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Cytotoxic Plants: Potential Uses in Prevention and Treatment of Cancer

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1. Introduction

Cancer is a leading cause of death worldwide and accounted for 7.6 million deaths (around 13% of all deaths) in 2008. Deaths from cancer worldwide are projected to continue to rise to over 11 million in 2030. [(2011) World health statistics]. Heredity and environmental changes affect the susceptibility to cancer affection. More than 30% of cancer could be prevented by modifying or avoiding key risk factors, including: tobacco use, being overweight or obese, low fruit and vegetable intake, physical inactivity, alcohol use, sexually transmitted HPV-infection, urban air pollution, indoor smoke from household use of solid fuels.

Plants have been used as a major source of remedies from the ancient time. The modern drug discovery and development is also dependent of medicinal plants (Saklani & Kutty, 2008). Using plants in the treatment of cancer has long history and dates back to ancient time. There are strong evidences about cancer preventing properties of various kinds of herbs used as food, fruit, spices, and vegetables (Dossus, 2008; Kruk, 2007; Moyad, 2004; Montesano, 2001; Lyman, 1992).

Dietary habits especially those involving fruits and vegetables have served the great interest in developing various preventive measures that influence cancer risk (Wu, 2009; Kurahashi, 2009). Phytochemicals of varied chemical structures from fruits and vegetables have already been studied extensively for their potential anticancer or chemopreventive efficacy (Ramos, 2008). Being the rich sources of vitamins, minerals, and fiber without posing “any side effects” made fruits and vegetables the best choice to lowering cancer risk and also in maintaining good general health.

The important role of plant derived compounds is undeniable. Paclitaxel (Wani et al., 1971), camptothecin (Wall, 1998), combrestatin (Cirla & Mann, 2003), epipodophyllotoxin (Canel et al., 2000) and Vinca alkaloids (vinblastine, vincristine) (Johnson et al., 1963) are some examples of herbal originated cancer treatments. These are also many other plant-derived compounds that are in clinical trials for cancers (Saklani & K. Kutty, 2008).

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Herbs and spices can defy the DNA damage which is the fundamental cause of cancer and can occur as a result of aging, genetic susceptibility, and exposure to an assortment of carcinogens.
Free radicals and different toxins have the important role in cancer development and progression through interaction with DNA. Numerous phytonutrients found in fruits, herbs and spices act as potent preventive agents against cancer by preventing the overproduction of toxic chemicals within the body, improving the body's detoxification processes.
Herbs and spices not only reduce the risks of developing cancer, but also act as efficient treatments for cancer. Herbs and spices are traditional cancer treatments of radiotherapy and chemotherapy enhancers, reducing the negative side effects of these therapies.
Edible vegetables, fruits, spices and whole grains contain significant amounts of bioactive phytochemicals, which are warrented health benefits beyond basic nutrition to reduce the risk of chronic disease and the process of carcinogenesis [Liu, 2004)
The National Cancer Institute (NCI) of the United States has introduced several plant-based foods that exert cancer-preventive properties, including garlic, soybeans, ginger, onion, turmeric, tomatoes and cruciferous vegetables (for example, broccoli, cabbage, cauliflower and Brussels sprouts). (Surh, 2003). Iridoids, phenols, phenolics, carotenoids, alkaloids, organosulfur compounds, and terpenoids are main class of phytochemicals.
Plants with cytotoxic effects respect to their sub family, species, phytochemical, and the stage of which they are in progress for cancer treatment are classified in table 1 to 38.
Each table is representive of phytochemical of a selected family. Each row illustrates the selected phytochemical of representative plant bioactives that have been shown to induce cytotoxic effects.

Anacardiaceae R.Brown

A family of 69 genera and 850 species mainly subtropical trees, shrubs, lianas or rarely perennial herbs with vertical resine – ducts in bark. The family contains dyeing and tanning materials and phenolic compounds (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Rhus verniciflua Stokes	total extract	not stated	metastatic colorectal cancer (mCRC)	clinical trial	Lee et al, 2009

Table 1. Anacardiaceae Cytotoxic Phytochemicals

Apiaceae Lindley

(**Umbelliferae** A.L. de Jussieu)

The plant family consists of 434 genera and 3780 species most members are herbs with furrowed stems and hollow internodes, some are annuals, some biennials, and some perennials. The three subfamilies are as follows: 1) Hydrocotyoideae 2) Saniculoideae and 3) Apioioideae.
Constituents of the family include essential oils, coumarins, furocumarins, chromonocoumarins, monoterpenes, sesquiterpenes, triterpenoid saponins, resins and acetylenic compounds. Alkaloids occur but are rare (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Angelica sinensis (Oliv.) Diels	citronellol	terpenoids	improve their immune function, improving their ability to fight off the cancer	randomized, double-blind, placebo-controlled study	Zhuang et al., 2009
Cuminum cyminum L.	apigenin and luteolin	flavonoids	cancer chemopreventive activities	cell culture, animal study	Aggarwal et al., 2008; Patel et al., 2007; Manju & Nalini, 2007
Foeniculum vulgare Mill.	anethole, [1-methoxy-4-(1-propenyl) benzene], anethole dithiolethione	phenylpropanoid	chemopreventive activities as indicated by suppression of the incidence and multiplicity of both invasive and non-invasive adenocarcinomas	cancer cells cell culture	Aggarwal et al., 2008

Table 2. Apiaceae Cytotoxic Phytochemicals

Apocynaceae A.L. de Jussieu

This family contains 380 genera and 4700 species
mostly in tropical and subtropical but also in few temperate regions. The members are trees, shrubs, lianas, vines, sometimes scculent and cactuslike.
Constituents of the family are some types of alkaloids, cardioactive glycosides, cyanogenic glycosides leucoanthyocyanins, saponins, tannins, coumarins, phenolic acids, cyclitols and triterpenoids (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Catharanthus roseus (L.) G.Don	methyl jasmonate	cyclopentanone derivatives	induces apoptosis	A549 human lung adenocarcinoma cells, myeloid leukemia cells	Balbi & Devoto, 2007
Rhazya stricta Decne.	didemethoxycarbonyl-tetrahydrosecamine, sewarine, tetrahydrosecamine, tetrahydrosecaminediol diacetate vallesiachotamine DL-1-(oxo-3,4-thero-3,4,5-trihydroxy-1-pentyl)-β-carboline, 16-epi-Z-isositsirkine	alkaloids	cytotoxic	cell culture	Gilani et al., 2007

Table 3. Apocynaceae Cytotoxic Phytochemicals

Araliaceae A.L. de Jussieu

A family of 39 genera and 1425 species mainly tropical shrubs, lianas or trees to occasionally herbs, aromatic with secretary canals containing volatile oils and resins. other constituents include saponins, a few alkaloids, acetylenic compounds, coumarins, diterpenoids and triterpenoids (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Panax ginseng C.A.Mey.	ginsenosides	saponins	anticancer effects: regulation of cell cycle, Induction of apoptosis, Inhibition of angiogenesis	*in vitro* and *in vivo*	Qi et al., 2010
Panax ginseng C.A.Mey.	ginsenosides	saponins	Re and Rg1 enhance angiogenesis, whereas Rb1, Rg3 and Rh2 inhibit it. Rh2, an antitumor agent,, P quinquefolium has better anticancer effects	*in vitro* and *in vivo*	Chen et al., 2008
Panax ginseng C.A.Mey.	total extract	not stated	anticancer antitumor	cell culture	Xiang et al., 2008
Panax ginseng C.A.Mey.	ginsenosides	saponins	the risk of cancer was shown to be lower in those who used ginseng	prospective cohort study	Yun et al., 1998; Kiefer et al., 2003
Panax ginseng C. A. Mey.	ginsenosides	saponins	antitumor/cytotoxicity activities	*in vitro* and *in vivo* against a wide variety of cancer cell lines or *in vivo* neoplasms	Chang et al., 2003

Table 4. Araliaceae Cytotoxic Phytochemicals

Asteraceae Bercht. & J. Presl

(Compositae Giseke)
The family is the largest family of flowering plants and contains about 1590 genera and 23600 species that comprise of herbs, shrubs or trees. Asteraceae divided into 3 subfamilies: 1) Baradosioideae 2) Cichorioideae and 3) Asteroideae.
The Asteraceae contains a wide variety of chemical constituents. Some of the essential oils found in the family contain acetylenic compounds. sesquiterpenes known as azulenes. mono sesquiterpene lactones occur. Alkaloids of the pyridine, pyrrolizidine, quinoline and diterpenoid types also occur in the family, other constituents include triterpenoid saponins, cyclitols, coumarins and flavonols (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Artemisia annua L.	different fractions	not stated	antiproliferative effect	cancer cell lines	Rabe et al., 2011

Artemisia annua L.	artemisinin	sesquiterpenoids	colon cancer	*in vitro*	McGovern et al., 2010
Artemisia annua L.	artemisinin	sesquiterpenoids	anticancer effects, cell cycle arrest, apoptosis, inhibition of angiogenesis, disruption of cell migration, and modulation of nuclear receptor responsiveness	in a variety of human cancer cell model systems	Firestone et al., 2009
Artemisia annua L.	different fractions	not stated	cytotoxic and pro-apoptotic	variety of cancer cell lines	Emami et al., 2009b
Artemisia annua L.	artemisinins	sesquiterpenoids	anticancer properties	in cell lines and animal models	Krishna et al., 2008
Artemisia annua L.	artemisinin	sesquiterpenoids	regulation of proliferation (BUB3, cyclins, CDC25A), angiogenesis (vascular endothelial growth factor and its receptor, matrix metalloproteinase-9, angiostatin, thrombospondin-1) or apoptosis (BCL-2, BAX, NF-kappaB). p53-dependent and -independent apoptosis	tumor cells	Efferth et al., 2007
Artemisia annua L.	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Vahdati-Mashhadian et al., 2009
Artemisia argyi H.Lév. & Vaniot	isoscopoletin	coumarins	lung cancer	*in vitro*	McGovern et al., 2010

Artemisia biennis Willd.	different fractions	not stated	antiproliferative effect		Rabe et al., 2011
Artemisia campestris L.	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Vahdati-Mashhadian et al., 2009
Artemisia chamaemelifolia Vill.	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Vahdati-Mashhadian et al., 2009
Artemisia ciniformis Krasch. & Popov ex Poljak.	different fractions	not stated	antiproliferative effect	cancer cell lines	Rabe et al., 2011
Artemisia diffusa Krasch. ex Poljakov	different fractions	not stated	antiproliferative effect	cancer cell lines	Rabe et al., 2011
Artemisia diffusa Krasch. ex Poljakov	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Emami et al., 2009a
Artemisia fragrans Willd.	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Vahdati-Mashhadian et al., 2009
Artemisia incana Druce	total extract	not stated	cytotoxic activity	human Caucasian	Vahdati-Mashhadian

				hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	et al., 2009
Artemisia khorassanica Podlech	different fractions	not stated	cytotoxic activity	variety of cancer cell lines	Mahmoudi et al., 2009
Artemisia kulbadica Boiss. & Buhse	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Emami et al., 2009a
Artemisia persica Boiss.	different fractions	not stated	antiproliferative effect	cancer cell lines	Rabe et al., 2011
Artemisia persica Boiss.	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Vahdati-Mashhadian et al., 2009
Artemisia santolina Schrenk	different fractions	not stated		cancer cell lines	Rabe et al., 2011
Artemisia santolina Schrenk	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Emami et al., 2009a
Artemisia sieberi Besser	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human	Emami et al., 2009a

				Caucasian larynx carcinoma (Hep-2)	
Artemisia turanica Krasch.	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Emami et al., 2009a
Artemisia vulgaris L.	different fractions	not stated	antiproliferative effect	cancer cell lines	Rabe et al., 2011
Artemisia vulgaris L.	total extract	not stated	cytotoxic activity	human Caucasian hepatocyte carcinoma (HepG-2) and human Caucasian larynx carcinoma (Hep-2)	Vahdati-Mashhadian et al., 2009
Inula britannica M.Bieb.	1-O-acetylbritannilactone	sesquiterpene lactones	cytotoxic, apopotic	cell culture	Khan et al., 2010
Inula britannica M.Bieb.	1,6-*O,O*-diacetylbritannilacton e	sesquiterpene lactones	cytotoxic, apopotic	cell culture	Khan et al., 2010
Inula britannica M.Bieb.	6α-O-(2-methylbutyryl)-britannilactone	sesquiterpene lactones	cytotoxic, apopotic, inflammation	cell culture	Khan et al., 2010
Inula britannica M.Bieb.	neobritannilactone A	sesquiterpenes lactones	cytotoxic, apopotic, inflammation	cell culture	Khan et al., 2010
Inula britannica M.Bieb.	neobritannilactone B	sesquiterpene lactones	cytotoxic, apopotic, inflammation	cell culture	Khan et al., 2010
Inula britannica M.Bieb.	quercetin, spinacetin, diosmetin	flavonoids	antioxidant, cytotoxic	cell culture	Khan et al., 2010
Saussurea costus (Falc.) Lipsch.	C17 polyene alcohol	polyenes	anticancer, antitumor, moderate cytotoxicity	against the human tumor cell lines A549, SK-OV3, SK-MEL-2, XF 498, and	Wang et al., 2010

				HCT 15	
Saussurea costus (Falc.) Lipsch.	lappadilactone, dehydrocostuslactone, and costunolide	sesquiterpene lactones	most potent cytotoxicities	HepG2, OVCAR-3, and HeLa cell lines	Wang et al., 2010
Saussurea costus (Falc.) Lipsch.	total extract	not stated	cytostatic effects, inducer of apoptosis	AGS gastric cancer cell line	Wang et al., 2010
Saussurea costus (Falc.) Lipsch.= *Saussurea lappa* C.B.Clarke	costunolide	sesquiterpene lactones	Anticancer, induction of apoptosis	in HL-60 human leukemia cells	Pandey et al., 2007
Saussurea costus (Falc.) Lipsch.= *Saussurea lappa* C.B.Clarke	total extract	not stated	induced apoptotic cell death	AGS gastric cancer cell line	Pandey et al., 2007
Saussurea costus (Falc.) Lipsch.= *Saussurea lappa* C.B.Clarke	lappadilactone, dehydrocostuslactone and costunolide	sesquiterpene lactones	cytotoxic	HepG2, OVCAR-3 and HeLa cell lines	Pandey et al., 2007
Saussurea costus (Falc.) Lipsch.= *Saussurea lappa* C.B.Clarke	dehydrocostus lactone	sesquiterpene lactone	induced apoptosis	human leukemia HL-60 cells	Pandey et al., 2007
Saussurea costus (Falc.) Lipsch.= *Saussurea lappa* C.B.Clarke	cynaropicrin	sesquiterpene lactones	pro-apoptotic activity	leukocyte cancer cell lines, such as U937, Eol-1 and Jurkat T cells	Pandey et al., 2007
Saussurea costus (Falc.) Lipsch.= *Saussurea lappa* C.B.Clarke	costunolide	sesquiterpene lactones	anti-angiogenic effect	vascular endothelial growth factor (VEGF)	Pandey et al., 2007
Saussurea costus (Falc.) Lipsch.= *Saussurea lappa* C.B.Clarke	C-17 polyene alcohol	polyenes	moderate cytotoxicities	human tumor cell lines A549, SK-OV3, SK-MEL-2, XF 498 and HCT 15	Pandey et al., 2007
Saussurea medusa Maxim.	arctiin and arctigenin	lignans	remarkable antitumorpromoting effect on two-stage carcinogenesis test	mouse-skin tumors, mouse pulmonary tumors	Wang et al., 2010

Saussurea spp.	costunolide	sesquiterpene lactones	inducer of apoptosis	HL-60 human leukemia cells	Wang et al., 2010
Saussurea spp.	arctigenin		inhibition of TNF-a induction		Wang et al., 2010
Saussurea spp.	dehydrocostuslactone	sesquiterpene lactones	induced apoptosis	human leukemia HL-60 cells	Wang et al., 2010
Saussurea spp.	cynaropicrin	sesquiterpene lactones	inhibited the proliferation, potential anticancer agent against some leukocyte cancer cells	leukocyte cancer cell lines, such as U937, Eol-1, and Jurkat T cells	Wang et al., 2010
Saussurea spp.	costunolide	sesquiterpene lactones	anti-angiogenic effect	human umbilical vein endothelial cells (HUVECs)	Wang et al., 2010
Silybum marianum (L.) Gaertn	total extract	not stated	prevention or treatment of liver dysfunction in patients undergoing anticancer therapy	patients with cancer	Ladas & Kelly, 2003
Silybum marianum (L.) Gaertn	silibinin, silymarin	flavonolignans	Prostate cancer, anticancer effects, inhibition of mitogenic and cell survival signaling	in different cancer cells, animal models	Singh et al., 2004
Silybum marianum (L.) Gaertn.	silibinin	flavonolignans	inhibition of multiple cancer cell signaling pathways, including growth inhibition, inhibition of angiogenesis, chemosensitization, and inhibition of invasion and metastasis	in animals and humans	Li et al., 2010
Silybum marianum (L.) Gaertn.	silybin, isosilybin, silychristin, silydianin and taxifoline	flavonolignans	suppression of the proliferation of a variety of tumor cells (e.g., prostate, breast,	cell culture, animal study and clinical trials	Agarwal et al., 2006

			ovary, colon, lung, bladder), angiogenesis (VEGF) and metastasis, as a chemopreventive agent, apoptosis induction, antitumor activity		
Silybum marianum (L.) Gaertn.	silybin and silymarin	flavonolignans	anticancer and canceroprotective	not stated	Kren et al., 2005
Silybum marianum (L.) Gaertn.	silymarin	flavonolignans	cancer prevention, adjuvant cancer treatment, and reduction of iatrogenic toxicity	clinical trials	Sagar et al., 2007
Silybum marianum (L.) Gaertn.	total extract	not stated	protective effect in certain types of cancer	clinical trials	Tamayo et al., 2007

Table 5. Asteraceae Cytotoxic Phytochemicals

Brassicaceae Burnett

(**Cruciferae** A.L. de Jussieu)
A family of 321 genera and about 3400 species of herbs and a few undershrubs. Many members of the family contain glucosinolates. Cardiac glycosides occur in some genera and the seeds usually contain mucilage and fixed oil (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Arabidopsis thaliana (L.) Heynh.	jasmonate	cyclopentanone derivatives	induces cell death and suppresses cell proliferation	in animals, several human cancer cell lines	Balbi & Devoto, 2007
Brassica spp.	indole-3-carbinol	glucosinolates	breast cancer, prostate cancer, endometrial cancer, colon cancer, and leukemic, induce G1/S arrest of the cell cycle, and induce apoptosis	*in vitro* and *in vivo*, clinical trials	Aggarwal & Ichikawa, 2005

Table 6. Brassicaceae Cytotoxic Phytochemicals

Campannlaceae A.L. de Juessieu

The family contains 79 genera and around 1900 species mostly herbs but some shrubs and pachycaul trees with a network of lacticifers in phloem. The members of the family contain phenolic compounds, tannins and triterpenoid glycosides (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Codonopsis pilosula Nannf.	a mixture of citronellol and extracts of *Ganoderma lucidum*, *Codonopsis pilosula* and *Angelicae sinensis*	not stated	Improvement of immune function, improving the ability to fight off the cancer, as well as any secondary infections that could compromise the treatment and the health	randomized, double-blind, placebo-controlled study	Zhuang et al., 2009

Table 7. Campannlaceae Cytotoxic Phytochemicals

Cannabaceae Martynov

A family of 10 genera and 80 species usually trees or shrubs but also herbs or vines. Widely distributed in tropical to temperate regions (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Humulus lupulus L.	hop acids	sesquiterpenoids	inhibiting cell proliferation and angiogenesis, by inducing apoptosis	*in vitro* and *in vivo*	Van Cleemput et al., 2009

Table 8. Cannabaceae Cytotoxic Phytochemicals

Clusiaceae Lindley

(**Guttiferae** A.L. de Jussieu)
The Clusiaceae contains about 30 genera and 1150 tropical species. They are trees shrubs or lianas with colored exudate in secretory canals or cavities. Constituents of the family include resins, volatile oils, alkaloids, xanthones and seed oil (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Garcinia cantleyana Whitmore	cantleyanones, 7-hydroxyforbesione, and deoxygaudichaudione A from	xanthones	cytotoxic effect	variety of cancer cell lines	Han et al., 2009
Garcinia gaudichaudii Planch. & Triana	gaudichaudiones, gaudichaudic acids, gaudichaudione H xanthones	xanthones	potent antitumor activity	variety of cancer cell lines	Han et al., 2009
Garcinia indica Choisy	gambogic acid (gamboges or kokum)	pigments	cytotoxic, apoptotic, antiangiogenesis and anticancer	*in vitro* and *in vivo*	Aggarwal et al., 2008

Garcinia spp.	gaudichaudione A	xanthones	induced the apoptosis	human leukemic cells	Han et al., 2009
Garcinia spp.	gambogic acid	pigments	induce apoptosis, can overcome the drug resistance, In vitro and in vivo studies	*in vitro* and *in vivo*	Han et al., 2009

Table 9. Clusiaceae Cytotoxic Phytochemicals

Combretaceae R. Brown

A family of 17 genera and 525 species, tropical and subtropical trees, shrubs or lianas, sometimes with erect monopodial trnnk supporting a series of horizontal, sympodial branches. Members of the family usually rich in tannin (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Combretum caffrum Kuntze	combretastatin A-4	phenolic compounds	potent antimitotic agent	cancer cells cell culture	Nam et al., 2003

Table 10. Combretaceae Cytotoxic Phytochemicals

Cornaceae Bercht. & Presl

A family of 2 genera and 80 species. Trees, shrubs or rarely rhizomatous herbs usually with iridoids, widespread; specially common in north temperate regions, rare in tropical and south temperate regions (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Camptotheca acuminata Decne.	camptothecin and its derivatives	alkaloids	anticancer drugs	cancer treatment in patients	Sirikantaramas et al., 2007

Table 11. Cornaceae Cytotoxic Phytochemicals

Crassulaceae J. St. Hilaire

The Crassulaceae contains 92 genera and around 1380 species almost cosmopolitan especially south Africa, rare in Australia and wcst Pacific. succulent herbs to shrubs; often with cortical or medullary vascular bundles; with crassulacean acid metabolism (CAM), tannins present, often with alkaloids, sometimes cyanogenic (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Rhodiola rosea L.	total extract	not stated	anticancer, decreased metastasis to the liver, and extended survival times	in animal experiments	Kelly et al., 2001

Table 12. Crassulaceae Cytotoxic Phytochemicals

Cupressaceae Gray

A family of 30 genera and 130 species. The family is subcosmopolitan of warm to cold temperate climate. Monoecious or dioecious resinous trees or shrubs. Leaves descussate or in whorls of 3 or 4, in young plants needle – like, usually small and scale – like in mature plants. Flowers, small, solitary, axillary or terminal on short shoots, cones terminals, woody, leathery or berry – like, cone – scales opposite or in whorls of 3, ovules usually several per scale. Seeds winged or not. Constituents of the family include essential oils, monoterpenes, sesquiterpenes diterpenes, tannins and flavomoids (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Cupressus sempervirens L. var. *horizentalis* (Mill.) Gordon	total extract	not stated	cytotoxic effect	cell culture	Emami et al., 2005
Juniperus excelsa M.Bieb. subsp. *excelsa*	total extract	not stated	cytotoxic effect	cell culture	Sadeghi-aliabadi et al., 2009a
Juniperus excelsa M.Bieb. subsp. *polycarpos* (K. Koch) Takhtajan	total extract	not stated	cytotoxic effect	cell culture	Sadeghi-aliabadi et al., 2009a
Juniperus foetidissima Willd.	total extract	not stated	cytotoxic effect	cell culture	Sadeghi-aliabadi et al., 2009b
Juniperus sabina L.	total extract	not stated	cytotoxic effect	cell culture	Sadeghi-aliabadi et al., 2009b
Platycladus orientalis (L.) Franco	total extract	not stated	cytotoxic effect	not stated	Emami et al., 2005

Table 13. Cupressaceae Cytotoxic Phytochemicals

Ericaceae A.L. de Jussieu

They Ericaceae contains 117 genera and 3850 species cosmopolitan except deserts usually montane in tropical regions. Trees, shrubs, lianas or subherbaceous, sometimes epiphytic, occasionally mycoparasitic herbs lacking chlorophyll, strongly associated with micorrhizal fungi. The family produces phenolic acids, phenolic glycosides aucubin glycosides, diterpenoids, triterpenoids, cyclitols and leucoanthecyanins. A few species are cyanogenic; saponins are absent (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Vaccinium macrocarpon Aiton	not stated	not stated	induction of apoptosis in tumor cells, reduced ornithine decarboxylase activity, decreased expression of matrix	*in vitro* tumor models	Neto et al., 2008

Vaccinium macrocarpon Aiton	polyphenolic extracts flavonols, proanthocyanidin oligomers, and triterpenoids isolated from the fruit.	flavonoids	inhibit the growth and proliferation of breast, colon, prostate, lung, and other tumors, induction of apoptosis in tumor cells, reduced ornithine decarboxylase activity, decreased expression of matrix metalloproteinases associated with prostate tumor metastasis, and antiinflammatory activities including inhibition of cyclooxygenases	*in vitro* studies using a variety of tumor models	Neto et al., 2007

Table 14. Ericaceae Cytotoxic Phytochemicals

Fabaceae Lindley

(**Leguminosae** A.L. de Jussieu)

This is the second – largest family of flowering plants and contains 720 genera and 19500 cosmopolitan species. Herbs, shrubs, trees or vines / lianas climbing by twining or tendrils; with a high nitrogen metabolism and unusual aminoacids, often with root nodules containing nitrogen – fixing bacteria, sometimes with secretory canals or cavities, tannins usually present, often with alkaloids; sometimes cyanogenic, sieve cell plastids with protein crystals and usually also starch grains.
The family is divided into three subfamilies: 1) Papilionoideae; 2) Mimosoideae and 3) Caesalpinoideae (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Glycine max (L.) Merr.	soy saponins	saponins	cancer protective effects	epidemiological studies	Kerwin et al., 2004
Glycyrrhiza inflata Batalin	licochalcone E,	flavonoids	potent cytotoxic effect	in tumor cells	Asl & Hosseinzadeh, 2008
Glycyrrhiza spp.	total extract	not stated	inhibits angiogenesis, induced apoptosis	*in vivo* and *in vitro*	Asl & Hosseinzadeh, 2008
Glycyrrhiza spp.	glycyrrhetinic acid	triterpenoids	trigger the proapoptotic pathway	in tumor cells	Asl & Hosseinzadeh, 2008
Glycyrrhiza spp.	isoliquiritigenin (ILG)	triterpenoids	antiproliferative activity, trigger the proapoptotic pathway	in tumor cells	Asl & Hosseinzadeh, 2008
Glycyrrhiza spp.	glabridin dibenzoylmethane	triterpenoids	antiproliferative activity, trigger	in tumor cells	Asl & Hosseinzadeh,

	(DBM)		the proapoptotic pathway		2008
Trigonella foenum graecum	diosgenin	saponins	suppress proliferation, invasion inhibition, cytotoxic, apoptotic, anti-cancer activity	cell culture, animal study	Aggarwal et al., 2008

Table 15. Fabaceae Cytotoxic Phytochemicals

Ginkgoaceae Engler

A family contains only a monotypic genus, limited to remote mountain valleys of China; possibly extinct in the wild. From among the many groups of compounds isolated from *Ginkgo biloba* it is diterpenelactons and flavonoids which have been shown to possess therapeutic activity (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Ginkgo biloba L.	total extract	not stated	chemopreventive action at various levels with antioxidant, antiangiogenic properties, reduce angiogenesis	cell culture, cancer model	Mahadevan et al., 2008
Ginkgo biloba L.	total extract	not stated	anticancer (chemopreventive) properties are related to its antioxidant, antiangiogenic and gene-regulatory actions	cell culture	Dubey et al., 2004
Ginkgo biloba L.	ginkgolide B	sesquiterpenoids	anticancer (chemopreventive) properties that are related to their antioxidant, anti-angiogenic and gene-regulatory actions	molecular, cellular and whole animal models	DeFeudis et al., 2003
Ginkgo biloba L.	not stated	flavonoids	anticancer (chemopreventive) properties that are related to their antioxidant, anti-angiogenic and gene-regulatory actions	molecular, cellular and whole animal models	DeFeudis et al., 2003

Table 16. Ginkgoaceae Cytotoxic Phytochemicals

Hypericaceae A. L. de Jussieu

The Hypericaceae consists of 9 genera and 540 species. Members of this family are trees, shrubs or herbs with clear or block resinous sap in secretory cavities (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Hypericum perforatum L.	hypericin	naphthodianthrones	antineoplastic activity upon irradiation, photosensitizer can induce both apoptosis and necrosis	*in vivo* and *in vitro*, potential clinical anticancer agent	Agostinis et al., 2002

Table 17. Hypericaceae Cytotoxic Phytochemicals

Iridaceae A. L. de Jussieu

A family of 70 genera nd 2000 species. The species are widely distributed usually geophytic herbs with rhizomes, corms or bulbs, less often evergreen or even shrubby, rarely annuals or achlorophyllous mycotroph. Constituents include quinones, aromatic ketones, carotenoid pigments, terpenoids, and flavonoids (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Crocus sativus L.	total extract	not stated	antitumor and cancer preventive activities of saffron and its main ingredients	experimental *in vitro* and *in vivo* investigations	Abdullaev & Espinosa-Aguirre, 2004
Crocus sativus L.	total extract	not stated	apoptosis induction in MCF-7 and MDA-MB-231 breast cancer cells	*in vitro*	Mousavi et al., 2009; Chryssanthi et al., 2007

Table 18. Iridaceae Cytotoxic Phytochemicals

Lamiaceae Martynov

(**Labiatae** A. L. de Jussieu)

A family of 238 genera and 6500 species. Trees, shrubs, annual or perennial herbs, rarely lianas.Young stems often 4 – angleded. Leaves opposite and simple. Flower are bisexuals, usually bracteolate and in cymes, thyrse or verticillasters or single. The family divided into 7 subfamilies.The Lamiaceae contains many species that are economically important either for their volatile oils or for use as spices. Among the constituents found in the family are essential oils, saponins, tannins, quinones, irodoids: alkaloids appear to be rare (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Ocimum sanctum L.	ursolic acid	triterpenoids	antitumor	not stated	Prakash & Gupta, 2005

Phlomis armeniaca Willd.	Phenyl propanoid caffeic acid, phenylethyl alcohol and phenylethylalcohol glycosides	phenolic compounds	anticancer activity	several kinds of cancer cells	Limem-Ben Amor et al., 2009
Phlomis brunneogaleata Hub.-Mor.	verbascoside, isoverbascoside, forsythoside B and 3-O-caffeoylquinic acid methyl ester	phenolic compounds	cytotoxic activity	L6 cell lines	Limem-Ben Amor et al., 2009
*Rosmarinus officinalis*L.	ursolic acid (3β-hydroxy-urs-12-en-28-oic acid)	triterpenoids	suppress tumorigenesis, inhibit tumor promotion, and suppress angiogenesis, inhibited proliferation, induced apoptosis	*in vitro* and *in vivo*	Aggarwal et al., 2008
Salvia chamelaeagnea P.J.Bergius,	total extract	not stated	cyotoxic	animals and humans	Kamatou et al., 2008
Salvia namaensis Schinz	total extract	not stated	cyotoxic	animals and humans	Kamatou et al., 2008
Salvia runcinata L.f.	total extract	not stated	cyotoxic	animals and humans	Kamatou et al., 2008
*Salvia africana–caerulea*L.	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia chamelaeagnea P.J.Bergius	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia dolomitica Codd	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia gariepensis E.Mey.	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia hypargeia Fisch. & Mey.	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia lanceolata Lam.	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia miltiorrhiza Bunge	in mixture with *coriolus versicolor* in capsules	not stated	could be beneficial for promoting immunological function in post-treatment of breast cancer patients	clinical trial	Wong et al., 2005
Salvia muirii L.Bolus	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia namaensis Schinz	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008

Salvia radula Benth.	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia repens Burch. ex Benth.	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al.,2008
Salvia runcinata L.f.	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Salvia verbenaca L.	total extract	not stated	cytotoxic effects on cancer cells	human cancer cell lines	Kamatou et al., 2008
Scutellaria barbata D.Don	aqueous extract	not stated	anticancer activity in women with metastatic breast cancer (MBC)	the trial was an open-label, phase 1B, multicenter, dose escalation study	Perez et al., 2010
Scutellaria spp.	Wogonin, Baicalein and Baicalin	flavones	potent anticancer activities, scavenge oxidative radicals, to attenuate NF-kappaB activity, to inhibit several genes important for regulation of the cell cycle, to suppress COX-2 gene expression and to prevent viral infections	*in vitro* and *in vivo*	Li-Weber 2009
Scutellaria lindbergii Rech. f.	different fractions	not stated	cytotoxic effects in different cancer cell lines in which apoptosis plays an important role, potential chemotherapeutic agent	cancer cell lines	Tayarani-Najaran et al., 2009
Scutellaria litwinowii Bornm. & Sint. ex Bornm	different fractions	not stated	cytotoxic effects in different cancer cell lines in which apoptosis plays an important role, potential chemotherapeutic agent	cancer cell lines	Tayarani-Najaran et al., 2011

Table 19. Lamiaceae Cytotoxic Phytochemicals

Liliaceae A. L. de Jussieu

A widely distributed family of 16 genera and about 600 species of perennials with bulbs or rhizomes; aerial stem unbranched. Leaves oval to filiform, usually parallel – veined.

Inflorescences usually raceme sometimes umbel, thyrse or 1 – flowered. Many members of the family contain alkaloids, which are of the steroidal, isoquinoline or purine types, other steroidal substances include sterols, cardenolides bufadienolides and steroidal saponins. Other constituents include quinones, flavonoids, the gamma – pyrone chelidonic acid, cyanogenic substances and fructosan – type carbohydrates. Some volatile oils of the family have antimicrobial properties (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Allium sativum L.	ajoene	thiosulfinates	anticancer activity, activation of the mitochondrial-dependent caspase cascade	*in vitro*	Kaschula et al., 2010
Allium sativum L.	not stated	not stated	garlic rich diet decreases risk of some cancers	epidemiological studies	Iciek et al., 2009
Allium sativum L.	not stated	not stated	Mortality in stomach cancer patients from the region where people have consumed high-garlic diet (about 20 g a day) was three times lower than in the second region in which consumption of plats of the family Allium was very low	trials carried out in China compared two big human populations living	Iciek et al., 2009
Allium sativum L.	not stated	not stated	negatively correlated with colon cancer, reduced risk of prostate cancer, reduced risk of breast cancer	epidemiological analysis,	Iciek et al., 2009
Allium sativum L.	DATS (diallyl trisulfide)	not stated	protection against gastric cancer	double-blind intervention study	Iciek et al., 2009
Allium sativum L.	alk (en)yl sulfides	thiosulfinates	anticancer effect	human colon cancer cells	Seki et al., 2008
Allium sativum L.	organosulfur compounds (OSCs)	thiosulfinates	inhibition of DNA adduct formation, upregulation of antioxidant defences and DNA repair systems, and suppression of cell proliferation by blocking cell cycle	epidemiological studies as well as laboratory data	Nagini et al., 2008

			progression and/or inducing apoptosis		
Allium sativum L.	diallylsulfides	thiosulfinates	not stated	not stated	Münchberg et al., 2007
Allium sativum L.	allicin and diallyltrisulfide	thiosulfinates	anticancer agents	cell culture	Münchberg et al., 2007
Allium sativum L.	allicin, methyl allyl trisulfide, and diallyl trisulfide	thiosulfinates	not stated	not stated	Ariga et al., 2006
Allium sativum L.	organosulfur compounds	thiosulfinates	anticarcinogenic and antitumorigenic	preclinical	Milner, 2006
Allium sativum L.	thiosulfinates such as allicin	thiosulfinates	anticancer and chemopreventive activities	not stated	Amagase, 2006
Allium sativum L.	organic allyl sulfur components	thiosulfinates	inhibitors of the cancer process, depression in nitrosamine formation and a reduction in carcinogen bioactivation	not stated	Milner et al., 2001
Allium sativum L.	thiosulfinates, allicin, S-allylcysteine, S-allylmercaptocysteine, N (alpha)-fructosyl arginine	thiosulfinates	not stated	not stated	Amagase et al., 2001
Aloe arborescens Mill.	in combination with pineal indole melatonin	not stated	stabilization of disease and survival, in patients with advanced solid tumors	a randomized study of chemotherapy versus biochemotherapy	Lissoni et al., 2009
Aloe vera L.	barbaloin,octapeptide, aloesin, aloe-emodin	antheraquinones	prolongation of the life span of tumor-transplanted animals, cytotoxicity, apoptosis	*in vitro* (acute myeloid leukemia (AML) and acute lymphocytes leukemia (ALL) cancerous cells) and *in vivo*	El-Shemy et al., 2010
Aloe vera L.	acemannan	polysaccharides	anti-tumour activity	*in vitro* models as well as in different animal species	Hamman et al., 2008
Aloe vera L.	gel	not stated	reduced tumour burden, tumour shrinkage, tumour necrosis and prolonged survival rates,	*in vitro* models as well as in different animal species	Hamman et al., 2008

			chemopreventative and anti-genotoxic effects on benzo[α]pyrene-DNA adducts		
Aloe vera L.	not stated	glycoproteins (lectins) and polysaccharides	anti-cancer effects, stimulation of the immune response	*in vitro* models as well as in different animal species	Hamman et al., 2008

Table 20. Liliaceae Cytotoxic Phytochemicals

Linaceae A. P. de Candolle ex Perleb.

A family of 10 genera and 280 species.
Lianas, shrubs and herbs sometimes cyanogenic. Leaves are spirals to opposites, simple, entire. Flowers bisexuals usually regulars and 5 – merous in cymose or racemose inflorescence. Constituents of the family in clued cyanogenaic glycosides, fixed oils, mucilage, diterpenes and triterpenes (Evans 2009; Judd et al., 2008; Mabberley 2008).
Family Linaceae

Species	Compound	Class of Compound	Effect	Status	Ref.
Linum usitatissimum L.	secoisolariciresinol	lignans	inhibited the invasion, inhibitory effect on breast and colon carcinoma, potent cytotoxic effect on human promyleocytic leukemia HL-60 cells, DNA damage and apoptosis, anticancer, antiapoptotic	cell culture	Sok et al., 2009
Linum usitatissimum L.	lariciresinol and pinoresinol	lignans	anticancer, antiapoptotic	cell culture	Sok et al., 2009
Linum usitatissimum L.	secoisolariciresinol diglucoside	lignans	anticancer, antiapoptotic	cell culture	Sok et al., 2009
Linum usitatissimum L.	hydroxymatairesinol, matairesinol	lignans	antitumor activity, anticarcinogenic effects	cell culture, animal experiment	Sok et al., 2009
Linum usitatissimum L.	enterolactone and enterodiol	Lignans	potential anticancer effects	randomized crossover study	Coulman et al., 2005

Table 21. Linaceae Cytotoxic Phytochemicals

Loranthaceae A. L. de Jussieu

A family of 84 genera and 950 species. Pantropical but no single genus spans both Old and New Worlds.
Typically brittle shroblets on tree – branches; less often trrestrial shrubs, lianas or even trees. The family contains glycoproteins, polypeptides, lignans, flavonoids, etc. (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Viscum album L.	total extracts	not stated	the evidence from RCTs to support the view that the application of mistletoe extracts has impact on survival or leads to an improved ability to fight cancer or to withstand anticancer treatments is weak.	randomized clinical trials (RCTs) and controlled clinical trials	Horneber et al., 2008
Viscum album L.	lectins	proteins	anti-metastatic effect, inhibition of tumour-induced angiogenesis, and in part due to an induction of apoptosis, suppress tumour growth	different tumour cell lines, in vivo	Pryme et al., 2006
Viscum album L.	aqueous extract (Isorel)	not stated	Isorel can improve immune competence and the overall health status of cancer patients undergoing surgery	clinical trial	Enesel et al., 2005
Viscum album L.	mistletoe lectins I, II, and III	proteins	improvement of quality of life in cancer patients	several preclinical studies, randomised phase III study	Stauder & Kreuser, 2002
Viscum album L.	total extract (Isorel)	not stated	benefit in terms of survival from combined postoperative chemotherapy and Isorel biotherapy, either adjuvant or palliative	Randomized and controlled study, patients with colorectal cancer stages Dukes C and D	Cazacu et al., 2003

Table 22. Loranthaceae Cytotoxic Phytochemicals

Lythraceae J. St. – Hilaire

A family contains 31 genera and 600 tropical with few temperate species. Herbs, less often sub shrubs or trees. Leaves are opposite and simple. Flowers are bisexuals, often heterostylons, solitary, fascicled in axils or terminal racemes, regular or not, with conspicuous hypanthium.

Constituents of the family include quinones, alkaloids and tannins (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Punica granatum L.	total exract	not stated	potential chemopreventive and anticancer agent	*in vitro* and *in vivo* animal models	Syed et al., 2007
Punica granatum L.	total exract	not stated	cancer chemoprevention, anticancer activities, interference with tumor cell proliferation, cell cycle, invasion and angiogenesis	mouse mammary organ culture, *in vitro* and *in vivo*, open-label, singlearm, 2-year, phase-2, Simon two-stage clinical trial	Lansky et al., 2007

Table 23. Lythraceae Cytotoxic Phytochemicals

Malvaceae A. L. de Jussieu

The Malvaceae consists of 113 genera and 5000 cosmopolitan species. Trees, shrubs, lianas and herbs, rarely scandent, usually with tufted or stellate hairs and parenchyma typically with scattered mucilage cell, mucilage cavities or mucilage canals. The family divided into 9 subfamilies. Constituents of the family include alkaloids, cardiac glycosides, saponins, tannins, pbenolic acids and mucilage (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Gossypium spp.	gossypol	polyphenols	anticancer	not stated	Wang et al., 2009

Table 24. Malvaceae Cytotoxic Phytochemicals

Melanthiaceae Batsch ex Borkh.

A family of 16 genera and about 120 species distributed in temperate and/or montane habitats. Members of this family perennial herbs sometimes pachycaul, with rhizomes and spirals of or distichous leaves. Inflorescence are spikes or racemes of usually bisexual flowers, steroidal saponins and various tonic alkaloids often present (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Veratrum grandiflorum O.Loes	resveratrol, trans-3,5,4'-trihydroxystilbene	stilbenoids	growth-inhibitory effects, suppression of angiogenesis, potentiate the	wide variety of tumor cells, including lymphoid and	Aggarwal et al., 2004

			apoptotic effects of cytokines (e.g., TRAIL), chemotherapeutic agents and gamma-radiation, chemopreventive effects, therapeutic effects against cancer	myeloid cancers; multiple myeloma; cancers of the breast, prostate, stomach, colon, pancreas, and thyroid; melanoma; head and neck squamous cell carcinoma; ovarian carcinoma; and cervical carcinoma	

Table 24. Melanthiaceae Cytotoxic Phytochemicals

Meliaceae A. L. de Jussieu

The Meliaceae contains 50 genera and 650 tropical and subtropical species. Trees, often pachycaul, rarely subshrubs or suckering shrublets, dioecious polygamous, monoecious or with only bisexual flowers, bark bitter and astringent. Leaves pinnate to bipinnate,unifolioate or simple, in spirals with usually entire leaflets and basally swollen petiole sometimes spiny. Flowers if unisexual often with rudiments of opposite sex, in spikes to thyrses, axillary to snpra – axillary. The family divided into two subfamilies. Significant constituents of the family are triterperoids and limonoids (Evans 2009; Judd et al., 2008; Mabberley 2008).
Family Meliaceae

Species	Compound	Class of Compound	Effect	Status	Ref.
Aglaia elliptifolia Merr.	rocaglamide	cyclopenta[b]benzofurans	antiproliferative activity, induce apoptosis in different human cancer cell lines	in a murine *in vivo* model, human cancer cell lines	Kim et al., 2006

Table 25. Meliaceae Cytotoxic Phytochemicals

Moraceae Gaudich.

A family of 38 genera and 1150 species of tropical and warm monoecious or dioecious trees, shrubs, lianas or rarely herbs, usually with laticifers with milky latex dis tribnted in all parenchy matous tissues. The family divided into 5 tribes. Constituents of the family include cardenolides and pyridine alkaloids (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Ficus spp.	6-O-acyl-d-glucosyl-sitosterol isoforms	latex	anti-proliferative activity, inhibited the growth of hepatic carcinoma xenografts by approximately 49%	in several tumor cell lines, *in vitro* in mice	Lansky et al., 2008

Ficus spp.	apigenin, carpachromene, and norartocarpetin	flavonoids	cytotoxic	In several cancer cell lines	Lansky et al., 2008
Ficus spp.	C-28 carboxylic acid functional groups	triterpenoids, phenanthroindolizidine alkaloids	cytotoxic	human cancer cell lines	Lansky et al., 2008
Ficus septica Burm. f.,	ficuseptine-A (6), (+)-tylophorine (19), and a mixture of (+)-antofine (1) and (+)-isotylocrebrine (12)	alkaloids	cytotoxic activity	in several cancer cell lines	Lansky et al., 2008
Ficus hispida L.f.	O-methyltylophorinidine	alkaloids	cytotoxic activity	in several cancer cell lines	Lansky EP 2008

Table 26. Moraceae Cytotoxic Phytochemicals

Oleaceae Hoffmannsegg & Link.

A family of 24 genera and 800 species of trees and shrubs, sometimes lianoid, usually with peltate secretory hairs. Sclereids often present, usually with phenolic glycosides. Other constituents of the family are saponins, tannins, coumarins and iridoid glycosides. Alkaloids are rare (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Olea europaea L.	not stated	Phenolic compounds	inhibit colon cancer development	in large intestinal cancer cell models, animals , and humans	Corona et al., 2009
Olea europaea L.	oleic acid	fatty acids	induces apoptosis and cell differentiation, colorectal chemoprotection	*in vitro* and *in vivo* studies	Waterman et al., 2007
Olea europaea L.	squalene	triterpenoids	chemoprotective effect, lower incidence of skin cancer, inhibitory action on chemically-induced skin carcinomas.	epidemiological data, animal studies	Waterman et al., 2007
Olea europaea L.	monounsaturated fatty acids, squalene, tocopherols, and phenolic compounds	Phenolic compounds	associated with low incidence and prevalence of cancer, including colorectal cancer	epidemiologic, *in vitro*, cellular, and animal studies	Hashim et al., 2005

Olea europaea L.	squalene and terpenoids acteosides, hydroxytyrosol, ????tyrosol and phenyl propionic acids hydroxytyrosol and tyrosol secoiridoids and lignans	phenolic antioxidants and squalene???	scavenging singlet oxygen generated by UV light, chemopreventive effects against colorectal cancer, potential as chemopreventive agents	animal, cellular and metabolic studie	Owen et al., 2004

Table 27. Oleaceae Cytotoxic Phytochemicals

Papaveraceae A. L. de Jussieu

The Papaveracea contains 430 genera and 770 species widely distributed in mainly temperate regions; specially diverse in the Northern Hemisphere, but also in southern Africa and eastern Australia. Herbs to soft – wooded shrubs; stem with vascular bundles sometimes in several rings with laticifers present and plants with white, cream, yellow, orange, or red sap, or with specialized elongated secretory cells and sap then mucilaginous, clear, sap with various alkaloids. The family is rich in alkaloids (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Chelidonium majus L.	total extract	not stated	has curative effects on a range of cancers	randomised clinical trials	Ernst & Schmidt, 2005

Table 28. Papaveraceae Cytotoxic Phytochemicals

Sapindaceae A. L. de Jussieu

The Sapindaceae is a family of 131 genera and 1450 species.
This family is divided into 3 subfamilies: 1) Hippocastanideae 2) Dodonaeoideae and 3) Sapindoideae. Mainly tropical and subtropical with a few genera most diverse in temperate regions. Trees, shrubs or lianas and herbaceous climbers. Constituents of the family inclued saponins, cyanogenic glycosides, cyclitols and coumarins.Alkaloids have been reported in a few species (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Litchi chinensis Sonn.	epicatechin, procyanidin B2, procyanidin B4	flavonoids	inhibition of proliferation and induction of apoptosis in cancer cells through upregulation and down-regulation of multiple genes, anti-breast cancer	cell culture	Li et al., 2007

Table 29. Sapindaceae Cytotoxic Phytochemicals

Solanaceae A. L. de Jussieu

The family comprise of 91 genera and 2450 species. Subcosmopolitan especially in tropical America. Shrubs, trees, lianas and herbs with branched hairs and often prickles; internal phloem around pith; some dioecious. Leaves simple, or lobed to pinnate or 3 – foliate, usually in spirals. Flowers solitary or in appearent basically cymose inflorescence. The Solanaceae is divided into two subfamilies: 1) Solanoideae and 2) Browallioideae.
The family contains a wide range of alkaloids which are great taxonomic interest. Types of alkaloid recorded are tropane, alkaloidal amine, indole, isoquinoline, purine, pyrazole, pyridine, pyrrolidine, quinolizidine, stroid alkaloids and glycoalkaloids. Other constituents include stroidal saponins, withanolides, coumarins, cyclitols, pungent principles, flavones, caretenoids and anthra quinons (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Capsicum annuum L.	capsanthin and capsorubin	carotenoids	potent P-gp inhibitors	cell culture	Molnár et al., 2010
Capsicum chinense Jacq.	capsaicin	capsaicinoids.	apoptosis inducer	cell culture	Meghvansi et al., 2010
Capsicum spp.	capsaicin (trans-8-methyl-N-vanillyl-6-nonenamide)	alkaloids	blocks the translocation of nuclear factor kappa B (NF-kB), activator protein 1 (AP-1), and signal transducer and activator of transcription (STAT3) signaling pathway	cell culture	Oyagbemi et al., 2010
Capsicum spp.	capsaicin (trans-8-methyl-N-vanillyl-6-nonenamide)	alkaloids	anticancer effects	cell culture, in animal models	Aggarwal et al., 2008
Lycopersicon esculentum Mill.	lycopene	carotenoids	prostate cancer	cell culture, animal, epidemiologic and case-control studies	Ansari & Ansari, 2005
Lycopersicon esculentum Mill.	lycopene	carotenoids	several types of cancer, including prostate cancer	*in vitro* and *in vivo* studies	Hwang et al., 2002
Lycopersicon esculentum Mill.	lycopene	carotenoids	cancer chemopreventive effects	animal models	Cohen et al., 2002
Nicotiana tabacum L.	alpha- and beta-2,7,11-cembratriene-4,6-diols	diterpenoids	anticancer activity	cell culture, mice, mouse, rats	El Sayed et al., 2007
Solanum incanum L.	diosgenin	saponins	suppress proliferation, invasion inhibition,	cell culture, animal study	Aggarwal et al., 2008

			Cytotoxic, apoptotic, anti-cancer activity		
Solanum xanthocarpum Schrad. & Wendl	diosgenin	saponins	suppress proliferation, invasion inhibition, Cytotoxic, apoptotic, anti-cancer activity	cell culture, animal study	Aggarwal et al., 2008

Table 30. Solanaceae Cytotoxic Phytochemicals

Ranunculaceae A. L. de Jussieu

A family of 56 genera and 2100 species. Widespread, but especially characteristic of temperate boreal regions of the Northern Hemisphere. Herbs, shrubs or occasionally vines. Leaves usually alternate and spiral, occasionally opposite, simples sometimes lobed or dissected, to compound, usually serrate, or crenate, with pinnate to occasionally palmate venation. Inflorescences determinate, sometimes appearing in de terminate or reduced to a single flower, terminal. Flowers usually bisexual. The family has diverse chemical constituents and is of considerable phytochemical and chemotaxonmic interest (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
*Nigella sativa*L.	Thymoquinone	not stated	suppress proliferation, invasion inhibition, Cytotoxic, apoptotic, anti-cancer activity, anti angiogenic	cell culture, animal study, *in vitro* and *in vivo*	Aggarwal et al., 2008

Table 31. Ranunculaceae Cytotoxic Phytochemicals

Rosaceae A. L. de Jussieu

A family of 85 genera and around 3000 species. The family is subcosmopolitan and most abundant in the northern Hemisphere. Herbs, shrubs, or trees, often rhizomatous, in frequently climbing; thorns sometimes present. This family is divided into 3 subfamilies and 17 tribes. Constituents of the Rosaceae include cyanogenic glycosides, saponins, tannins, sugar alcohols, cyclitols, terpenoids and mucilage; alkaloids and coumarins are rare (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Aronia arbutifolia (L.) Pers.	not stated	anthocyanins and procyanidins	anticancer	*in vitro* and in *in vivo* studies	Kokotkiewicz et al., 2010
Aronia melanocarpa (Michx.) Elliott	not stated	anthocyanins and procyanidins	anticancer	*in vitro* and *in vivo* studies	Kokotkiewicz et al., 2010

Fragaria × *ananassa* (Weston) Duchesne ex Rozier	ellagic acid, and certain flavonoids: anthocyanin, catechin, quercetin and kaempferol	flavonoids	anticancer activity, blocking initiation of carcinogenesis, and suppressing progression and proliferation of tumors	in several different experimental systems	Hannum et al., 2004

Table 32. Rosaceae Cytotoxic Phytochemicals

Rubiaceae A. L. de Jussieu

The Rubiaceae consists of 563 genera and 10900 species. Members of the family are cosmopolitan, but most diverse in tropical and subtropical regions. The Rubiaceae divided into 4 subfamilies. In the family, alkaloids of indole, oxindole, quinoline and purine types are common; anthraquinones occur in some genera of the Rubiaceae. Other constituents of the family inclued anthocyanins, cyclitols, coumarins, diterpenoids, triterpenoids and iridoid glycosids.

Species	Compound	Class of Compound	Effect	Status	Ref.
Morinda citrifolia L.	total extract	not stated	potential anticancer activity, immunomodulatory activity	cell culture, phase I clinical study	McClatchey et al., 2002

Table 33. Rubiaceae Cytotoxic Phytochemicals

Rutaceae A. L. de Jussieu

A family of 158 genera and 1900 species. Nearly cosmopolitan, but mainly tropical and sub tropical. Usually trees or shrubs, sometimes with thorns, spines, or prickles. The Rutaceae is divided into 5 subfamilies.

Constituents of this family include a wide variety of alkaloids, volatile oils, rhamno – glucosides, coumarins and terpenoids. Alkaloids include alkaloidal amines, imidazole, indole isoquinoline, pyridine, pyrrolidine, quinazoline types. Many of the fruits are rich in citric and other acids and in vitamin c (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Citrus spp.	limonoids	triterpenoids	chemopreventive agents for cancer, Reduction of skin tumours	animal studies	Silalahi et al., 2002
Citrus spp.	nomilin	triterpenoids	inhibitor of carcinogenesis	animal studies for forestomach tumours	Silalahi, 2002
Citrus spp.	nobiletin and tangeretin dietary fibre	flavonoids	anticancer activity	*in vivo* and *in vitro*	Silalahi et al., 2002
Citrus spp.	β-carotene	not stated	pro-tumorigenic properties	not stated	Silalahi et al., 2002

Citrus spp.	ascorbic acid	not stated	prevents oxidation of specific chemicals to their active carcinogenic forms, protects against in vivo oxidation of lipids and DNA	*in vivo*, in humans	Silalahi et al., 2002
Citrus spp.	dietary fibre and pectin	polysaccharides	influence colon cancer by physical dilution of colon content, absorption of bile acids and carcinogens, decreased transit time, altered bile acid metabolism and the effects of fermentation, namely, the production of short-chain fatty acids, lowering of pH and stimulation of bacterial growth, absorbing carcinogens in the gastrointestinal tract, reducing the risk of bowel cancer,	in human	Silalahi et al., 2002
Citrus spp.	flavanone and flavone O- and C-glycosides and methoxylated flavones???	flavonoids	anti-inflammatory and anticancer actions	*in vitro* and *in vivo*	Manthey et al., 2001

Table 34. Rutaceae Cytotoxic Phytochemicals

Taxaceae Bercht. & J. Presl

A family of 6 genera and 28 species. Small or moderately sized dioecious trees or shrubs, usually not resinous or only slightly resinous, fragrant or not. Wood without resin canals, leaves simple, persistent for several years, shed singly, spirals, often twisted so as to appear 2 – ranked, linear, flattned, entire, acute at apex, with 0 – 1 resin canals. Some species of Taxus investigated for taxane alkaloids (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Taxus baccata L.	total extract	not stated	cytotoxic effect	Cell culture	Emami et al., 2005

Table 35. Taxaceae Cytotoxic Phytochemicals

Theaceae Mirbel

A family of 7 genera and about 240 species. Usually evergreen trees and shrubs. Leaves simple, entire to toothed usually in spirals and coriaceous, often withering red. Flowers usually large and bisexual, hypogynous to epigynous, solitary and axillary. Among the constituents are purine alkaloids, saponins, tannins and fixed oil (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Camellia sinensis (L.) Kuntze	(-)-epigallocatechin gallate (EGCG)	polyphenols	synergists with anticancer drugs	cell culture	Suganuma et al., 2011
Camellia sinensis (L.) Kuntze	catechins (specifically EGCG)	polyphenols	targeting of lipid rafts by EGCG	cell culture	Patra et al., 2008
Camellia sinensis (L.) Kuntze	catechins (specifically EGCG)	polyphenols	growth factor-mediated pathway, the mitogen-activated protein (MAP) kinase-dependent pathway, and ubiquitin/proteasome degradation pathways	phase I and II clinical trials	Chen et al., 2008
Camellia sinensis (L.) Kuntze	catechin, (-)-epigallocatechin	polyphenols	antioxidant, antiangiogenesis, and antiproliferative	review to summarize recent findings on the anticancer and medicinal properties of green tea	Cooper et al., 2005 b
Camellia sinensis (L.) Kuntze	epigallocatechin gallate (EGCg)	polyphenols	antioxidant, anti-angiogenesis, and antiproliferative	review to summarize recent findings on the anticancer and medicinal properties of green tea	Cooper et al., 2005 a
Camellia sinensis (L.) Kuntze	catechin EGCG	polyphenols	antioxidant properties of the catechins with anticancer effects	preclinical research	Moyers et al., 2004
Camellia sinensis (L.) Kuntze	catechins and polyphenols	polyphenols	both cytostatic and cytotoxic activity towards cancer cells	*in vitro* and *in vivo* research	Colic & Pavelic, 2000

Table 36. Theaceae Cytotoxic Phytochemicals

Zingiberaceae Martynov

The Zingiberaceae family of 50 genera and 1500 species widespread in tropical regions; chiefly in shaded to semi – shaded forest understory habitats; occasionally in wetlands. Small to large, spicy – aromatic herbs, scattered secretory cells containing ethereal oils, various terpenes, and phenyl – propanoid compounds. The family is divided into two subfamilies: 1) Costoideae and 2) Zingiberoideae.

Volatile oils and pungent principles are a feature of the family. Other constituents include the colouring matters known as curcominoids, tannins, phenolic acids, leucoantheyanins,flavonoids, ketones and terpenoids. Only a few isolated of alkaloids have been reported (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Curcuma longa L.	curcumin, difluorocurcumin analogs	polyphenols	prevention of tumor progression and/or treatments of human malignancies	promising leads for conducting first in-depth animal studies and subsequently clinical trials	Padhye et al., 2010
Curcuma longa L.	curcumin	polyphenols	anticancer activities	not stated	Agarwal et al., 2007
Curcuma longa L.	curcumin	polyphenols	cancer chemoprevention , antitumor	cell epidemiological studies, Preclinical studies	Thangapazham et al., 2006
Curcuma longa L.	curcumin	polyphenols	cancer prevention	human clinical trials	Aggarwal et al., 2008
Curcuma longa L.	curcumin, demethoxycurcumin and bisdemethoxycurcumin	polyphenols	Anti-cancer activity	progress clinical trials	Jurenka et al., 2009
Curcuma longa L.	turmerone, atlantone, and zingiberone	sesquiterpenoids	anti-cancer activity	progress clinical trials	Jurenka et al., 2009
Zingiber officinale Roscoe	[6]-gingerol	phenolic compounds	cytotoxic, apoptotic, anti-cancer activity	cell culture, animal study	Aggarwal et al., 2008
Zingiber officinale Roscoe	pungent vallinoids, viz. [6]-gingerol and [6]-paradol, shogaols, zingerene	phenolic compounds	cancer preventive activity	in experimental carcinogenesis	Shukla et al., 2007
Zingiber zerumbet Smith.	zerumbone [2,6,9,9-tetramethyl-(2E,6E,10E)-cycloundeca-2,6,10-trien-1-one]	phenolic compounds	cytotoxic, apoptotic, anti-cancer activity	cell culture, animal study	Aggarwal et al., 2008

Table 37. Zingiberaceae Cytotoxic Phytochemicals

Zygophyllaceae R. Brown

A family of 26 genera and 280 tropical species. Small trees, shrubs to herbs with stems often sympodial and jointed at the nodes, xylem with vessels, tracheids, and fibers arranged in horizon tally aligned tiers; usually producing steroidal or teriterponoid saponins, sesquiterpenes and alkaloids (Evans 2009; Judd et al., 2008; Mabberley 2008).

Species	Compound	Class of Compound	Effect	Status	Ref.
Larrea divaricata Cav.	nordihydroguaiaretic acid	phenolic compounds	anticancer, antioxidant, antimicrobial, anti-inflammatory and immunosuppressive activities	phase I/II clinical trials as an anticancer agent	Chen et al., 2009

Table 38. Zygophyllaceae Cytotoxic Phytochemicals

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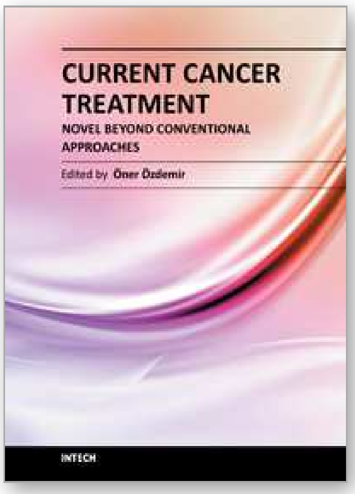

Current Cancer Treatment - Novel Beyond Conventional Approaches
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Currently there have been many armamentaria to be used in cancer treatment. This indeed indicates that the final treatment has not yet been found. It seems this will take a long period of time to achieve. Thus, cancer treatment in general still seems to need new and more effective approaches. The book "Current Cancer Treatment - Novel Beyond Conventional Approaches", consisting of 33 chapters, will help get us physicians as well as patients enlightened with new research and developments in this area. This book is a valuable contribution to this area mentioning various modalities in cancer treatment such as some rare classic treatment approaches: treatment of metastatic liver disease of colorectal origin, radiation treatment of skull and spine chordoma, changing the face of adjuvant therapy for early breast cancer; new therapeutic approaches of old techniques: laser-driven radiation therapy, laser photo-chemotherapy, new approaches targeting androgen receptor and many more emerging techniques.