenterol 24:4846–4861. https://doi.org/10.3748/wjg.v24.i43.4846

Mehreen Sadaf H, Bibi Y, Arshad M et al (2021) Analysis of *Peganum harmala*, *Melia azedarach* and *Morus alba* extracts against six lethal human cancer cells and oxidative stress along with chemical characterization through advance Fourier Transform and nuclear magnetic resonance spectroscopic methods tow. Saudi Pharm J 29:552–565. https://doi.org/10.1016/j.jsps.2021.04.016

Meng FC, Wei XD, Sun Y et al (2021) Cytotoxic triterpenoid saponins from *Thalictrum atriplex*. Nat Prod Res 35:5757–5764. https://doi.org/10.1080/14786419.2020.1834550

Meral O, Alpay M, Kismali G et al (2014) Capsaicin inhibits cell proliferation by cytochrome c release in gastric cancer cells. Tumour Biol 35:6485–6492. https://doi.org/10.1007/S13277-014-1864-6

Meselhy KM, Shams MM, Sherif NH, El-Sonbaty SM (2019) Phenolic profile and in vivo cytotoxic activity of rice straw extract. Pharmacogn J 11:849–857. https://doi.org/10.5530/pj.2019.11.137

Metwaly AM, Ghoneim MM, Eissa IH et al (2021) Traditional ancient Egyptian medicine: a review. Saudi J Biol Sci 28:5823–5832

Miyahara Y, Hibasami H, Katsuzaki H et al (2000) Sesamol induces apoptosis in human lymphoid leukemia Molt 4B cells. Food Sci Technol Res 6:201–203. https://doi.org/10.3136/fstr.6.201

Moga A, Dimienescu OG, Balan A et al (2021) Pharmacological and therapeutic properties of *Punica granatum* phytochemicals: possible roles in breast cancer marius. Molecules. https://doi.org/10.3390/molecules26041054

Moghadamnia Y, Kani SNM, Ghasemi-Kasman M et al (2019) The anti-cancer effects of *Capparis spinosa* hydroalcoholic extract. Avicenna J Med Biotechnol 11:43–47

Mohamed GA (2014) New cytotoxic cycloartane triterpene from *Cassia italica* aerial parts. Nat Prod Res 28:976–983. https://doi.org/10.1080/14786419.2014.902820

Mohamed GA, Ibrahim SRM, Shaala LA et al (2014) Urgineaglyceride A: a new monoacylglycerol from the Egyptian *Drimia maritima* bulbs. Nat Prod Res 28:1583–1590. https://doi.org/10.1080/14786419.2014.927468

Mohamed TA, Elshamy AI, Abd-ElGawad AM et al (2021) Cytotoxic and chemotaxonomic study of isolated metabolites from *Centaurea aegyptiaca*. J Chin Chem Soc 68:159–168. https://doi.org/10.1002/jccs.202000156

Mohammed MMD, El-Sharkawy ER (2017) Cytotoxic new furoquinoline alkaloid isolated from *Ammi majus* L. growing in Egypt. Nat Prod Res 31:645–652. https://doi.org/10.1080/14786419.2016.1217858

Mohammed RS, Abou Zeid AH, El-Kashoury EA et al (2014) A new flavonol glycoside and biological activities of *Adenanthera pavonina* L. leaves. Nat Prod Res

28:282–289. https://doi.org/10.1080/14786419.2013.856903

Mohammed M, Mahdi MF, Talib B, Abaas IS (2021) Identification and isolation of lupeol and β-sitosterol from Iraqi Bauhinia variegata and determination the cytotoxic activity of the hexane extract of its leaves, stems and flowers. Res J Pharm Technol 14:5703–5708. https://doi.org/10.52711/0974-360X.2021.00991

Monti E, Marras E, Prini P, Gariboldi MB (2020) Luteolin impairs hypoxia adaptation and progression in human breast and colon cancer cells. Eur J Pharmacol 881:173210. https://doi.org/10.1016/j.ejphar.2020.173210

Mori A, Lehmann S, O'Kelly J et al (2006) Capsaicin, a component of red peppers, inhibits the growth of androgen-independent, p53 mutant prostate cancer cells. Cancer Res 66:3222–3229. https://doi.org/10.1158/0008-5472.CAN-05-0087

Moustafa SMA, Menshawi BM, Wassel GM et al (2014) Screening of some plants in Egypt for their cytotoxicity against four human cancer cell lines. Int J PharmTech Res 6:1074–1084

Mukavi JW, Mayeku PW, Nyaga JM, Kituyi SN (2020) In vitro anti-cancer efficacy and phyto-chemical screening of solvent extracts of *Kigelia africana* (Lam.) Benth. Heliyon 6:e04481. https://doi.org/10.1016/j.heliyon.2020.e04481

Myint ZW (2022) ArtemiCoffee in patients with rising PSA. ClinicalTrials.gov

Nabatanzi A, Nkadimeng SM, Lall N et al (2020) Antioxidant and anti-inflammatory activities of *Kigelia africana* (Lam.) Benth. Evid-Based Complement Altern Med 2020:1–11. https://doi.org/10.1155/2020/4352084

Nalini S, Nandini S, Shivappa Suresh G et al (2016) An electrochemical perspective assay for anticancer activity of *Calotropis Procera* against Glioblastoma cell line (LN-18) using carbon nanotubes- graphene nano- conglomerate as a podium. Adv Mater Lett 7:1003–1009. https://doi.org/10.5185/amlett.2016.6395

National Cancer Institute Breast cancer in women. https://www.nhs.uk/conditions/breast-cancer/. Accessed 29 Nov 2022b

National Cancer Institute Cancer Stat Facts: Laryngeal Cancer. https://seer.cancer.gov/statfacts/html/laryn.html. Accessed 21 Jan 2023d

National Cancer Institute Cancer Stat Facts: Leukemia. https://seer.cancer.gov/statfacts/html/leuks.html. Accessed 20 Mar 2023c

National Cancer Institute Cancer Stat Facts: Non-Hodgkin Lymphoma. https://seer.cancer.gov/statfacts/html/nhl.html. Accessed 20 Mar 2023f

National Cancer Institute Cancer Stat Facts: Stomach Cancer. https://seer.cancer.gov/statfacts/html/stomach.html. Accessed 29 Nov 2022e

National Cancer Institute Gallbladder Cancer—Patient Version. https://www.cancer.gov/types/gallbladder. Accessed 18 Mar 2023g

National Cancer Institute What Is Cancer? https://www.cancer.gov/about-cancer/understanding/what-is-cancer. Accessed 12 Dec 2022a

Nezhad SA, Es-haghi A, Tabrizi MH (2020) Green synthesis of cerium oxide nanoparticle using *Origanum majorana* L. leaf extract, its characterization and biological activities. Appl Organomet Chem 34:55. https://doi.org/10.1002/aoc.5314

Nguyen TB, Nguyen TMH, Le TTH et al (2020) Curcumin nanoemulsion: evaluation of stability and anti-cancer activity in vitro. J Nano Res 64:21–37. https://doi.org/10.4028/www.scientific.net/JNanoR.64.21

Nowacki L, Vigneron P, Rotellini L et al (2015) Betanin-enriched red beetroot (*Beta vulgaris* L.) extract induces apoptosis and autophagic cell death in MCF-7 cells. Phyther Res 29:1964–1973. https://doi.org/10.1002/ptr.5491

Nuñez-Sánchez MA, Dávalos A, González-Sarrías A et al (2015) MicroRNAs expression in normal and malignant colon tissues as biomarkers of colorectal cancer and in response to pomegranate extracts consumption: critical issues to discern between modulatory effects and potential artefacts. Mol Nutr Food Res 59:1973–1986. https://doi.org/10.1002/mnfr.201500357

Oeyen E, Hoekx L, De Wachter S et al (2019) Bladder cancer diagnosis and follow-up: the current status and possible role of extracellular vesicles. Int J Mol Sci 20:821. https://doi.org/10.3390/ijms20040821

Omer E, Elshamy A, Taher R et al (2019) *Cakile maritima* Scop. extracts inhibit Caco2 and HeLa human carcinoma cell growth: GC-MS analysis of an anti-proliferative extract. Pharmacogn J 11:258–266. https://doi.org/10.5530/pj.2019.11.40

Orabi MAA, Sakagami H, Umemura N et al (2021) Two new C-glycosidic ellagitannins and accompanying tannins from Lawsonia inermis leaves and their cytotoxic effects. Fitoterapia 153:104925. https://doi.org/10.1016/j.fitote.2021.104925

Osman ME-S, El-Beih AA, Khatab O-KH et al (2020) Bioactivity of mycoendophytes isolated from medicinal plants growing in different geographical Egyptian habitats. Jundishapur J Nat Pharm Prod. https://doi.org/10.5812/jjnpp.64785

Ovidi E, Garzoli S, Laghezza Masci V et al (2021) GC-MS investigation and antiproliferative activities of extracts from male and female flowers of *Schinus molle* L. Nat Prod Res 35:1923–1927. https://doi.org/10.1080/14786419.2019.1644628

Pacifico S, Bláha P, Faramarzi S et al (2022) Differential radiomodulating action of *Olea europaea* L. cv. Caiazzana leaf extract on human normal and cancer cells: a joint chemical and radiobiological approach. Antioxidants 11:1603. https://doi.org/10.3390/antiox11081603

Palaniswamy UR, McAvoy RJ, Bible BB, Stuart JD (2003) Ontogenic variations of ascorbic acid and phenethyl isothiocyanate concentrations in watercress (Nasturtium officinale R.Br.) leaves. J Agric Food Chem 51:5504–5509. https://doi.org/10.1021/JF034268W/SUPPL_FILE/JF034268WSI20030602_025328

Pandey S, Agrawal RC (2010) Chemopreventive potential of *Bauhinia variegata* flower extract against DMBA-induced skin papillomagenesis in mice. Pharmacologyonline 1:39–46

Pandey P, Khan F, Alzahrani FA et al (2021) A novel approach to unraveling the apoptotic potential of Rutin (Bioflavonoid) via targeting Jab1 in cervical cancer cells. Molecules 26:5529. https://doi.org/10.3390/molecules26185529

Pang X, Huang H, Wei Y, Leng J (2022) ethanolic leaf extract of C. angustifolia instigates ROS mediated apoptosis within glioblastoma C6 cells. J Oleo Sci 71:ess22143. https://doi.org/10.5650/jos.ess22143

Pansare AV, Kulal DK, Shedge AA, Patil VR (2016) hsDNA groove binding, photocatalytic activity, and in vitro breast and colon cancer cell reducing function of greener SeNPs. Dalt Trans 45:12144–12155. https://doi.org/10.1039/C6DT01457G

Pantuck AJ, Leppert JT, Zomorodian N et al (2006) Phase II study of pomegranate juice for men with rising prostate-specific antigen following surgery or radiation for prostate cancer. Clin Cancer Res 12:4018–4026. https://doi.org/10.1158/1078-0432.CCR-05-2290

Parra-Perez AM, Pérez-Jiménez A, Gris-Cárdenas I et al (2022) Involvement of the PI3K/AKT intracellular signaling pathway in the AntiCancer activity of hydroxytyrosol, a polyphenol from Olea europaea, in hematological cells and implication of HSP60 levels in its anti-inflammatory activity. Int J Mol Sci 23:7053. https://doi.org/10.3390/ijms23137053

Pasta V, Dinicola S, Giuliani A et al (2016) A randomized trial of Boswellia in association with betaine and myo-inositol in the management of breast fibroadenomas. Eur Rev Med Pharmacol Sci 20:1860–1865

Pavan Kumar MA, Suresh D, Sneharani AH (2022) Senna mediated facile green synthesis of nano ceria and its photocatalytic and biological application. Mater Today Proc 49:882–890. https://doi.org/10.1016/j.matpr.2021.06.195

Perrone A, Plaza A, Bloise E et al (2005) Cytotoxic furostanol saponins and a megastigmane glucoside from *Tribulus parvispinus*. J Nat Prod 68:1549–1553. https://doi.org/10.1021/np0502138

Petiwala SM, Johnson JJ (2015) Diterpenes from rosemary (*Rosmarinus officinalis*): defining their potential for anticancer activity. Cancer Lett 367:93–102

Pourhassan M, Zarghami N, Rahmati M et al (2010) The inhibitory effect of Curcuma longa extract on telomerase activity in A549 lung cancer cell line. Afr J Biotechnol 9:912–919. https://doi.org/10.5897/AJB09.904

Pramanik KC, Srivastava SK (2012) Apoptosis signal-regulating kinase 1-thioredoxin complex dissociation by capsaicin causes pancreatic tumor growth suppression by inducing apoptosis. Antioxid Redox Signal 17:1417–1432. https://doi.org/10.1089/ARS.2011.4369

Qais FA, Alomar SY, Imran MA, Hashmi MA (2022) In-silico analysis of phytocompounds of *Olea europaea* as potential anti-cancer agents to target PKM2 protein. Molecules 27:5793. https://doi.org/10.3390/molecules27185793

Rabelo AC, Borghesi J, Carreira ACO et al (2021) Calotropis procera (Aiton) Dryand (Apocynaceae) as an anti-cancer agent against canine mammary tumor and osteosarcoma cells. Res Vet Sci 138:79–89. https://doi.org/10.1016/j.rvsc.2021.06.005

Rabelo ACS, Miglino MA, Arbizu S et al (2022) Calotropis procera induced caspase-dependent apoptosis and impaired Akt/mTOR signaling in 4T1 breast cancer cells. Anticancer Agents Med Chem 22:3136–3147. https://doi.org/10.2174/1871520622666220608122154

Radwan MM, El-Sebakhy NA, Asaad AM et al (2004) Kahiricosides II–V, cycloartane glycosides from an Egyptian collection of *Astragalus kahiricus*. Phytochemistry 65:2909–2913. https://doi.org/10.1016/J.PHYTOCHEM.2004.08.037

Radwan MM, El-Sebakhy NA, Asaad AM et al (2007) Spinocoumarin I, a new coumarin derivative from *Astragalus spinosus* Forssk. Nat Prod Commun 2:919–922

Rafati M, Ghasemi A, Saeedi M et al (2019) *Nigella sativa* L. for prevention of acute radiation dermatitis in breast cancer: a randomized, double-blind, placebo-controlled, clinical trial. Complement Ther Med 47:102205. https://doi.org/10.1016/j.ctim.2019.102205

Rahman S, Salehin F, Iqbal A (2012) Retraction: in vitro antioxidant and anticancer activity of young *Zingiber officinale* against human breast carcinoma cell lines. BMC Complement Altern Med 12:206

Rahmati-Yamchi M, Ghareghomi S, Haddadchi G et al (2014) Fenugreek extract diosgenin and pure diosgenin inhibit the hTERT gene expression in A549 lung cancer cell line. Mol Biol Rep 41:6247–6252. https://doi.org/10.1007/s11033-014-3505-y

Ramamurthy C, Sampath KS, Arunkumar P et al (2013) Green synthesis and characterization of selenium nanoparticles and its augmented cytotoxicity with doxorubicin on cancer cells. Bioprocess Biosyst Eng 36:1131–1139. https://doi.org/10.1007/s00449-012-0867-1

Ramya E, Jyothi L, Vivek Vardhan P et al (2020) Optical and biomedical applications of eco-friendly biosynthesized silver nano spheres using zingiber officinale root extract. Nano Express 1:010021. https://doi.org/10.1088/2632-959X/ab85d1

Randive DS, Shejawal KP, Bhinge SD et al (2020) Green synthesis of gold nanoparticles of isolated citrus bioflavonoid from orange: characterization and in vitro cytotoxicity against colon cancer cell lines colo 320DM and Ht29. Indian Drugs 57:61–69. https://doi.org/10.53879/id.57.08.12514

Ranjbari J, Alibakhsh A, Arezumand R, et al (2014) Effects of Curcuma longa extract on Telomerase activity in lung and breast cancer cells. Zahedan J Res Med Sci 16:1–6

Ravindranath MH, Ramasamy V, Moon S et al (2009) Differential growth suppression of human melanoma cells by tea (*Camellia sinensis*) Epicatechins (ECG, EGC and EGCG). Evid-Based Complement Altern Med 6:523–530. https://doi.org/10.1093/ecam/nem140

Rawangkan A, Wongsirisin P, Namiki K et al (2018) Green tea catechin is an alternative immune checkpoint inhibitor that inhibits PD-L1 expression and lung tumor growth. Molecules 23:2071. https://doi.org/10.3390/molecules23082071

Rawla P, Sunkara T, Barsouk A (2019a) Epidemiology of colorectal cancer: incidence, mortality, survival, and risk factors. Gastroenterol Rev 14:89–103. https://doi.org/10.5114/pg.2018.81072

Rawla P, Sunkara T, Thandra KC, Barsouk A (2019b) Epidemiology of gallbladder cancer. Clin Exp Hepatol 5:93–102. https://doi.org/10.5114/ceh.2019.85166

Rizwana H, Bokahri NA, Rashed SA et al (2022) Characterizing silver nanoparticles biosynthesized from salvia rosmarinus and assessing their in vitro antifungal and cytotoxic activities against phytopathogens and cervical cells. J Anim Plant Sci 32:764–774

Roda E, Bottone MG (2022) Editorial: brain cancers: new perspectives and therapies. Front Neurosci. https://doi.org/10.3389/fnins.2022.857408

Roepke M, Diestel A, Bajbouj K et al (2007) Lack of p53 augments thymoquinone-induced apoptosis and caspase activation in human osteosarcoma cells. Cancer Biol Ther 6:160–169. https://doi.org/10.4161/cbt.6.2.3575

Romero SA, Pavan ICB, Morelli AP et al (2021) Anticancer effects of root and beet leaf extracts (*Beta vulgaris* L.) in cervical cancer cells (HeLa). Phyther Res 35:6191–6203. https://doi.org/10.1002/ptr.7255

Rosendahl AH, Perks CM, Zeng L et al (2015) Caffeine and caffeic acid inhibit growth and modify estrogen receptor and insulin-like growth factor I receptor levels in human breast cancer. Clin Cancer Res 21:1877–1887. https://doi.org/10.1158/1078-0432.CCR-14-1748

Roth MT, Cardin DB, Borazanci EH et al (2020) Phase II clinical trial of novel agent PBI-05204 in patients with metastatic pancreatic adenocarcinoma (mPDA). J Clin Oncol 38:698–698. https://doi.org/10.1200/JCO.2020.38.4_suppl.698

Rubin B, Manso J, Monticelli H et al (2019) Crude extract of *Origanum vulgare* L. induced cell death and suppressed MAPK and PI3/Akt signaling pathways in SW13 and H295R cell lines. Nat Prod Res 33:1646–1649. https://doi.org/10.1080/14786419.2018.1425846

Ruth C, Seong-HO L (2016) Anticancer properties of Capsaicin against human cancer. Anticancer Res 36:837–843

Sadeghi S, Davoodvandi A, Pourhanifeh MH et al (2019) Anticancer effects of cinnamon: insights into its apoptosis effects. Eur J Med Chem 178:131–140. https://doi.org/10.1016/j.ejmech.2019.05.067

Sadeghi RV, Parsania M, Sadeghizadeh M, Haghighat S (2022) Investigation of curcumin-loaded OA400 nanoparticle's effect on the expression of E6 and E7 human papillomavirus oncogenes and P53 and Rb factors in HeLa cell line. Iran J Pharm Res. https://doi.org/10.5812/ijpr-130762

Saeed M, Jacob S, Sandjo LP et al (2015) Cytotoxicity of the sesquiterpene lactones neoambrosin and damsin from ambrosia maritima against multidrug-resistant cancer cells. Front Pharmacol. https://doi.org/10.3389/fphar.2015.00267

Said A, Tundis R, Hawas UW et al (2010) In vitro antioxidant and antiproliferative activities of flavonoids from *Ailanthus excelsa* (Roxb.) (Simaroubaceae) leaves. Zeitschrift Für Naturforsch C 65:180–186. https://doi.org/10.1515/znc-2010-3-403

Salama MM, Kandil ZA, Islam WT (2012) Cytotoxic compounds from the leaves of *Gaillardia aristata* Pursh. growing in Egypt. Nat Prod Res 26:2057–2062. https://doi.org/10.1080/14786419.2011.606219

Salaroli R, Andreani G, Bernardini C et al (2022) Anticancer activity of an *Artemisia annua* L. hydroalcoholic extract on canine osteosarcoma cell lines. Res Vet Sci 152:476–484. https://doi.org/10.1016/j.rvsc.2022.09.012

Salem MM, Davidorf FH, Abdel-Rahman MH (2011) In vitro anti-uveal melanoma activity of phenolic compounds from the Egyptian medicinal plant *Acacia nilotica*. Fitoterapia 82:1279–1284. https://doi.org/10.1016/j.fitote.2011.08.020

Salih AA, Ahmed TE, Nigam DM (2020) Study the effect. Extracts and inhibitory potency of plant *Capparis spinosa* on breast cancer cells. Indian J Forensic Med Toxicol 14:2656–2661

Sánchez AM, Sánchez MG, Malagarie-Cazenave S et al (2006) Induction of apoptosis in prostate tumor PC-3 cells and inhibition of xenograft prostate tumor growth by the vanilloid capsaicin. Apoptosis 11:89–99. https://doi.org/10.1007/S10495-005-3275-Z

Sánchez AM, Martínez-Botas J, Malagarie-Cazenave S et al (2008) Induction of the endoplasmic reticulum stress protein GADD153/CHOP by capsaicin in prostate PC-3 cells: a microarray study. Biochem Biophys Res Commun 372:785–791. https://doi.org/10.1016/J.BBRC.2008.05.138

Sankar R, Karthik A, Prabu A et al (2013) Origanum vulgare mediated biosynthesis of silver nanoparticles for its antibacterial and anticancer activity. Colloids Surf B Biointerfaces 108:80–84. https://doi.org/10.1016/j.colsurfb.2013.02.033

Sary HG, Singab ANB, Orabi KY (2016) New cytotoxic guaianolides from *Centaurea Aegyptiaca*. Nat Prod Commun 11:711–714. https://doi.org/10.1177/1934578X1601100603

Satsangi N, Preet S (2016) Exploring nanobiotechnology in controlling malaria and cancer. In: 2016 IEEE region 10 humanitarian technology conference (R10-HTC). IEEE, pp 1–11

Sellam LS, Zappasodi R, Chettibi F et al (2020) Silibinin downregulates PD-L1 expression in nasopharyngeal carcinoma by interfering with tumor cell glycolytic metabolism. Arch Biochem Biophys 690:108479. https://doi.org/10.1016/j.abb.2020.108479

Sertel S, Eichhorn T, Plinkert PK, Efferth T (2011) Krebshemmende Wirkung des ätherischen Salbei-Öls auf eine Plattenepithelzellkarzinom-Zelllinie der Mundhöhle (UMSCC1). HNO 59:1203–1208. https://doi.org/10.1007/s00106-011-2274-3

Severino P, Andreani T, Chaud M et al (2015) Essential oils as active ingredients of lipid nanocarriers for chemotherapeutic use. Curr Pharm Biotechnol 16:365–370

Shafqat N, Azizi A, Mumin NH (2021) Phytochemicals with anti 5-alpha-reductase activity: a prospective for prostate cancer treatment. F1000Research 10:221

Shao J, Fang Y, Zhao R et al (2020) Evolution from small molecule to nano-drug delivery systems: an emerging approach for cancer therapy of ursolic acid. Asian J Pharm Sci 15:685–700. https://doi.org/10.1016/j.ajps.2020.03.001

Sharma P, McClees S, Afaq F (2017) Pomegranate for prevention and treatment of cancer: an update. Molecules 22:177. https://doi.org/10.3390/molecules22010177

Shin D-S, Kim J-H, Lee S-K et al (2006) Synthesis and biological evaluation of dimeric cinnamaldehydes as potent antitumor agents. Bioorg Med Chem 14:2498–2506. https://doi.org/10.1016/j.bmc.2005.11.028

Shin DH, Kim OH, Jun HS, Kang MK (2008) Inhibitory effect of capsaicin on B16–F10 melanoma cell migration via the phosphatidylinositol 3-kinase/Akt/Rac1 signal pathway. Exp Mol Med 40:486–494. https://doi.org/10.3858/EMM.2008.40.5.486

Siriwarin B, Weerapreeyakul N (2016) Sesamol induced apoptotic effect in lung adenocarcinoma cells through both intrinsic and extrinsic pathways. Chem Biol Interact 254:109–116. https://doi.org/10.1016/j.cbi.2016.06.001

Sissons HA (1976) The WHO classification of bone tumors. In: Malignant bone tumors. Springer Berlin Heidelberg, Berlin, Heidelberg, pp 104–108

Small W, Bacon MA, Bajaj A et al (2017) Cervical cancer: a global health crisis. Cancer 123:2404–2412. https://doi.org/10.1002/cncr.30667

Smith MA, Altekruse SF, Adamson PC et al (2014) Declining childhood and adolescent cancer mortality. Cancer 120:2497–2506. https://doi.org/10.1002/cncr.28748

Soliman FM, Fathy MM, Salama MM et al (2014) Cytotoxic activity of acyl phloroglucinols isolated from the leaves of *Eucalyptus cinerea* F. Muell. ex Benth. cultivated in Egypt. Sci Rep. https://doi.org/10.1038/srep05410

Soliman NA, Ismail EH, Abd El-Moaty HI et al (2018) Anti-helicobacter pylori, anti-diabetic and cytotoxicity activity of biosynthesized gold nanoparticles using Moricandia nitens water extract. Egypt J Chem 61:691–703

Solouki N, Mohammadi-Gollou A, Sagha M, Mohammadzadeh-Vardin M (2021) *Origanum vulgare* extract induces apoptosis in Molt-4 leukemic cell line. J Cell Biotechnol 6:105–112. https://doi.org/10.3233/JCB-200026

Srisayam M, Weerapreeyakul N, Kanokmedhakul K (2017) Inhibition of two stages of melanin synthesis by sesamol, sesamin and sesamolin. Asian Pac J Trop Biomed 7:886–895. https://doi.org/10.1016/j.apjtb.2017.09.013

Stingl JC, Ettrich T, Muche R et al (2011) Protocol for minimizing the risk of metachronous adenomas of the CoLorectum with green tea extract (MIRACLE): a randomised controlled trial of green tea extract versus placebo for nutriprevention of metachronous colon adenomas in the elderly population. BMC Cancer 11:360. https://doi.org/10.1186/1471-2407-11-360

Su SH, Sundhar N, Kuo WW et al (2022) Artemisia argyi extract induces apoptosis in human gemcitabine-resistant lung cancer cells via the PI3K/MAPK signaling pathway. J Ethnopharmacol. https://doi.org/10.1016/j.jep.2022.115658

Sugimoto S, Yamano Y, Desoukey SY et al (2019) Isolation of sesquiterpene-amino acid conjugates, onopornoids A-D, and a flavonoid glucoside from *Onopordum alexandrinum*. J Nat Prod 82:1471–1477. https://doi.org/10.1021/acs.jnatprod.8b00948

Suresh S, Muthukrishnan L, Vennila S et al (2020) Mechanistic anticarcinogenic efficacy of phytofabricated gold nanoparticles on human lung adenocarcinoma cells. J Exp Nanosci 15:160–173. https://doi.org/10.1080/17458080.2020.1761014

Tamimi AF, Juweid M (2017) Epidemiology and outcome of glioblastoma. In: Glioblastoma. Codon Publications, pp 143–153

Tawfeeq TA, Jasim GA, Nasser A, Al-Sudani BT (2021) Isolation of lupeol and gallic acid with cytotoxic activity of two different extracts from the leaves of Iraqi *Conocarpus erectus* L. Res J Pharm Technol. https://doi.org/10.52711/0974-360X.2021.00606

Tawfik MM, Galal B, Nafie MS et al (2023) Cytotoxic, apoptotic activities and chemical profiling of dimorphic forms of Egyptian halophyte *Cakile maritima* scop. J Biomol Struct Dyn 41:147–160. https://doi.org/10.1080/07391102.2021.2004231

Tawila AM, Sun S, Kim MJ et al (2020) Chemical constituents of *Callistemon citrinus* from Egypt and their antiausterity activity against PANC-1 human pancreatic cancer cell line. Bioorg Med Chem Lett 30:127352. https://doi.org/10.1016/j.bmcl.2020.127352

Thoennissen NH, O'Kelly J, Lu D et al (2010) Capsaicin causes cell-cycle arrest and apoptosis in ER-positive and-negative breast cancer cells by modulating the EGFR/HER-2 pathway. Oncogene 29:285–296. https://doi.org/10.1038/onc.2009.335

Tian L, Wang S, Jiang S et al (2021) Luteolin as an adjuvant effectively enhances CTL anti-tumor response in B16F10 mouse model. Int Immunopharmacol 94:107441. https://doi.org/10.1016/j.intimp.2021.107441

Torky ZA, Moussa AY, Abdelghffar EA et al (2021) Chemical profiling, antiviral and antiproliferative activities of the essential oil of *Phlomis aurea* Decne grown in Egypt. Food Funct 12:4630–4643. https://doi.org/10.1039/D0FO03417G

Torre LA, Trabert B, DeSantis CE et al (2018) Ovarian cancer statistics, 2018. CA Cancer J Clin 68:284–296. https://doi.org/10.3322/caac.21456

Torres RG, Casanova L, Carvalho J et al (2018) Ocimum basilicum but not *Ocimum gratissimum* present cytotoxic effects on human breast cancer cell line MCF-7, inducing apoptosis and triggering mTOR/Akt/p70S6K pathway. J Bioenerg Biomembr 50:93–105. https://doi.org/10.1007/s10863-018-9750-3

Tselepi M, Papachristou E, Emmanouilidi A et al (2011) Catalytic inhibition of eukaryotic topoisomerases I and II by flavonol glycosides extracted from *Vicia faba* and *Lotus edulis*. J Nat Prod 74:2362–2370. https://doi.org/10.1021/np200292u

Tseng C-P, Huang Y-L, Chang Y-W et al (2020) Polysaccharide-containing fraction from *Artemisia argyi* inhibits tumor cell-induced platelet aggregation by blocking interaction of podoplanin with C-type lectin-like receptor 2. J Food Drug Anal 28:115–123. https://doi.org/10.1016/j.jfda.2019.08.002

Ullah MF, Ahmad A, Bhat SH et al (2022) Functional profiling of *Achillea fragrantissima* (a perennial edible herb) against human cancer cells and potential nutraceutical impact in neutralizing cell proliferation by interfering with VEGF and NF-κB signaling pathways. Ital J Food Sci 34:35–47

Valcic S, Timmermann BN, Alberts DS et al (1996) Inhibitory effect of six green tea catechins and caffeine on the growth of four selected human tumor cell lines. Anticancer Drugs 7:461–468. https://doi.org/10.1097/00001813-199606000-00011

Valdés A, García-Cañas V, Artemenko KA et al (2017) Nano-liquid chromatography-orbitrap MS-based quantitative proteomics reveals differences between the mechanisms of action of carnosic acid and carnosol in colon cancer cells. Mol Cell Proteomics 16:8–22. https://doi.org/10.1074/mcp.M116.061481

Venugopal K, Ahmad H, Manikandan E et al (2017) The impact of anticancer activity upon *Beta vulgaris* extract mediated biosynthesized silver nanoparticles (ag-NPs) against human breast (MCF-7), lung (A549) and pharynx (Hep-2) cancer cell lines. J Photochem Photobiol B Biol 173:99–107. https://doi.org/10.1016/j.jphotobiol.2017.05.031

Verdura S, Cuyàs E, Cortada E et al (2020) Resveratrol targets PD-L1 glycosylation and dimerization to enhance antitumor T-cell immunity. Aging (Albany NY) 12:8–34. https://doi.org/10.18632/aging.102646

von Hagens C, Walter-Sack I, Goeckenjan M et al (2017) Prospective open uncontrolled phase I study to define a well-tolerated dose of oral artesunate as add-on therapy in patients with metastatic breast cancer (ARTIC M33/2). Breast Cancer Res Treat 164:359–369. https://doi.org/10.1007/s10549-017-4261-1

Wang F, Zhao J, Liu D et al (2016) Capsaicin reactivates hMOF in gastric cancer cells and induces cell growth inhibition. Cancer Biol Ther 17:1117–1125. https://doi.org/10.1080/15384047.2016.1235654

Wang H, Ge X, Qu H et al (2020a) Glycyrrhizic acid inhibits proliferation of gastric cancer cells by inducing cell cycle arrest and apoptosis. Cancer Manag Res 12:2853–2861. https://doi.org/10.2147/CMAR.S244481

Wang Z, Li MY, Zhang ZH et al (2020b) Panaxadiol inhibits programmed cell death-ligand 1 expression and tumour proliferation via hypoxia-inducible factor (HIF)-1α and STAT3 in human colon cancer cells. Pharmacol Res 155:104727. https://doi.org/10.1016/j.phrs.2020.104727

Watanabe M, Iizumi Y, Sukeno M et al (2017) The pleiotropic regulation of cyclin D1 by newly identified sesaminol-binding protein ANT2. Oncogenesis 6:e311–e311. https://doi.org/10.1038/oncsis.2017.10

WCRF (2018) Liver cancer | World Cancer Research Fund International. In: World Cancer Res. Fund. https://www.wcrf.org/cancer-trends/liver-cancer-statistics/. Accessed 5 Nov 2022

Woo SM, Kwon TK (2016) Jaceosidin induces apoptosis through Bax activation and down-regulation of Mcl-1 and c-FLIP expression in human renal carcinoma Caki cells. Chem Biol Interact 260:168–175. https://doi.org/10.1016/j.cbi.2016.10.011

World Cancer Research Fund International (2020) World Cancer Research Fund International: Prostate cancer statistics. https://www.wcrf.org/cancer-trends/prostate-cancer-statistics/. Accessed 6 Nov 2022

World Health Organization (2021) Breast cancer. In: World Heal. Organ. https://www.who.int/news-room/fact-sheets/detail/breast-cancer.

World Health Organization (2022) Cancer. https://www.who.int/news-room/fact-sheets/detail/cancer. Accessed 18 Mar 2023

Wu M-S, Aquino LBB, Barbaza MYU et al (2019) Anti-inflammatory and anticancer properties of bioactive compounds from *Sesamum indicum* L.—a review. Molecules 24:4426. https://doi.org/10.3390/molecules24244426

Wudtiwai B, Makeudom A, Krisanaprakornkit S et al (2021) Anticancer activities of hesperidin via suppression of up-regulated programmed death-ligand 1 expression in oral cancer cells. Molecules 26:5345. https://doi.org/10.3390/molecules26175345

Wutka A, Palagani V, Barat S et al (2014) Capsaicin treatment attenuates cholangiocarcinoma carcinogenesis. PLoS One. https://doi.org/10.1371/journal.pone.0095605

Xiao H, Yang CS, Li S et al (2009) Monodemethylated polymethoxyflavones from sweet orange (*Citrus sinensis*) peel inhibit growth of human lung cancer cells by apoptosis. Mol Nutr Food Res 53:398–406. https://doi.org/10.1002/mnfr.200800057

Xu AH, Chen HS, Sun BC et al (2003) Therapeutic mechanism of ginkgo biloba exocarp polysaccharides on gastric cancer. World J Gastroenterol 9:2424. https://doi.org/10.3748/WJG.V9.I11.2424

Xu L, Zhang Y, Tian K et al (2018) Apigenin suppresses PD-L1 expression in melanoma and host dendritic cells to elicit synergistic therapeutic effects. J Exp Clin Cancer Res 37:261. https://doi.org/10.1186/s13046-018-0929-6

Xu B, Ganesan K, Mickymaray S et al (2020) Immunomodulatory and antineoplastic efficacy of common spices and their connection with phenolic antioxidants. Bioact Compd Heal Dis 3:15. https://doi.org/10.31989/bchd.v3i2.687

Yan W, Liu Y, Mansooridara S et al (2020) Chemical characterization and neuroprotective properties of copper nanoparticles green-synthesized by *Nigella sativa* L. seed aqueous extract against methadone-induced cell death in adrenal phaeochromocytoma (PC12) cell line. J Exp Nanosci 15:280–296. https://doi.org/10.1080/17458080.2020.1778167

Yang ZH, Wang XH, Wang HP et al (2010) Capsaicin mediates cell death in bladder cancer T24 cells through reactive oxygen species production and mitochondrial depolarization. Urology 75:735–741. https://doi.org/10.1016/j.urology.2009.03.042

Yang Y, Huynh N, Dumesny C et al (2020) Cannabinoids inhibited pancreatic cancer via P-21 activated kinase 1 mediated pathway. Int J Mol Sci 21:8035. https://doi.org/10.3390/ijms21218035

Ye Y, Song Y, Zhuang J et al (2019) Anticancer effects of echinacoside in hepatocellular carcinoma mouse model and HepG2 cells. J Cell Physiol 234:1880–1888. https://doi.org/10.1002/jcp.27063

Ying H, Wang Z, Zhang Y et al (2013) Capsaicin induces apoptosis in human osteosarcoma cells through AMPK-dependent and AMPK-independent signaling pathways. Mol Cell Biochem 384:229–237. https://doi.org/10.1007/S11010-013-1802-8

Yokota T, Matsuzaki Y, Koyama M et al (2007) Sesamin, a lignan of sesame, down-regulates cyclin D1 protein expression in human tumor cells. Cancer Sci 98:1447–1453. https://doi.org/10.1111/j.1349-7006.2007.00560.x

Young MK, Hwang JT, Dong WK, et al (2007) Involvement of AMPK signaling cascade in capsaicin-induced apoptosis of HT-29 colon cancer cells. In: Annals of the New York Academy of Sciences. pp 496–503

Yu J, Chen W, Wang D et al (2023) Cytotoxic constituents from the leaves and stems of *Panax quinquefolius*. Nat Prod Res 37:919–927. https://doi.org/10.1080/14786419.2022.2097226

Zhang Y, Chen AY, Li M et al (2008) *Ginkgo biloba* extract kaempferol inhibits cell proliferation and induces apoptosis in pancreatic cancer cells. J Surg Res 148:17–23. https://doi.org/10.1016/J.JSS.2008.02.036

Zhang XW, Wang S, Tu PF, Zeng KW (2018) Sesquiterpene lactone from *Artemisia argyi* induces gastric carcinoma cell apoptosis via activating NADPH oxidase/reactive oxygen species/mitochondrial pathway. Eur J Pharmacol 837:164–170

Zhang SQ, Xu HB, Zhang SJ, Li XY (2020) Identification of the active compounds and significant pathways of artemisia annua in the treatment of non-small cell lung carcinoma based on network pharmacology. Med Sci Monit. https://doi.org/10.12659/MSM.923624

Zhang X, Han L, Li P et al (2021) Region-specific biomarkers and their mechanisms in the treatment of lung adenocarcinoma: a study of *Panax quinquefolius* from Wendeng, China. Molecules 26:6829. https://doi.org/10.3390/molecules26226829

Zhao Y-P, Wang H, Yang G et al (2016) Anti-tumor mechanism of *Artemisia annua* based on bioinformatics. China J Chin Mater Med 41:2695–2700. https://doi.org/10.4268/cjcmm20161421

Zheng M, Ekmekcioglu S, Walch ET et al (2004) Inhibition of nuclear factor-κB and nitric oxide by curcumin induces G2/M cell cycle arrest and apoptosis in human melanoma cells. Melanoma Res 14:165–171. https://doi.org/10.1097/01.cmr.0000129374.76399.19

Zheng L, Chen J, Ma Z et al (2015) Capsaicin causes inactivation and degradation of the androgen receptor by inducing the restoration of miR-449a in prostate cancer. Oncol Rep 34:1027–1034. https://doi.org/10.3892/or.2015.4055

Zick SM, Turgeon DK, Vareed SK et al (2011) Phase II study of the effects of gingsser root extract on eicosanoids in colon mucosa in people at normal risk for colorectal cancer. Cancer Prev Res 4:1929–1937. https://doi.org/10.1158/1940-6207.CAPR-11-0224