Traditionally Used Medicinal Plants with Anticancer Effect: A Review

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ABSTRACT

Cancer is the second major cause of death after cardiovascular diseases. It is a group of many closely related diseases. Several synthetic drugs are used to cure this disease but they have their toxicity and hence a number of research activities is going on to investigate the natural plant derived chemotherapeutic agents. More than 50% of modern drugs in clinical use are of natural agents. In recent years owing to the concern of side effects people prefer more and more use of natural plant products for cancer. For these reasons, World Health Organization (WHO) supports the use of traditional medicines which are efficacious and less toxic compared with conventional agents. The basic aim of this review is to highlight on the potential of newly discovered anticancer compounds from traditional medicinal plants to be used as leads for anticancer drug development. 85 different plant sources have been listed in the present review along with the phytoconstituents present in these plants possessing anticancer potential. The present paper is a comprehensive review of different literature sources. It will be helpful to explore the medicinal value of the herbal plants against the cancer and for the new drug discovery from them for the researchers and scientists around the world.

Keywords: Cancer, Side Effects, Anticancer Properties, Medicinal Plants, Phytoconstituents.

INTRODUCTION

Cancer is a general term which causes a series of malignant diseases that may affect different parts of the body. These diseases are characterized by a rapid and uncontrolled formation of abnormal cells. Cancer harms the body when damaged cells divide uncontrollably to form lumps or masses of tissue called tumors (except in the case of leukemia where cancer prohibits normal blood function by abnormal cell division in the blood stream). Tumors can eventually grow and interfere with the digestive, nervous, and circulatory systems and can release hormones that alter body function. Tumors that stay at one site and demonstrate limited growth are usually considered to be benign. When a tumor successfully spreads to other parts of the body and grows, invading and destroying other healthy tissues, it is said to be metastasized. Metastasis is the most lethal aspect of carcinogenesis.

Cancer is known to be the second most common cause of death. In 2012, there were 14.1 million new cancer cases, 8.2 million cancer deaths and 32.6 million people who live with cancer (within 5 years of diagnosis) reported by IARC worldwide. Treatment options, depending on the stage and type of cancer, include: Surgery, Radiation therapy, Chemotherapy, Biological therapy, Hormone therapy etc. Chemotherapy can sometimes cause side effect like fatigue, sleep disturbance, appetite loss, hair loss, sore mouth, changes in taste, fever and infection, anxiety, depression, nausea, and vomiting. Moreover, during the last decade, novel synthetic chemotherapeutic agents currently in use clinically have not succeeded to fulfill expectations despite the considerable cost of their development. Therefore, there remains a constant demand to develop new, effective, and affordable anticancer drugs.¹

In recent years there has been an increased trend in the use of medicinal plants in the developing countries because of their safety and less adverse effect especially when compared with synthetic conventional drugs. Till now NCI had investigated more than 35,000 plant species which resulted in the discovery of anticancer drugs such as Vincristine, Vinblastine, Taxol, Etoposide analogs, Indicine—N-oxide, Camptothecin and analogs and many others. With the knowledge of available traditional medicine, a new approach could be adopted which combine some or all of above methods.² Paclitaxel (Taxol TM) was originally isolated from Taxus brevifolia used in treatment of ovarian and breast cancers which

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was assumed to bind the tubulin subunit of microtubules and stabilizes the microtubule to normal disassembly. Herbs these days are also being used as chemoprotectant against cytotoxicity that are caused by anticancer drugs. So, this present review aimed at exploring the potential anticancer compounds from the medicinal plants.

The Mechanism on Cancer Therapy:

1. Inhibiting cancer cell proliferation directly by stimulating macrophage phagocytosis and enhancing natural killer cell activity.

2. Promoting apoptosis of cancer cells by the increase of production of interferon, interleukin-2 immunoglobulin and complement in blood serum.

3. By enhancing the number of leukocytes and platelets by stimulating the hemopoietic function.

4. By enforcing the necrosis of tumor and inhibiting its translocation and spread by the blockage of blood source of tumor tissue.

5. Promoting reverse transformation of tumor cells into normal cells.

Advantages of Herbal Drugs Over Conventional Drugs

Folk medicines of natural origin have been used for centuries in every culture all over the world. Scientists and medical professionals have shown increased interest in this folk medicine area as they recognized the true health benefits of these remedies. A herb (also called a botanical) is a plant or part of plant used for its scent, flavor, and / or therapeutic properties. Products that are made from botanicals used to maintain or improve health have been called herbal supplements, botanicals, or phytomedicines.

Common reasons for use of herbal medicines include health promotion, disease prevention, poor outcomes and limited treatment options for a serious illness, exhaustion of conventional therapies, dissatisfaction with, or inefficacious conventional therapies, fatal side effects or risks associated with conventional medicine, belief that herbal and natural products are better or safer, preference for personal involvement in the decision making process, and cultural or spiritual preference. Whereas side effects of allopathic medications vary wildly from mild to severe and there are many. These may include insomnia, vomiting, fatigue, dry mouth, diarrhea, constipation, dizziness, suicidal thoughts, hostility, depression, mania, seizures, coma, anemia, hair loss, high blood sugar, shoplifting, swelling, impotency, panic attacks, confusion, fainting and death.

The increasing costs of conventional cancer treatments (chemotherapy and radiation) and the lack of effective drugs to cure solid tumors encouraged people from different countries to depend more on folk medicine which is rooted in medicinal plants use. Of over 2069 anti-cancer clinical trials recorded by the National Cancer Institute as being in progress as of July 2004, over 160 are drug combinations including these agents against a range of cancers.

In view of the complications of the therapies that are currently considered for cancer, high costs of conventional cancer therapies, and growing evidence of cancer in both developed and developing countries, it seems necessary to develop more novel approaches with higher efficiency so that the disease intensity could be declined. In this regard, there is considerable scientific and commercial interest in the development of new anticancer agents from natural sources and the research aimed to develop new anticancer drugs has been turned into a significant research area. In fact, naturally derived combinations have been considered under pharmacists' focus to synthesize new drugs and treat diseases due to availability, less frequent side effects and drug interactions, and cheapness. Herbal therapies although, still an unwritten science is well established in some cultures and tradition and have become a way of treatment in almost 80% of the people in rural areas, especially those in Asia, Latin America and Africa.

MEDICINAL PLANTS WITH ANTICANCER ACTIVITY

Plants are the chief source of natural products that are commonly and successfully used in medicine. Populations, who consume a high level of natural herbal products, generally have a declined incidence of cancer. There is lately great interest in screening for plants to be used in cancer prevention and treatment. The present study is focused to screen some traditionally used medicinal plants for available anticancer effect. Few types of plants species present are listed and detailed (common names, plant type, family, part used, active constituents, mechanism of action, type of cancer treated) below (Table 1).

CONCLUSION

From the present review, it can be concluded that herbal medicinal plants and their derivatives are active against various type of cancers like lymphomas, breast, ovarian, lung, liver, stomach, prostate and testicular cancers. The cheap herbal medicinal treatment which may highly be recommended to the rural and poor people especially of developing countries to treat effectively the cancers of different type is an ideal choice. The investigated traditional medicinal plants in this article could be a key to identify the compounds with anti-cancer effects; therefore, if their compounds are examined, they might help to develop new, more efficient drugs, in addition to contributing to identify the main mechanisms involved in cancer.
### Table 1: Anticancer medicinal plants

| Sr. No. | Scientific Name            | Common name         | Plant Type | Family          | Part(s) Used | Important Compounds                                                                 | Mechanisms                                                                                                                                                                                                 | Types of Cancer treated                                                                 |
|---------|----------------------------|---------------------|------------|----------------|-------------|-------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| 1.      | *Ferula assa-foetida*      | Asafoetida - Devil’s Dung | Herb       | Apiaceae       | Shoot, resin | Coumarin compounds (especially sesquicoumarins), sulfur-containing compounds, and b-sitosterol and oleic acid | Inhibition of mutagenesis, DNA destruction and cancer cells proliferation; increase of proteolytic enzymes activity                                                                 | Liver cancer 9                              |
| 2.      | *Thymus vulgaris*          | Thyme               | Sub shrub  | Lamiaceae      | Shoot       | Thymol and carvacrol                                                                 | Cell cycle arrest                                                                                                                          | Prostate cancer 10, Head cancer 11            |
| 3.      | *Thymbra spicata*          | Mediterranean thyme | Shrub      | Lamiaceae      | Shoot       | Thymol and carvacrol                                                                 | Inhibition of DNA destruction                                                                                                                | Lung cancer 12                               |
| 4.      | *Taverniera spartea*       | Aelijaan            | Shrub      | Fabaceae       | Shoot       | Isoflavonoid compounds and saponins                                                   | Induction of necrosis and apoptosis                                                                                                          | Breast and prostate cancer 13               |
| 5.      | *Peganum harmala*          | Harmel              | Herb       | Nitrariaceae    | Seed        | Alkaloids                                                                            | Induction of apoptosis (by caspase activation and increase of proteolytic enzymes activity)                                                  | Breast cancer (Both in vitro and in vivo) 14, cervix cancer 15,16 |
| 6.      | *Viola tricolor*           | Heartsease          | Herb       | Violaceae      | Shoot       | Flavonoids (especially rutin and quercetin)                                          | Cell cycle arrest                                                                                                                          | Cervix cancer 16                            |
| 7.      | *Achillea wilhelmsii*      | Allheal, bloodwort  | Herb       | Asteraceae     | Shoot       | Phenolic compounds (especially flavonoids and monoterpenes such as 1,8-cineole and a-pinene) | Induction of apoptosis                                                                                                                      | Colon cancer 17                             |
| 8.      | *Mentha pulegium*          | Pennyroyal, squawmint | Herb       | Lamiaceae      | Shoot       | Pulegone, menthone, piperitone, limonene, isomenthone, octen-3-ol                      | Induction of apoptosis                                                                                                                      | Blood cells cancer 18                        |
| 9.      | *Ammi visnaga*             | Bisnaga             | Herb       | Apiaceae       | Shoot       | Visnadine, cimifugin, khellol, b-sitosterol, kaempferol, quercetin                   | Cell cycle arrest                                                                                                                          | Breast cancer 19                            |
| 10.     | *Camellia sinensis*        | Tea plant           | Shrubs or small trees | Theaceae | Leaf | Epicatechin, epigallocatechin, epigallocatechin-gallate, epigallocatechin-3-gallate | Inhibition of cancer cells proliferation (by inhibit of 5-a reductase enzyme activity)                                                   | Lung, bladder, skin, prostate and breast cancer (Both in vitro and in vivo) 20                  |
| 11.     | *Avisennia marina*         | Grey mangrove       | Shrub or tree | Acanthaceae | Leaf | Flavonoids (especially naphthoquinoine compounds such as 3chlorodeoxylapachol)       | Antioxidant effects; induction of apoptosis                                                                                                   | Breast, larynx cancer 21,22                  |
| 12.     | *Silybum marianum*         | Cardusmarianus      | Herb       | Asteraceae     | Seed        | Flavonoids (especially silymarin)                                                    | Antioxidant effects; cell cycle arrest                                                                                                | Colorectal cancer and colon cancer (Both in vitro and in vivo) 23, breast cancer 24             |
| 13.     | *Artemisia absinthium*     | Wormwood            | Herb       | Asteraceae     | Root, Shoot | Artemisinin, quercetin, isorhamnetin, limonene, myrecene, linalool, a-pinene, b-pinene, artemesinate | Inhibition of cancer cells proliferation (decrease in response to nuclear receptors); inhibition of angiogenesis and cell migration; induction of apoptosis | Colon 25, blood cells cancer 26              |
| 14.     | *Curcuma longa*            | Turmeric             | Herb       | Zingiberaceae  | Rhizome     | Curcumin                                                                             | Inhibition of cancer cells proliferation (by adjusting gene expression); inhibition of angiogenesis; induction of apoptosis | Leukemia, glioblastoma and colon cancer (In vitro) 31, Lung 28,29, Breast 28, prostate 30, cervix 13 and larynx 12 cancer |

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| Sr. No. | Scientific Name | Common name | Plant Type | Family | Part(s) Used | Important Compounds | Mechanisms | Types of Cancer treated |
|--------|----------------|-------------|------------|--------|-------------|---------------------|------------|------------------------|
| 15.    | *Crocus sativus* L | Saffron crocus | Herb | Iridaceae | Stigma | Phenolic compounds (especially quercetin), Crocetin, picrocrocin, and safranal | Inhibition of cancer cells proliferation (inhibits DNA synthesis) | Sarcoma and oral cancer (Both *in vitro* and *in vivo*), breast, colon, liver cancer |
| 16.    | *Zingiber officinale* | Ginger | Herb | Zingiberaceae | Rhizome | Flavonoids (especially kaempferol, catechin, fisetin, and quercetin) | Induction of apoptosis | Ovary, cervix, colon, liver and urinary cancer (*in vitro* and *in vivo*), prostate cancer |
| 17.    | *Olea europaea* | Olive | Tree or Shrub | Oleaceae | Leaf, fruit | Oleic acid, pinoresinol, oleuropein, acidic triterpenes, oleanolic acid, maslinic acid | Inhibition of cancer cells proliferation (inhibition of HER2 gene expression); inhibition of angiogenesis; induction of apoptosis | Breast, colon cancer |
| 18.    | *Taxus baccata* L | Yew | Tree | Taxaceae | Leaf | Taxol, cabazitaxel, batatasaxetol | Cell cycle arrest | Prostate cancer (*in vivo*), Breast, bladder and pancreatic cancer (*in vivo*), cervix and blood cells cancer |
| 19.    | *Nigella sativa* | Black cumin | Herb | Ranunculaceae | Seed | Thymoquinone, dinitroquinone | Cell cycle arrest; induction of apoptosis | Colon, prostate, breast and pancreas cancer |
| 20.    | *Allium sativum* L | Garlic | Bulbous herb | Amaryllidaceae | Fruit | Allicin, ajene | Cell cycle arrest; induction of apoptosis | Lymphoma, cervix cancer (*in vivo*), breast, prostate, colon, larynx cancer |
| 21.    | *Lepidium sativum* | Cress | Herb | Brassicaceae | Shoot | Vitamins (A, B, C and E), isothiocyanate, alilnolenic acid, glucosinolates | Antioxidant effects; cell cycle arrest | Breast and blood cells cancer |
| 22.    | *Trigonella foenumgraceum* L | Fenugreek | Herb | Fabaceae | Shoot | Flavonoids and alkaloids (such as gingerol, cedrene, zingerone, vanillin, and eugenol) | Antioxidant effects; induction of apoptosis | Breast cancer |
| 23.    | *Glycyrrhiza glabra* | Liquorice | Herb | Fabaceae | Root | Glycyrrhizin | Inhibition of cancer cells proliferation (bcl-2 phosphorylation); morphological changes in cancer cells and induction of apoptosis | Prostate, breast, lung, stomach and kidney cancer (*in vivo*), breast, lung cancer |
| 24.    | *Physalis alkekengi* L | Bladder cherry | Herb | Solanaceae | Fruit | Physalins | Induction of apoptosis | Cervix cancer |
| 25.    | *Lagenaria siceraria* Stan dl | Bottle gourd | Herb | Cucurbitaceae | Shoot, fruit | Vitamins (B group and C), sapoins, cucurbitacin | Cell cycle arrest | Lung and breast cancer |
| 26.    | *Ferula gummosa* | Galbanum | Herb | Aplineae or Umbelliferae | Shoot | Sesquiterpenes and coumarins | Inhibition of cancer cells proliferation (distribution in the biosynthesis of nucleic acids and proteins); decrease of cells viability (increase of reactive oxygen species production); induction of apoptosis (by activation of caspases) | Lung, skin, stomach cancer |
| 27.    | *Urtica dioica* L | Common nettle | Herb | Urticaceae | Leaf | Phenolic compounds | Antioxidant effects; cell cycle arrest | Prostate cancer |
| 28.    | *Ammi majus* | Bishop’s weed | Herb | Aplineae | Shoot, seed | Coumarin compounds (especially psoralens) | Cell cycle arrest; induction of apoptosis | Breast cancer |
| Sr. No. | Scientific Name       | Common name         | Plant Type       | Family            | Part(s) Used | Important Compounds                                                                 | Mechanisms                                                                 | Types of Cancer treated                  |
|--------|-----------------------|---------------------|------------------|-------------------|-------------|-------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|------------------------------------------|
| 29     | Rosa damascene        | Damask rose         | Deciduous shrub  | Rosaceae          | Petal       | Phenolic compounds (such as gallic acid, catechin, and epicatechin)                  | Antioxidant effects; DNA protection                                             | Lung\(^64\), breast\(^64\), cervix\(^67\) cancer |
| 30     | Astragalus cystosus   | Milkvetch           | Herb or small shrub | Fabaceae          | Shoot       | Lectins, flavonoids and terpenoids                                                   | Cell cycle arrest; induction of apoptosis                                         | Lung\(^68\) cancer                       |
| 31     | Myrtus communis       | Common myrtle       | Shrub            | Myrtaceae         | Leaf        | Polyphenols, myrtycummuloine, semimyrtcummuloine, 1,8-cineole, a-pine, myrtenyl acetate, limonene, linalool, aterpinolene | Antioxidant effects, induction of apoptosis (DNA fragmentation and activation caspases) | Breast\(^63,70,71\), cervix\(^72\) cancer |
| 32     | Vinca rosea           | Madagascar periwinkle | Herb             | Apocynaceae       | Shoot       | Vincristine, vindoline, vinfunine, vinblastin, catharantin                           | Antioxidant effects; inhibition of cancer cells proliferation (effect on microtubules) | Breast and larynx cancer\(^70\)          |
| 33     | Citrullus colocynthis | Bitter apple        | Herb             | Cucurbitaceae     | Fruit       | Cucurbitacin, quercetin, b-sitosterol                                               | Cell cycle arrest; induction of apoptosis                                         | Liver cancer\(^72\)                     |
| 34     | Polygonum aviculare   | Common knotgrass    | Herb             | Polygonaceae      | Shoot       | Tannins, saponins, flavonoids and alkaloids                                         | Antioxidant effects; cell cycle arrest; induction of apoptosis                    | Breast\(^73\), cervix\(^74,75\) cancer |
| 35     | Astroudaucus orientalis | -                   | Herb             | Apiaceae          | Root, shoot | a-pine, a-thujene, a-copaene, fenchylacetate, myrecene, sabine                      | Cell cycle arrest; induction of apoptosis                                         | Breast\(^76\) cancer                    |
| 36     | Actinidia chinensis   | Kiwi fruit, China gooseberry | Tree             | Actinidiaceae     | Root        | Polyvaccharide known as “ACPSR”                                                     | Inhibition of prostaglandin E receptor 3 (EP3) expression\(^77\)                | Hepatocellular carcinoma\(^77\)         |
| 37     | Aegle marmelos        | Bael                | Tree             | Rutaceae          | Stem bark   | Lupeol                                                                               | Cell cycle arrest\(^78\)                                                         | Breast cancer, malignant lymphoma, malignant ascites, malignant melanoma, leukaemia |
| 38     | Agave americana       | Century plant       | Herb             | Agavaceae         | Leaf        | Steroidal saponin, alkaloid, coumarin, isoflavonoid, hecogenin and Vitamins, (A, B, C) | Cytotoxic and antitumor activity                                                 | Cancerous tumor                          |
| 39     | Aloe vera             | Aloe                | Herb             | Asphodelaceae     | Leaf        | Aloe-emodin                                                                           | activates the macrophages, enhances activity of the immune cells against cancer\(^79\), inhibit metastases\(^80\) | Leukemia, stomach cancer (In vivo)\(^81\) |
| 40     | Alpinia galanga       | Thai ginger          | Herb             | Zingiberaceae     | Rhizome     | Acetoxy-chavicol-acetate (ACA), Pinocembrin, Galangin                                | Arrests cell proliferation and induces apoptosis, possesses strong antioxidant, antimutagenic and anti-inflammatory properties | Breast, lung, stomach, colon, prostate cancer, multiple myeloma, leukaemia |
| 41     | Amoora rohituka       | Rohituka tree        | Tree             | Meliaceae         | Stem bark   | Amooranin (a triterpene acid)                                                       | Arrests G2/M phase of the cell cycle and induces apoptosis                      | Breast and cervical cancers, colon cancer Lymphocytic leukemia (In vitro)\(^82\) |
| 42     | Andrographis paniculata | King of Bitters     | Herb             | Acanthaceae       | Whole plant | Flavonoids and labdanediterpenoids, Andrographolid                                  | Stimulates cytotoxic and potent immune stimulating activity                      | Colon cancer (Both in vitro and in vivo)\(^83\)            |
| Sr. No. | Scientific Name    | Common name | Plant Type | Family      | Part(s) Used                  | Important Compounds | Mechanisms                                                                                                                                                                                                 | Types of Cancer treated                                                                                           |
|--------|-------------------|-------------|------------|-------------|-------------------------------|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| 43     | Annona muricata   | Graviola    | Tree       | Annonaceae  | Fruit, seeds, leaves, and bark| Acetogenins        | Blocks production of adenosine triphosphate allowing chemotherapy to be more effective, inhibits NADH oxidase and blocks ATP production in mitochondria limiting the ability of cancer cells to grow. | Lung, solid human-breast cancer, tumor carcinoma, pancreatic carcinoma, prostatic adenocarcinoma, colonic adenocarcinoma, human lymphoma, liver cancer and multiple-drug resistant human-breast adenocarcinoma |
| 44     | Apis mellifera    | European honey bee | Not applicable | Apideae | Not applicable | Protein | Stimulates tumor necrosis factor-alpha (TNF-α), inhibits of cell proliferation, induces of apoptosis, and cell cycle arrest.                                                                                   | Renal, lung, prostate, bladder, melanoma, osteosarcoma, mammary and lymphoid cancer.                                                                                       |
| 45     | Ananas comosus    | Pineapple   | Herb       | Bromeliaceae | Stem | Bromelain | Enhances cytotoxic activity of the monocytes and the macrophages inhibiting growth of cancer, inhibits growth of cancer cells, induces caspase-dependent apoptosis and causes cleavage of p53, removal of MUC1, and attenuation of phospho-Akt and Bcl2. | Leukaemia, gastrointestinal carcinoma, Cholangiocarcinoma, tongue cancer.                                                                                                |
| 46     | Angelica sinensis | Female ginseng | Herb       | Apiaceae   | Root | Polysaccharide known as “AR-4” | Induction of interferon production, stimulation of the immune cell proliferation and enhancement of antitumour activity of the immune cell and cell cycle arrest and apoptosis. | Cervix cancer, brain tumor, colorectal carcinogenesis, Glioblastomatousmultiforme.                                                                                   |
| 47     | Annona species    | Monkey species | Trees or shrubs | Annonaceae | Leaves | Acetogenins | Exhibit different level of cytotoxicity, show anti-metastatic features, induce apoptosis                                                                                                                      | Leukemia and sarcoma, nasopharyngeal carcinoma.                                                                                                                             |
| 48     | Arctium lappa     | Greater burdock | Herb       | Asteraceae  | Seeds, root, fruit, leaves   | Arctigenin, Lappaol F | Prevents mutations in the oncogenes, reduces the size of tumour, relieves the pain and prolongs the survival period, arrests cell cycle at G1 and G2 phases and induces apoptosis. | Malignant melanoma, lymphoma and cancers of the pancreas, breast, ovary, oesophagus, bladder, bile duct and the bone, lung, cervix, prostate cancer and leukemia, liver cancer. |
| 49     | Artemisia asiatica | Not specified | Hardy herb or shrub | Asteraceae | Aerial parts and leaves | Isoliquiritigenin | Restrains the cell cycle progression at G2/M phase, enhances the expression of p21CIP1/WAF1, a universal inhibitor of cyclin-dependent kinases (CDKs) and induces apoptosis.                  | Liver tumor, skin tumor, lung cancer.                                                                                                                                          |
| 50     | Astragalus membranaceus | Astragalus | Herb       | Fabaceae   | Root | Swainsonine | Prevent metastases                                                                                                                                          | Liver cancer, gastrointestinal cancers.                                                                                                                                     |
| 51     | Azadirachta indica | Neem         | Tree       | Meliaceae  | Leaves and flowers | Liminoids and Nimbolide | Inhibits growth and spread of various cancers by inducing apoptosis, prevents metastasis, effect activates tumour suppressor gene and inhibits VEGF and phosphoinositols PISK/Akt pathways, suppression of NF-κB signaling, and cyclooxygenase pathway. | Breast, lung, stomach, prostate and skin cancer, colon cancer, prostate cancer, malignant lymphoma, malignant melanoma and leukaemia. |
| Sr. No. | Scientific Name      | Common name          | Plant Type | Family            | Part(s) Used             | Important Compounds                                                                 | Mechanisms                                                                                     | Types of Cancer treated                                                                 |
|---------|----------------------|----------------------|------------|-------------------|--------------------------|---------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|
| 52.     | Bauhinia variegata   | Mountain ebony       | Tree       | Caesalpiniaeae    | Flower, leaf, stem bark  | Cyanidinglucoside, malvidinglucoside, peonjinglucoside and kaempferolgalactoside       | Inhibit growth and spread of various cancers                                      | Cancers of breast, lung, liver, oral cavity, melanoma, liver tumor, larynx cancer and human breast |
| 53.     | Berberis vulgaris    | Common barberry      | Shrub      | Berberidaceae     | Roots stem and bark      | Berberine, berbamine, chelidonic acid, oxycaanthine and palmatine                      | Arrests cancer cell cycle in G1-phase and induces apoptosis increases the penetration of some chemotherapy drugs through the blood-brain barrier | Prostate cancer, liver cancer and leukaemia, intracranial tumours breast cancer, stomach and oral cavity cancers, colon cancer |
| 54.     | Betula alba          | Birch                | Tree       | Betulaceae        | Leaves                   | Betulinic Acid                                                                      | Kill cancerous cells, induces antiproliferative effect, decreases cancer cell motility and induces apoptotic cell death, also decreases bc2 and cyclin D1 genes expression, and increased bax gene expression.         | Prostate cancer, Human melanoma xenografts and leukemia (In vitro), neuroblastoma, rabdomyosarcoma, medulloblastoma, glioma, thyroid, breast, lung and colon carcinoma |
| 55.     | Betula utilis        | Himalayan birch      | Tree       | Betulaceae        | Bark                     | Betulin, ursolic acid (UA)                                                          | Apoptotic                                                                    | Liver and the lung cancer, breast cancer, melanomas                             |
| 56.     | Bolbostemma paniculatum | Tu Bei Mu           | Herb       | Cucurbitaceae     | Stem tuber               | Tubeimoside-V                                                                      | Apoptotics, exhibits promised cytotoxic activity which may be linked to the inhibition of DNA synthesis and may induce phenotypic reverse transformation of tumor cells. | Globlastoma cells                                                                     |
| 57.     | Cannabis sativa      | Marijuana            | Herb       | Cannabaceae       | Leaf                     | Cannabinoids, stereo isomers ofcannabidiol                                          | Anti-tumor activity by modulating key cell-signaling pathways | Breast cancer, brain tumors, Lung, pancreas, prostate and colorectal cancer (Both - in vitro and in vivo) |
| 58.     | Catharanthus roseus  | Madagascar periwinkle| Herb or Sub shrub | Apocynaceae | Bark, leaves | Vinblastine, vincristine  | Inhibits formation of mitotic spindle in the metaphase that arrests division of the cancerous cells | Hodgkin's disease, non- Hodgkin's lymphoma, pancreas, testis, breast, lung, bladder and the cervix cancer, acute lymphocytic leukaemia, Wilm's tumour, neuroblastoma, rhabdomyosarcoma, Ewing's sarcoma, lymphoma |
| 59.     | Cinnamomum cassia    | Chinese cinnamon     | Tree       | Lauraceae         | Bark                     | Coumarin                                                                             | Decreases lipid peroxidation, inhibits of bacteria, such as Helicobacter pylori, that facilitate the invasion and progression of cancer, exhibits potent antiproliferative effect, modulates cancer cell survival pathways, reduces the levels and activities of NFkB and AP1 and their target genes such as Bcl-2 and Bcl-xL. | Promyelocytic leukaemia, liver cancer, prostate and breast cancer, cervical carcinoma, colorectal carcinoma, epitheloid cervix carcinoma, glioblastoma multiform tumor, lymphoblast lung, oral cancer, basal cell carcinoma. |
| 60.     | Colchicum luteum     | Yellow colchicum     | Herb       | Liliaceae         | Not specified            | Colchicines                                                                          | Shows antimitotic activity                                                          | Hodgkin lymphoma, myeloid leukemia and skin cancers                               |
| 61.     | Combretum caffrum    | Cape bush-willow     | Tree       | Combretaceae      | Bark, kernal and fruit    | Combretastatin                                                                       | Inhibits blood supply to the tumour,                                              | Colon, and leukemia and lung cancer (In vivo)                                     |
| Sr. No. | Scientific Name      | Common name | Plant Type | Family       | Part(s) Used | Important Compounds                        | Mechanisms                                                                 | Types of Cancer treated                                      |
|--------|----------------------|-------------|------------|--------------|--------------|--------------------------------------------|--------------------------------------------------------------------------|------------------------------------------------------------------|
| 62.    | Coriandrum sativum   | Coriander   | Herb       | Apiaceae     | Root, leaves | Beta-carotene, quercetin and rutin          | Helps to remove free radicals, antiproliferative activity and inhibition of metastasis | Breast adenocarcinoma, Colon Cancer                               |
| 63.    | Daphne mezereum      | Mezereum    | Shrub      | Thymelaeeaceae | Leaves       | Mezerein                                   | Exhibits a potent antileukemic activity                                 | Lymphocytic leukemia, Lung cancer                                |
| 64.    | Echinacea angustifolia | Herb        | Astersaceae | Whole plant  |              | Arabinogalactan                           | Activates the macrophages                                               | Carcinoma of the oesophagus and thecolon                          |
| 65.    | Emblica officinalis  | Amla        | Herb       | Phyllanthaceae | Fruit        | Emblicanin A and B, quercetin              | Inhibits mutations in genes, repairs chromosomal abnormalities, inhibits growth and spread of various cancers | Breast, uterus, pancreas, stomach, liver cancer and malignant ascies |
| 66.    | Fagopyrum esculentum | Buckwheat   | Herb       | Polygonaceae | Seeds        | Amygdalin, rutin, Buckwheat inhibitor-1 protein | Produces cyanide that kills the cancerous cells                           | T-acute lymphoblastic leukemia (T-ALL) cells (in vitro)            |
| 67.    | Ginkgo biloba        | Kew tree    | Tree       | Ginkgoaceae  | Leaves       | Ginkgetin and Ginkgolides (A and B)        | Induces apoptosis                                                        | Invasive oestrogen-receptor negative breast cancer, gliblastoma multiforme, and cancers of ovary, colon, prostate and liver |
| 68.    | Glycine max          | Soybean     | Herb       | Fabaceae     | Seeds        | Genistein and daidzein                     | Inhibits of cancer cell proliferation, promotes cell differentiation and induces of apoptosis, blocks angiogenesis, acts as a tyrosine kinase inhibitor | Breast, uterus, cervix, lung, stomach, colon, pancreas, liver, kidney, prostate, testis, oral cavity, larynx, skin cancer, malignant lymphoma, rhabdomyosarcoma, nasopharyngeal carcinoma, malignant brain tumours and leukaemia |
| 69.    | Gossypium hirsutum   | Upland cotton | Shrub, Subshrub, Tree | Malvaceae | Whole plant | Gossypol                                   | Possesses antitumor properties on many cytosolic and mitochondrial enzyme systems that is fundamental for tumor cell growth | Colon, lung, prostate, breast, brain cancer, melanoma, endometrial, adrenocortical cancer |
| 70.    | Indigofera tinctoria | True indigo | Shrub       | Fabaceae     | Leaf         | Flavonoids, saponins, tannins, phenols and anthroquinone | Antioxidant and cytotoxic activity, cell cycle arrest                  | Lung cancer                                                      |
| 71.    | Lentinus edodes      | Shiitake    | Fungus     | Polyporaceae | Fruiting bodies | Lentinan, terpenoids and steroids           | Stimulates increased production and activity of natural killer cells and macrophages, which destroy tumor cells possess hypolipidemic and antithrombotic activity | Lung carcinoma, Colon cancer                                      |
| 72.    | Linum usitatissimum  | Flax        | Herb       | Linaceae     | Seeds        | Lignans                                    | Lignan metabolites bear a structural similarity to estrogens and can bind to estrogen receptors and inhibit the growth of estrogen-stimulated breast cancer | Breast cancer                                                   |
| 73.    | Nothapodytes foetida | Nothapodyes Tree | Tree   | Icacinaceae | Barks and heartwood | Acetylcamptothecin, Camptothecin, ScoopoletinCamptothecin | Inhibits DNA topoisomerase found in cancerous cells, halts the process of mutation and development of the cancer cells | Colon cancer                                                    |
| Sr. No. | Scientific Name       | Common Name           | Plant Type | Family               | Part(s) Used        | Important Compounds                                                                 | Mechanisms                                                                                       | Types of Cancer treated |
|-------|-----------------------|-----------------------|------------|----------------------|---------------------|-------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------------------|
| 74.   | Ocrosia elliptica     | Elliptic yellowwood   | Tree       | Apocynaceae          | Leaves              | Ellipticine and 9-methoxy ellipticine                                                | Lipophilic derivatives of ellipticine act by binding to the DNA                                   | Breast and the kidney cancer |
| 75.   | Ocimum sanctum        | Tulsi                  | Herb       | Lamiaceae            | Leaves              | Eugenol, orientin, cirsinole, Ursolic acid cismaritin, Caryophyllene, camphor         | Blocks supply of oxygen and nutrients to the cancer cells and kills them by starving             | Breast cancer, liver cancer, tissue-protective, fibrosarcoma, Sarcoma-180 solid tumor |
| 76.   | Oldenlandia diffusa   | Snake-Needle Grass     | Herb       | Rubiaceae            | Stem bark, leaves, fruit peel | Oldenlandosides, stigmasterol, usoric acid,                                        | Works by a typical cytotoxic effect on cancer cells and by inducing apoptosis                        | Ovary, lung, uterus, stomach, liver, colon, rectum, brain and leukaemia |
| 77.   | Origanum vulgare      | Oregano                | Herb       | Lamiaceae            | Whole plant         | Rosmarinic acid                                                                    | Exerts a modulatory role on tissue lipid peroxidation, induced apoptosis by increasing BAX levels, decreasing BCL2 expression | Colon cancer, breast cancer, lung cancer, human skin cancer, liver cancer, stomach cancer |
| 78.   | Panax ginseng         | Ginseng                | Herb       | Araliaceae           | Root                | Flavonoids, polysaccharides, and polyacetylenes                                    | Inhibits growth of cancer by interfering with the DNA synthesis, regenerates the natural killer cells, stimulates the macrophages | Breast, cervical, bladder, and thyroid cancers, ovaries, larynx, pancreas, esophagus, and stomach cancer |
| 79.   | Pfaffia paniculata    | Suma                   | Herb       | Amaranthaceae        | Roots               | Presents cytotoxic substances                                                      | Shows degeneration of cytoplasmic components and profound morphological and nuclear alterations of cancer cells | Estrogen-positive breast cancer |
| 80.   | Picrorrhiza kurroa     | Kutki                  | Herb       | Plantaginaceae       | Whole plant         | Picrosides-I, II and III and kutkoside                                                | Decreases levels of lipid peroxidases and hydroperoxidases, free radical producing agents, and helps to facilitate the recovery of a powerful antioxidant in the liver | Liver cancer |
| 81.   | Plumbago zeylanica    | Ceylon leadwort        | Herb       | Plumbaginaceae       | Roots               | Plumbagin                                                                           | Inhibits cancer cell proliferation                                                                 | Breast cancer, liver cancer, fibrosarcoma, malignant ascites and leukaemia, skin cancer |
| 82.   | Podophyllum hexandrum  | Himalayan May Apple    | Herb       | Berberidaceae        | Leaves, Rhizome     | Podophyllotoxin and podophyllin                                                   | Inhibits growth and spread of cancers                                                              | Breast, ovary, lung, liver, urinary bladder, testis, brain, neuroblastoma, Hodgkin’s disease, lymphoma and leukaemia |
| 83.   | Prunella vulgaris      | Common self-heal       | Herb       | Lamiaceae            | Whole plant         | Ursolic acid and oleanolic acid                                                      | Inhibits growth and spread of cancers                                                               | Breast, cervix, lung, oral cavity, stomach, colon, thyroid cancer, anti-HIV |
| 84.   | Psoralea corylifolia  | Babchi                 | Herb       | Fabaceae             | Seeds               | Bavachinin, Psoralindencorylentin and pсорalen                                       | Induces apoptosis in both androgen-responsive and androgen refractory prostate cancers             | Lung cancer, liver cancer, osteosarcoma, fibrosarcoma, and leukaemia |
| 85.   | Viscum album          | European mistletoe     | Tree       | Santalaceae          | Sprouts, fruits     | Lectins (such as viscumin), and phenolic compounds (such as digallic acid)          | Induces apoptosis via activation of caspase cascades and anti-angiogenesis activity             | Breast, cervix, ovary, lung, stomach, colon, rectum, kidney, testis cancer |
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