**An Overview on Cancer-Fighting Phytochemicals from Selected Medicinal Plants in Bengal**

**ABSTRACT**

Bengal possesses a diverse gene pool of ethno-botanically important plant species for alternative medicinal agents. Herbal remedies, also known as botanical medicine, have been recognized as a promising complementary treatment for cancer. In this article, we have methodically highlighted and summarized most popular and effective Bengal plants which possess phytocomponents with anti-cancer properties. Several in vitro as well as in vivo studies demonstrated the details of plant derived metabolites and their promising efficacy against different cancer cell lines. Therefore, recapitulated data about the bioactivity of these phytochemicals, with special emphasis on Bengal medicinal plants will enrich our knowledge about developing carefully designed standardized drug in controlling the carcinogenic processes traditionally over conventional therapies to prevent this global health crisis.

**KEYWORDS:** Phytochemicals; Anti-cancer; Medicinal plant; Traditional medicine

**INTRODUCTION**

Cancer remains to be one of the leading causes of mortality worldwide. Though the modern conventional therapeutic approach has indisputably enhanced survival rate, metastasized cancer remains untreatable. Hence, continued searching for more efficient and effective chemoprevention is clearly desirable to improve the treatment [1]. According to an estimation of World Health Organization, 80 % of rural population rely chiefly on medicinal herbs and traditional medicine as a primary healthcare system [2]. In the Ayurveda, numerous plants with medicinal properties are documented in various texts but it requires newer guidelines of standardization, production and quality control. It has been reported that approximately 50% of all modern pharmaceutic in clinical use are plant derived [3]. Many of these have been recognized to have apoptotic activity in various cancer cells of human origin [1]. Any part of a medicinal plant such as seeds, bark, leaves, roots, flowers, fruits can contain some bioactive substances that can be used for therapeutic or medicinal purposes. Phytochemicals are the secondary metabolites that are taxonomically extremely diverse in nature and an excellent reservoir of potential precursors of new drugs based on their modes of pharmacological action [4,5]. Moreover, these bioactive compounds such as flavonoids, terpenoids and alkaloids have received considerable attention for their anti-mutagenic, anti-malignant, antineoplastic and potential chemo preventive...
properties through their effects on signal transduction in cell proliferation and angiogenesis [5].

India is a heritage country in term of natural resources and biodiversity. West Bengal (a state occupies only 2.7% of India's land area) possesses an enormous number of medicinal plants [6]. The tropic of cancer passes almost through the middle of the state. Diverse climatic conditions of West Bengal include a tropical wet-dry climate in the southern part and a humid subtropical climate in the north (http://www.westbengalforest.gov.in). The total forested area of West Bengal is 11879 sq. km. which is 13.38% of the total geographic area of the state (http://www.westbengalforest.gov.in/history.php). At present West Bengal has 23 districts which are distributed in five agro-climatic zones i.e. Darjeeling Himalayan hill region, Tarai – Dooars region, western undulating high land and plateau, north and southern plains of Bengal and Gangetic deltaic regions are favourable to establish the diversity of plants [7]. But unscientific and unorganized harvesting and production of raw materials, lesser concern about quality control, fluctuation in demand and supply, lack of coordination, research and inefficient marketing infrastructure are the main difficulties to promote these therapeutic plants effectively. As per recommendations of the National Medicinal Plant Board (NMPB) as well as West Bengal State Medicinal Plant Board (WBSMPB) some medicinal plant species are recognized for the scientific cultivation in West Bengal. These herbal plants are prioritized because of its vast uses in Indian System of Medicine and Homeopathy (ISM & H). Department of AYUSH (Ayurveda, Yoga, Unani, Siddha and Homeopathy systems) of the Government of India regulates researches on indigenous alternative medicines and their quality control and practices (https://www.ayush.gov.in/). Therefore, scientific cultivation, conservation, suitable maintenance measures regarding harvesting and marketing of medicinal plants may lead to greater success in cancer prevention.

### PLANTS WITH ANTICANCER ACTIVITY

According to previous reports, these medicinal plants contain some important active components i.e. vitamins, carotene, enzymes, minerals, polysaccharides, polyphenols, flavonoids, lignin, xanthones, etc. [Figure 1] which exert potent anticarcinogenic and antimetastatic activities [1]. Plants described in this study are endemic in West Bengal state and also well acknowledged possessing several antioxidants. A significant number of research work has been done about the anticancer efficacy of these plants. Thus, the various combinations of the phytochemicals extracted from these plants may undergo further assessment for their synergistic activity after identification. With the above background, this review article enumerates 20 medicinal plants from West Bengal, according to their suppressive and antiproliferative effect on specific cancer types as well as anti-tumor, antimetastatic and antioxidant properties [Table 1]. We have chosen these plant species based on their availability throughout the state, their popularity among people and last but not the least their significant ability to cure the deadly disease cancer to some extent.

### Table 1: Medicinal Plants with Anticancer Activity

<table>
<thead>
<tr>
<th>Serial No.</th>
<th>Scientific Name with Family</th>
<th>Active Components</th>
<th>Effect in Cancer</th>
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</thead>
</table>
| 1          | *Achyranthes aspera* (Amaranthaceae) | Achyranthine, phenolic compounds | • cytotoxic activity against pancreatic cancer  
• antiproliferative activity against breast and cervix cancer |
| 2          | *Aerva lanata* (Amaranthaceae) | Aervitrin, aervolanine, campesterol, kaempferol | • antiproliferative activity against hepatic cancer cells (Hep3B)  
• induce apoptosis of MCF – 7 cells |

**Figure 1:** Schematic representation of isolation techniques and types of phytochemicals.
<table>
<thead>
<tr>
<th>No.</th>
<th>Plant Name</th>
<th>Phytochemicals</th>
<th>Effects on Cancer Cells</th>
</tr>
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</table>
| 3   | *Allium sativum* (Liliaceae) | Allicin, alliin, allixin, Z-again | • suppress colorectal, lung and esophageal cancers  
• anti-proliferative effects on cancer stem cells of brain malignancies (Glioblastoma multiforme) |
| 4   | *Alstonia scholaris* (Apocynaceae) | Echitamine, alstonidine, alstonin | • cytotoxic activity against human lung cancer cell lines, adenocarcinoma (MOR-P)  
• cytotoxicity against HepG2, HL60, HeLa, KB, MCF-7 cells, Vero cells, fibrosarcoma |
| 5   | *Andrographis paniculata* (Acanthaceae) | Andrographolide, xanthones, stigmasterols | • anti-proliferative activity against HT-29 (colon cancer), KB (human epidermoid carcinoma) cells and P388 (lymphocytic leukaemia)  
• antitumor activity against breast cancer cell lines |
| 6   | *Artemisia indica* (Asteraceae) | Ludartin, lupeol | • strong inhibitory activity against cultured MCF-7, BHY, Miapaca-2, Colo-205 and A-549 cell lines  
• toxic effects on liver cancer cells (HepG2) |
| 7   | *Azadirachta indica* (Meliaceae) | Nimboide,azadirachtins, nimocinol, isomeldenin, azadirachtol, | • anticancer activity in lung cancer, osteosarcoma, neuroblastoma, choriocarcinoma, leukemia and melanoma  
• suppress viability of HeLa cervical cancer cells and breast cancer cells |
| 8   | *Bauhinia variegata* (Fabaceae) | Flavonoids, anthraquinones, saponins | • cytotoxic activity against ovarian cancer cell lines  
• chemo-preventive against human epithelial larynx cancer (HEp2) and human breast cancer (HBL-100) cell lines |
| 9   | *Butea monosperma* (Fabaceae) | Butrin, butein, butin, isobutrin, isocoreopsin | • isocoreopsin exhibits remarkable efficacy in cell mortality on human colon and liver cancer cell lines  
• floral extracts exhibit strong inhibitory activity on HCT-116 cells |
| 10  | *Calotrophis gigantea* (Asclepiadaceae) | Pregnanes, terols, flavonol glycosides, usharin, gigantin, giganteol, giganteol | • antitumor activity of methanol extract  
• anticancer effect against human epidermal carcinoma of the nasopharynx tissue |
| 11  | *Camellia sinensis* (Theaceae) | Epigallocatechin-3-gallate, epigallocatechin, epicatechin-3-gallate, epicatechin | • inhibit tumour cell proliferation of leukaemia cells and hepatocellular carcinoma cell  
• prevent growth of skin tumors |
| 12  | *Cassia fistula* (Leguminosae) | Rhein, emodine, physion, chrysophanol, Obtusin, chrysoobtusin | • remarkable chemopreventive ability  
• tumour inhibitory activity of methanolic extract of seed on the growth of Ehrlich ascites carcinoma |
<table>
<thead>
<tr>
<th>No.</th>
<th>Plant Name</th>
<th>Genus (Family)</th>
<th>Active Components</th>
<th>Anticancer Activities</th>
</tr>
</thead>
</table>
| 13  | **Centella asiatica**      | (Apiaceae)           | Asiatic acid, kaempferol, asiaticosside                                               | - induces apoptosis of MCF-7 breast cancer cells, human melanoma SK-MEL-2 cells and human HepG2 cell line  
- effective antiproliferative activity on skin and lung cancer cells                                        |
| 14  | **Curcuma longa L.**       | (Zingiberaceae)      | Curcumin, demethoxycurcumin, bisdemethoxycurcumin                                   | - activity against melanoma, leukemia, colon, CNS, renal, and breast cancer cell lines  
- inhibits the proliferation of several tumor cells                                                                                                                                                                      |
| 15  | **Emblica officinalis**    | (Euphorbiaceae)      | Pyrogallol, gallic acid                                                              | - cause decrease in HepG2 and H520 cell viability  
- induce apoptosis in Hela (cervical), A549 (lung), MDA MB 231 (breast), SK OV3 (ovarian) and SW620 (colorectal) cell lines                                                                                                                                 |
| 16  | **Oroxylum indicum**       | (Bignoniaceae)       | Baicalein, oroxylin A                                                                | - cytotoxic activity in MDA-MB-435S and Hep3B cell lines  
- anticancer activity when treated against CT-26 colon carcinoma and human breast cancer cells                                                                                                                                 |
| 17  | **Semecarpus anacardium**  | (Anacardiaceae)      | Galluflavanone, phenolic compounds                                                   | - cytotoxic effects against acute myeloblastic leukemia (HL-60), chronic myelogeneous leukemia (K-562),  
- anticancer activity against breast adenocarcinoma (MCF-7) and cervical epithelial carcinoma (HeLa) cell lines                                                                                                                                 |
| 18  | **Syzygium cumini**        | (Myrtaceae)          | Betulinic acid, Kaempferol 7-O-methylether isoquercitin, quercetin                   | - induce apoptosis in human cervical cancer cell lines HeLa, A2780, MCF7, PC-3, H460 and SiHa cell lines  
- pro-apoptotic properties against breast cancer cells                                                                                                                                                                  |
| 19  | **Vitex negundo**          | (Verbenaceae)        | Evn-50                                                                              | - cytotoxic effect on breast cancer, prostate cancer and ovarian cancer  
- broad spectrum cytotoxic activity on hormone dependent as well as hormone independent cancers                                                                 |   |
| 20  | **Withania somnifera**     | (Solanaceae)         | Withaferin A                                                                        | - in-vitro cytotoxicity against A-549 (lung), PC-3 (prostate), HCT-15 (colon), and IMR-32 (neuroblastoma) cell lines.  
- efficient cytotoxicity on MCF-7, A549 and PA-1 cancer cell line                                                                                                                                                  |

**Table 1:** Name of the selected Bengal plants, active components and their role in anticancer studies.
**Achyrantes aspera**

**Family:** Amaranthaceae  
**Parts Used:** Leaf, stem, seed

**Activity:** In traditional medicinal system of Ayurveda *A. aspera* (local name: Apang) is well known for hepatoprotective, diuretic, immunostimulatory and anti-cancer properties [8,9]. *A. aspera*, an annual shrub frequently found in tropical and warmer regions in India reportedly contains fatty acids, oleic acid, triterpenoid based saponins, oleanolic acid, triacontanol, dihydroxy ketones, betaine, achyrantline and various amino acids [10]. The methanol extract of *A. aspera* shows higher quantity of phenolic compounds compared to aqueous extract [9]. It has been reported that leaf extract is used to treat cancer, particularly breast and cervix cancer [10]. Alkaloid extract of leaf induced apoptosis in breast cancer cell through p53 pathways [11]. Several studies demonstrated that the methanolic extract of leaves contains potent antiproliferative and cytotoxic activity against pancreatic cancer cell lines through the inhibition in the expression of pro metastatic and angiogenic genes [8].

**Aerva lanata**

**Family:** Amaranthaceae  
**Parts Used:** Aerial parts

**Activity:** In traditional Ayurvedic medicines, *A. lanata* (local name: Chaya) was found to be effective against several medical conditions for its antihyperglycemic, hepatoprotective, anti-diabetic, anti-urolithiasis, immunomodulatory properties [12]. *A. lanata* extracts have significant amount of biologically active secondary metabolites like polyphenols, flavanoid glycosides, aervitrin, aervolanine, aervoside, aervosporphin, echaitein, chlorogenine, porphyrosine and porphyrine, amyrin betulin, campesterol [12]. Some previous studies proved free radical scavenging activity of ethanol, chloroform and hexane extracts of *A. lanata* leaves [13]. *A. lanata* displays strong antiproliferative activity and induced apoptosis of Hep3B (hepatic cancer cells) cell lines [14]. Previous studies showed that p53 mRNA expression was found to decrease Hep3B cells in a dose dependent manner and induced apoptotic activity when treated with petroleum ether extract of *A. lanata* [14]. The methanolic callus extract of this plant contains potential anticancer property on MCF – 7 cell lines for its significant anti-proliferative activity by induction of the apoptosis in cancer cells. Also the methanol extract of the aerial parts of *A. lanata* has proven to be a source of potent anticancer and antioxidant compounds when treated on Ehrlich Ascites Carcinoma (EAC) cells in Swiss albino mice by monitoring inhibition of tumor cell growth, measurement of tumor weight and survival time of mice [15].

**Allium sativum**

**Family:** Liliaceae  
**Parts Used:** Bulb

**Activity:** *A. sativum* (local name: Rasun) has been attributed in the Indian medicinal system to possess several medicinal effects. The consumption of garlic offers multiple beneficial properties for its chemo-preventive as well as anti-tumor activity [16]. It has been reported that garlic extract contains some organosulfur phytochemicals like diallylthiosulfinate (allicin), S-allylcysteine sulfoxide (alliin), allixin, adenosine, allyl1,5-hexadienyl trisulphide, allyl methyl trisulphide and eight vital amino acids [17]. There is convincing evidence that the consumption of garlic bulb extract reduces the risk of colorectal, lung and esophageal cancers [16]. Studies showed that garlic can also act against stomach cancer by repressing *Helicobacter pylori* [18]. *A. sativum* shows higher free radical scavenging activity also cause cell cycle arrest [17]. It has been found from studies that garlic in several forms can change carcinogen metabolism, reduce formation of carcinogenic products, induce phase II detoxification enzymes including glutathione transferases, quinone reductase, promote apoptosis in cancer cells and inhibit tumour initiation [16]. Several studies demonstrated that the bioactive phytochemicals of garlic modifying the cytokine pattern which leads to an inhibition of a NFkB, a prime regulator of pro-inflammatory gene expression [19]. The immune modulatory activity of garlic shifts a proinflammatory and immunosuppressive cellular environment to an enhanced anti-tumor response which helps in tumorsuppression. Garlic contains two very effective trace metals, germanium and selenium, which have potential therapeutic value in cancer treatment [17]. Researchers hypothesized that the phytocomponents present in garlic evokes anti oxidative, immune-modulating and anti-inflammatory responses which suppress a developing malignancy [18]. Z-again, a component derived from garlic reportedly has a range of biological properties like anti proliferative effects on cancer stem cells (CSC) of brain malignancies like Glioblastoma multiforme (GBM) [18].

**Alstonia scholaris**

**Family:** Apocynaceae  
**Parts Used:** Bark

**Activity:** *A. scholaris* (local name: Saptaparni) is a medicinal plant, whose bark have been pharmacologically proven to possess anticancer properties [20]. It is most extensively used in different cultures and civilizations such as India, in herbal formulations for many years [20]. The bark of this species are rich in alkaloids, steroids, triterpenoids, and flavonoids but it is valued for its alkaloids such as echitamine, alstonidine, alstonin, dita, ditainetlstenovene, echicaoutchin, echicerin, echiretin, porphyrine, echaitein, chlorogenine, porphyrine, and reserpine [21]. The powerful alkaloids of *A. scholaris* protect cells...
from the damage by free radicals [21]. From earlier researches it has been revealed that the methanolic extracts of the root bark possess cytotoxic activity against human lung cancer cell lines, adenocarcinoma (MOR-P), and large cell carcinoma (COR-L23). Studies showed that a hydroalcoholic extract of A. scholaris also has promising antineoplastic effects [22]. The antineoplastic activity of this bark extract from the same tree in vitro study against HeLa cells (cultured human cervical neoplastic cells) showed that the rate of cell mortality was dependent on the season when the plant bark was harvested and the cytotoxic effects were highest in summer (IC50 of 30 µg/ml) [22]. Echitamine, a bioactive phytochemical of bark extract also has cytotoxicity against HepG2, HL60, HeLa, KB, MCF-7 cells, Vero cells, fibrosarcoma, and Ehrlich ascites carcinoma in vitro [23]. Alstonine, another indole alkaloid present in A scholaris, is reported to possess antineoplastic effect [24].

Multiple reports also demonstrated that the triterpenoid lupeol present in A. scholaris induced cell cycle arrests at G1-S phase and is responsible for increase in the expression of p21 protein in PC-3 cells as well as decrease in cyclin D1, cyclin D2, and cdk2 expressions. It has been reported that bioactive bark components reduce the expression of Ras oncoprotein [22]. Additionally, studies revealed that bark extracts downregulate Bcl2, upregulate Bax, activate caspase-3, and induce poly(ADP) ribose polymerase cleavage, and activate caspase-3, -9, and apaf1 genes in CWR22Rnu1 and PC-3 neoplastic cells which lead to apoptosis [22].

**Andrographis paniculate**

**Family:** Acanthaceae  
**Parts Used:** Aerial part

**Activity:** A. paniculate (local name: kalmegh) has been widely recognized as a natural remedy for various physiological disorders. Diversified medicinally active phytochemicals like flavonoids, diterpenoid lactone, xanthones, stigmasterols have been isolated from the extract of A. paniculate [25]. The methanol extract (concentration of 10 µg/mL) of aerial part displays the anti-proliferative activity against HT-29 (colon cancer) cells by 50% but the aqueous extract did not inhibit the proliferation of HT-29 cells [26]. Andrographolide, a diterpenoid, repressed the proliferation of cancer cells promisingly. Previous studies demonstrated that andrographolide exhibited cytotoxic activity against KB (human epidermoid carcinoma) cells and P388 (lymphocytic leukaemia) [26]. Andrographolide 1 (diterpene lactone) of A. paniculate extract also has antitumor activity against breast cancer cell lines and mouse myeloid leukaemia cells [27]. Some recent reports displayed the potential of andrographolide (1) to act as a promising anticancer chemotherapeutic compound as it blocks cell cycle progression by decreasing cyclin-dependant kinase (CDK4) expression [27].

**Artemisia indica**

**Family:** Asteraceae  
**Parts Used:** Leaves, flowering stems

**Activity:** Aerial parts of A. indica (local name: Naagdana) has been reported to have anti-parasitic, hepatoprotective, anti-helminthic and antiseptic properties [28]. It deserves further research into the chemoprevention and anticancer activity [28]. Among the 43 compounds isolated from extracted essential oils (representing 96.6% of the oil), artemisia ketone (42.1%), germacrene B (8.6%), borneol (6.1%) and cis-chrysanthenyl acetate (4.8%) are some major phytoconstituents exhibiting significant cytotoxic and antioxidant activities [29]. Some biological evaluation demonstrated that the essential oil from A. indica leaves have strong toxic effects on liver cancer cells HepG2 [30]. Essential oil extracted from A. indica exhibited significant reduction of cell viability against the HT-29 cells of colon cancer, THP-1 cells of leukaemia, A-549 cell of lung cancer [30]. A strong inhibitory activity of the ethyl acetate extraction of A. indica (having ludartin and lupeol) was reported against cultured human tumor cell lines MCF-7, BHY, Miapaca-2, Colo-205 and A-549. Researchers also revealed that the anti-proliferative effects of ludartin and lupeol as anticancer agents may be due to the significant DNA damage and loss of mitochondrial membrane potential. However, a favourable interaction between the chemicals may be responsible for the overall antiproliferative action of the extract [28].

**Azadirachta indica**

**Family:** Meliaceae  
**Parts Used:** Leaf, seed, bark

**Activity:** A. indica (local name: Neem), a plant containing are markedly diverse array of phytochemicals like terpenoids, flavonoids, coumarins, carbohydrates, proteins were found to cure different ailments due to its anti-plasmodial, antioxidant, antiangiogenic, anti-cancer, anti-bacterial, antiviral, and fungicidal activities [31]. Its varied pharmacological properties attributed to extractions of different parts of these plants containing phytocompounds like azadirachtins, nimocinol, isomeldenin, azadirachtol (a tetranortriterpenoid), 2,3′-dehydrosalanol gedunin, nimbin, nimolicinol, odoratone, azadironolide, isoazadironolide [31]. The chemo-preventive effects of dietary doses of aqueous neem leaf extract are useful for its anticancer activity [32]. Leaf and seed extract have potential antioxidant activity. Previous studies demonstrated that polysaccharides and limonoids present in the neem bark, leaves and seed oil reduced tumors and exhibited efficacy against lymphocytic leukemia.
Researchers revealed that nimbolide, a triterpenoid present in the extract, arrested the HT-29 (human colon carcinoma cells) in G2/M and G0/G1 stages apparently through upregulation of p21 thereby inhibit tumorigenesis [33]. Nimbolide has also exhibited anticancer activity in numerous cancer types such as lung cancer, osteosarcoma, neuroblastoma, choriocarcinoma, leukemia and melanoma. Also, Azadirachtin and nimbolide of neem suppressed the viability and increase in apoptosis of HeLa cervical cancer cells [34]. The neem extracts also exhibit anti-proliferative effects in both estrogen-dependent as well as independent breast cancer cells and the neem seed oil can inhibit the growth of HeLa cervical cancer cells [34].

**Bauhinia variegata**

*Family*: Fabaceae  
*Parts Used*: Leaf

**Activity**: *B. variegata* (local name: Raktakanchan) is reported to have different phytochemicals, which possess a wide range of activities and give protection against some skin diseases, stomatitis and chronic diseases reported in Indian Ayurvedic medicine [35]. The study revealed the presence of secondary metabolites such as terpenoids, phenolics, flavonoids, anthraquinones, saponins, tannins, and alkaloids in *B. variegata* leaf extract [35]. Flavonoids extracted from *B. variegata* stem have been shown to possess cytotoxic activity against Dalton's ascetic lymphoma, leukemia, and many more cancer cell lines [36]. *B. variegata* leaf extracts have capability to combat oxidative damage because of its iron binding, radical neutralization ability. It has been reported that extracted flavones are more selective against ovarian cancer cell lines and the presence of flavonoids, anthraquinones, and saponins are responsible for its promising anticancer activity [36]. Ethanol extract of *B. variegata* showed a significant chemo-preventive and cytotoxic effect against human epithelial larynx cancer (HEp2) and human breast cancer (HBL-100) cell lines [37].

**Butea monosperma**

*Family*: Fabaceae  
*Parts Used*: Flower

**Activity**: *B. monosperma* (local name: Raktakanchan) is reported to have different phytochemicals, which possess a wide range of activities and give protection against some skin diseases, stomatitis and chronic diseases reported in Indian Ayurvedic medicine [35]. The study revealed the presence of secondary metabolites such as terpenoids, phenolics, flavonoids, anthraquinones, saponins, tannins, and alkaloids in *B. variegata* leaf extract [35]. Flavonoids extracted from *B. variegata* stem have been shown to possess cytotoxic activity against Dalton's ascetic lymphoma, leukemia, and many more cancer cell lines [36]. *B. variegata* leaf extracts have capability to combat oxidative damage because of its iron binding, radical neutralization ability. It has been reported that extracted flavones are more selective against ovarian cancer cell lines and the presence of flavonoids, anthraquinones, and saponins are responsible for its promising anticancer activity [36]. Ethanol extract of *B. variegata* showed a significant chemo-preventive and cytotoxic effect against human epithelial larynx cancer (HEp2) and human breast cancer (HBL-100) cell lines [37].

**Camellia sinensis**

*Family*: Theaceae  
*Parts Used*: Leaf

**Activity**: *C. sinensis* (local name: Cha) is one of the most common drinks consumed worldwide as green tea, a rich source of nutritional flavonoids like epigallocatechin-3-gallate, epigallocatechin, epicatechin-3-gallate and epicatechin [46]. Studies have shown that green tea has a potential to inhibit tumour cell proliferation and induce mortality of leukaemia cells [46]. Some previous research demonstrated that epigallocatechin-3-gallate has free radicals scavenging activity and by arresting cell cycle it suppresses the proliferation of hepatocellular carcinoma cell [47]. Several investigations have suggested that epigallocatechin gallate (EGCG), the major tea polyphenol along with other polyphenols have possess significant free radical scavenging activity, showed remarkable efficacy in cell mortality on human colon and liver cancer cell lines (50 μg/ml in HT-29 and 100 μg/ml in HepG2) [40]. Intraperitonal administration of the aqueous extract of flowers of *B. monosperma* in the X-15-myc onco mice showed antitumorgenic activity [39]. Ethyl acetate, butanol and aqueous solutions derived from total methanol extract of *B. monosperma* flowers have effective free radical scavenging activities due to the higher phenolic content [39]. Cytotoxic property of *B. monosperma* floral extracts revealed significant inhibitory effect on HCT-116 cells [41].
anti-inflammatory and anti-cancer properties that may help prevent the onset and growth of skin tumors [48]. C. sinensis is a potent anti-carcinogen with no side effects [47]. The antioxidant activity of tea polyphenols is not only due to their ability to scavenge superoxide but also due to increased activity of some detoxifying enzymes such as glutathione peroxidase, glutathione reductase, glutathione-S-transferase, catalase and quinine reductase in small intestine, liver and lungs [49]. Moreover, researchers found that people who drank tea were less susceptible to develop stomach cancer, colorectal cancer, esophageal cancer, pancreatic cancer and lung cancer than those who did not drink green tea [47].

**Cassia fistula**

**Family:** Leguminosae  
**Parts Used:** Flower, seed, leaf, bark  
**Activity:** *C. fistula* (local name: Amaltaas), a well-known Indian medicinal plant possesses significant antimicrobial, anti-inflammatory, hepatoprotective, wound healing and hypoglycemic activity [50]. It has been reported that *C. fistula* leaf extract have a rich amount of anthraquinone glycosides, flavonoids and phenolic compounds [50]. It is also suggested that anthraquinone glycoside (rhein, emodine, physion, chrysophanol, Obtusin, chrysoobtusin etc) have an anticancer activity. *C. fistula* extracts are high in total phenolics and proanthocyanidin content which are responsible for the synergistic oxidative potency of the extracts [51]. The results of some studies revealed that methanol extract of *C. fistula* seed has an antitumor activity [52]. Researchers demonstrated the tumour inhibitory activity of methanolic extract of *C. fistula* seed on the growth of Ehrlich ascites carcinoma [53]. Oral administration of bark extracts in 7, 12-dimethyl benz(a) anthracene (DMBA) induced oral squamous cell carcinoma in hamster showed complete prevention of carcinogenesis due to its remarkable chemopreventive ability [54].

**Centella asiatica**

**Family:** Apiaceae  
**Parts Used:** leaf  
**Activity:** *C. asiatica* (local name: Thankuni) is valued in traditional Ayurveda medicine for treating a variety of diseases like skin problems, wound healing, mental fatigue, stomach ulcers, diarrhea, epilepsy, and for revitalizing the nerves and brain cells. The scientific studies have demonstrated a variety of biochemical components i.e. amino acids (mainly Alanine and serine), flavonoids, terpenoids, essential oils, alkaloids present in aerial parts of this herb [55]. The flavonoids of leaf extract include kaempferol, kaempferol-3-o-β-D-glucuronide, quercetin, quercetin-3-o-β-D-glucuronide, castillicetin, castilliferol, apigenin, rutin, luteolin etc and the triterpenes are composed of asiatic acid, madecassic acid, asiaticosside, madecassoside, centelloside, madasadiacid, brahmoside, brahmiside, thakiniside, isothankuniside, centic acid, and cenellicacid [55]. *C. asiatica* methanolic extract showed concentration dependent inhibition of cell proliferation and induction of apoptosis in MCF-7 breast cancer cells [56]. At a concentration above 0.1% of *C. asiatica* juice, an increased DNA damage and apoptotic cell death was noticed on human HepG2 cell line [57]. Asiatic acid, a phytocompound from *C. asiatica* showed effective antiproliferative activity on skin and lung cancer cells and also responsible for induction of apoptosis and lowering viability in human melanoma SK-MEL-2 cells [56]. When treated with 40 μg/ml concentration of asiatic acid, a reduction up to 50% in viability in ovarian cancer cells was observed and it also showed cell cycle arrest at the G0/G1 phase followed by increased apoptosis by 7-10 folds [58]. A partially purified fraction of methanol extract of *C. asiatica* inhibited the tumour growth with no toxic effects on lymphocytes and leaf water extract has a chemo preventive effect on colon tumorigenesis [59].

**Curcuma longa L.**

**Family:** Zingiberaceae  
**Parts Used:** Root, stem and leaves  
**Activity:** Curcumin, a phenolic compound from the plant *Curcuma longa L.* (local name: Haldi) has shown a wide-spectrum chemo-preventive, antioxidant and antitumor activities. Curcumin is the natural yellow pigment in turmeric isolated from the rhizome of the plant *C. longa* [60]. Curcumin was found to inhibit the generation of ROS including superoxide dismutase and hydrogen peroxide in peritoneal macrophages. Curcumin as an anti-inflammatory agent, inhibits the proliferation of several tumour cells [60]. Recently, curcumin has been listed as the third generation of antitumor drug by the US National Cancer Institute (NCI) [61]. Curcumin, demethoxycurcumin and bisdemethoxy curcumin are the most common antitumor constituents in the curcurminoids of turmeric [62]. Curcumin I, curcumin II (monodemethoxycurcumin) and curcumin III (bisdemethoxycurcumin) from *C. longa* was assayed for their cytotoxicity, antioxidant and anti-inflammatory activities [63]. These compounds showed activity against melanoma, leukemia, colon, CNS, renal, and breast cancer cell lines [63]. Cell viability assays demonstrated the efficacy of rubusoside-solubilized curcumin against human colon, breast, and pancreatic cancer cell lines. Multiple mechanisms of action of curcumin are responsible for various effects on cancer cells including cell cycle arrest at G1/S stage, apoptosis induction which has been
observed in different tumor cell lines [64].

**Emblica officinalis**

**Family:** Euphorbiaceae  
**Parts Used:** Fruit pulp

**Activity:** *E. officinalis* (local name: Amlaki) has been used in Asian herbal pharmaceuticals for treatment of various illnesses specially in case of gastrointestinal problems [65]. It has been reported that the medicinal fruit of *E. officinalis* contains unique biologically active ingredients tannoids and flavanoids, having powerful antioxidant properties and high content of the antioxidant vitamin C, gallic acid [65]. The isolated ingredients from fruit extract have shown their protective effect against lipid peroxidation [66]. From previous studies, it has been proven that fruit extract act as an antimutagen directly as well as against mutagens that need metabolic activation and it also showed anticarcinogenic activity against methylcholanthrene-induced sarcoma formation [67]. The anticancer properties of the bioactive components of fruit extract is exerted through the removal of free radicals and by inhibiting Phase-I enzymes which are required for the activation of carcinogen and activation Phase-II enzymes (antagonist of Phase-I enzyme) [67]. It has been proven that aqueous extracts of *E. officinalis* cause decrease in the HepG2 cell viability by reducing ROS generation as well as improving reduced intracellular GSH levels. *E. officinalis* aqueous extracts also induce apoptosis in several cancer cell lines i.e. Hela (cervical), A549 (lung), MDA MB 231 (breast), SK OV3 (ovarian) and SW620 (colorectal) [68]. Pyrogallol, a bioactive catechin compound of *E. officinalis* fruit extracts showed significant anti proliferative activity against H520 (lung squamous cell carcinoma) and human lung cancer cell lines H441 (lung adenocarcinoma) [69]. Development of pyrogallol based high potency anti lung cancer drug needs to be supported by further researches.

**Oroxylum indicum**

**Family:** Bignoniaceae  
**Parts Used:** bark

**Activity:** The medicinally active plant *O. indicum* (local name: Sonapatha) has drawn considerable attention in research because of wide nutritional and medicinal properties to treat biliousness, fevers, intestinal worms, leucoderma, inflammation, diarrhoea, dysentery, diaphoretic, bronchitis pneumonia and respiratory troubles etc. [70]. Bioactive phenolic compounds present in *O. indicum* extract are baicalein, oroxylin A, chrysin and its variety of derivatives. [70]. *O. indicum* in its methanol and aqueous extracts have previously been reported for its cytotoxicity in MDA-MB-435S and Hep3B cell lines [71]. The bark decoction of *O. indicum* has also been reported for its use in treating cancer, despite the lack of mechanistic evidence about this therapeutic function [72]. *O. indicum* bark extracts were furthermore reported to possess anti-proliferative property on human breast cancer cells [73]. The stem bark extract of *O. indicum* showed effectual cytotoxicity, apoptosis-inducing abilities and distinctive anti-metastatic potentials against estrogen receptor-negative breast cancer [71]. Baicalein, a naturally occurring flavonoid compound isolated from *O. indicum* possesses effectual anticancer activity when treated against CT-26 colon carcinoma [70].

**Semecarpus anacardium**

**Family:** Anacardiaceae  
**Parts Used:** Nut

**Activity:** The fruits of *S. anacardium* (local name: Bhallatak), a tropical tree growing wild in the Indian subcontinent, are used extensively for the treatment of human cancers in the Ayurvedic medicine [74]. The nut milk extract of this plant exhibits anti-tumor activity by inducing the in vivo antioxidant system or by suppressing hypoxic and angiogenic factors (hypoxia inducible factor-1 alpha), vascular endothelial growth factor, and inducible nitric oxide synthase [74]. The oil extracted from *S. anacardium* nut is reported to have cytotoxic effects against acute myeloblastic leukemia (HL-60), chronic myelogenous leukemia (K-562), breast adenocarcinoma (MCF-7) and cervical epithelial carcinoma (HeLa) cell lines [75]. Phytochemical analysis of the nut reveals the presence of bioflavonoids (gallulflavanone), bhilawansols, phenolic compounds, glycosides and sterols [76]. *S. anacardium* oil having strong antioxidant capacity showed its anti-tumour activity through a mechanism which does not cause any acute physiological disturbance [77]. Reports have also established that a single injection of nut extract could bring complete inhibition of tumour growth in rats. *S. anacardium* nut extract may be a potential antineoplastic agent against mammary carcinoma cell [78].

**Syzygium cumini**

**Family:** Myrtaceae  
**Parts Used:** Fruit, seed

**Activity:** *S. cumini* (local name: Kaalojaam), a large evergreen tree native to India and Unani medicine for its therapeutic potentials [79]. The various parts of the plant (bark, leaf, fruit and seed) is reported to possess antioxidant, anti-inflammatory, anti-microbial, anti-bacterial, anti-HIV, anti-leishmanial, anti-fungal, nitric oxide scavenging, free radical scavenging, antitumor, anti- clastogenic, anti-diarrheal, gastroprotective, anti-ulcerogenic and chemotherapeutic activities [80]. These parts have been extensively investigated for their bioactive phytochemical properties and shown to have significant potential in cancer therapy [81].


DOI: https://doi.org/10.30654/MJPS.10005
constituents like maleic acid, oxalic acid, gallic acid, ellagic acid, oleanolic acid, betulonic acid, isoquercitin, quercetin, myricetin, kaempferol, cyanidin glycoside, flavonoids, tannins, essential oils and triterpenoids [81]. Some of these components may be collectively responsible for the antineoplastic, radioprotective, chemopreventive properties of such plant extract [81]. Anthocyanins and Betulinic acid, Cyanidin diglycoside, Ferulic acid were reported for their potent anticancer activity. Study showed that ethanol extract of fruit containing Kaempferol 7-O-methylether and Y-Sitosterol is responsible for their antioxidant and anti-leukemia activities [79]. The crude extract of S. cumini fruits inhibited growth and induced apoptosis in human cervical cancer cell lines HeLa and SiHa in a dose and time-dependent manner [82]. S. cumini fruit extract has been further observed to have anti-tumor and anti-oxidative potential against chemically induced stomach carcinogenesis [80]. Some studies also revealed the significant cytotoxic activity of the seed extract of S. cumini on various cancer cell lines (A2780, MCF7, PC-3, H460) [82]. Previous experiments have shown that the standardized fruit extract of this plant possesses antiproliferative as well as pro-apoptotic properties against breast cancer cells.

**Vitex negundo**

**Family:** Verbenaceae  
**Parts Used:** Leaves, seed

**Activity:** Traditionally, plant parts of *V. negundo* (local name: Nishinda) are used for the treatment of skin-ulcers, leukoderma, rheumatoid arthritis, bronchitis, leucoderma, gonorrhoea, bronchitis etc. *V. negundo* also exhibits anti-bacterial, anti-fungal, anti-inflammatory, anti-tumor activity [83]. The phytochemical study of ethanolic extract of leaves of *V. nigundo* indicated the presence of flavonoids, Alkaloids and terpenoids [84]. The anti-tumour effect shown by the ethanolic extract may be due to antioxidant potential of flavonoids [84]. Evn-50 is a mixture of lignan compounds extracted from *V. negundo* possesses a broad spectrum of cytotoxic activity for various cancers including hormone dependent and hormone independent cancers ranging from pancreatic cancer, liver cancer, kidney cancer, lung cancer, gastric cancer, and colon cancer [85]. This cytotoxicity of EVn-50 may be due to cell cycle arrest at G2/M phase as observed by flow cytometric study, followed by apoptosis of cancer cells. EVn-50 exerts cytotoxic effect on some hormone related cancers including breast cancer, choriocarcinoma, prostate cancer and ovarian cancer, possibly via apoptosis inducing mechanism and so acknowledged as potential anticancer compound [85].

**Withania somnifera**

**Family:** Solanaceae  
**Parts Used:** Root, stem and leaves

**Activity:** In Indian traditional Ayurvedic medicine *W. somnifera* (local name: Ashwagandha) is well proven as a potential source of various anticancer components due to the presence of several bioactive components acting as free radical scavengers, reducing agents and quenchers of singlet oxygen [86]. Some recent studies using 50% ethanol extract of root, stem and leaves of *W. somnifera* exhibited in-vitro cytotoxicity against five human cancer cell lines of four different tissues i.e. A-549 (lung), PC-3(prostrate), DU-145 (prostrate), HCT-15 (colon), and IMR-32 (neuroblastoma) [87]. *W. somnifera* also has anti-inflammatory, anti-tumour and radio-sensitizing actions and analgesic activity [87]. Studies on *W. somnifera* suggest that it decreases tumour cell proliferation and boosts the efficiency of radiation therapy while potentially mitigating unwanted side effects. Hydro alcoholic (1:1) sample of *W. somnifera* (leaves) shows efficient cytotoxicity on MCF-7, A549 and PA-1 cancer cell line (breast, lung and ovary respectively) [86]. In a study, *W. somnifera* was suggested as an alternative long-term therapy to prevent the spread of cancer cells. In this case, the root extracts were tested against vimentin pro-metastatic protein. Thus, different formulations of *W. somnifera* were used to establish as cell motility inhibitor in case of breast tumours [88]. Withaferin A, an active anticancer agent extracted from the leaf of the plant [89]. Moreover, some experiments proved that the lower concentrations of root extract of *W. somnifera* can constrain breast cancer metastasis with negligible adverse effects in rat model [88,89]. These findings paved the way for researchers to focus on the bioactivities of this plant and to formulate the composition for medicinal use.

**ANTICANCER APPLICATIONS OF PHYTOCHEMICALS**

The curative properties of these plants are due to the presence of complex phytochemical constituents of diverse compositions grouped alkaloids, glycosides, corticosteroids, essential oils etc. [Figure 2]. Plant derived medicines are basically multi-compounds extract with complicated compositions in which fractional components possess chemo preventive activity.
C. sinensis, C. longa, O. indicum, S. tanacardium, A. aspera, A. lanata, B. variegate, B. monosperma, are isolated from antineoplastic agent, Alstonine [24]. Many phenolic compounds with chemo preventive effects. anticancer agents. Phytochemical studies revealed that phytochemical-based medicine containing isolated bioactive medicinal activities. But it is still a challenge to formulate an ideal separate and screen the phytochemical constituents of certain to have more advantages over conventional procedures to have more advantages over conventional procedures to have more advantages over conventional procedures. Several emerging analytical separation methods are reported with aferin A, CID: 265237 (accessed on 19th July 2020). (R) ferulic acid, CID: 445858 (S) betulinic acid, CID: 64971 (T) (P) baicalein, CID: 5281605; (Q) gallocatechin, CID: 101326873 (N) asiatic acid, CID: 119034 (O) curcumin, CID: 969516 isocoreopsin, CID: 12309899; (K) epigallocatechin gallate, CID: 65064; (L) proanthocyanidin, CID: 108065 (M) kaempferol, CID: 5280863 (N) asiatic acid, CID: 119034 (O) curcumin, CID: 969516 (P) baicalein, CID: 5281605; (Q) gallocatechin, CID: 101326873 (R) ferulic acid, CID: 445858 (S) betulinic acid, CID: 64971 (T) withaferin A, CID: 265237 (accessed on 19th July 2020).

Several emerging analytical separation methods are reported to have more advantages over conventional procedures to separate and screen the phytochemical constituents of certain medicinal activities. But it is still a challenge to formulate an ideal phytochemical-based medicine containing isolated bioactive anticancer agents. Phytochemical studies revealed that A. aspera, A. scholaris, B. variegate, C. asiatica, V. negundo possess alkaloid compounds with chemo preventive effects. A. scholaris from (Apocynaceae) has been reported to have an alkaloid derivative antineoplastic agent, Alstonine [24]. Many phenolic compounds are isolated from A. aspera, A. lanata, B. variegate, B. monosperma, C. sinensis, C. longa, O. indicum, S. anacardium. Epigallocatechin gallate, a polyphenol isolated from C. sinensis (Theaceae) leaf reported to have broad chemopreventive efficacy [47]. Proanthocyanidin is another polyphenol (oligomeric flavonoid) identified in C. fistula (Leguminosae) extract has potent anti-carcinogenic activity [51].Curcumin, a natural polyphenol present in C. longa (Zingiberaceae) modulates cell signalling thus interfering cancer cell proliferation and angiogenesis [60]. E. officinalis (Euphorbiaceae) fruit extracts contain a bioactive polyphenol called pyrogallol that exhibited significant anti-proliferative activity [69]. Ferulic acid, a phenolic compound present in S. cumini (Myrtaceae) extract has promising chemo preventive as well as anti-neoplastic activity against various cancer cell lines [80,81]. Campesterol, a phytosterol possessing radical scavenging activity have been isolated from A. lanata (Amaranthaceae) [12,13]. Some organosulfur phytochemicals like allicin from A. sativum (Liliaceae) have promising repressing properties against numerous cancer cell lines [17]. Various bioactive flavonoid compounds are isolated from A. paniculate, A. indica, B. variegate, B. monosperma, C. asiatica, C. gigantea, C. sinensis, C. fistula, S. anacardium and V. negundo. Isocoreopsin, a flavonoid extract of butanol B. monosperma flower showed excellent efficacy against human liver and colon cancer cell lines [40]. Kaempferol, a flavonol present in C. asiatica (Apiaceae) extract was reported to have metastasis and angiogenesis repressing capacity [55]. Baicalein, a flavonoid extracted from O. indicum (Bignoniaceae) was known to suppress invasiveness of colorectal cancer [70]. Gallocatechin, a new biflavonone isolated from S. anacardium nut shells are known to possess cancer preventive potential [76]. Extracts of A. aspera, A. scholaris, A. paniculate, A. indica, B. variegate, C. gigantea, C. asiatica, S. cumini, V. negundo have been reported to contain terpenoid compounds. Andrographolide, a diterpenoid from A. paniculate (Acanthaceae) exhibited cytotoxic activity against human epidermoid carcinoma cells, breast cancer cell lines and lymphocytic leukaemia [26]. Nimbolide, a tetranortriterpenoid isolated from A. indica (Meliaceae) leaf involved in modulating multiple signalling pathways in malignant cells which showed potent chemopreventive activity [33]. Asiatic acid, a pentacyclic triterpenoid extracted from C. asiatica (Apiaceae) possesses excellent anti-proliferative efficacy against various cancer cell lines including human lung cancer [58]. Evin-50, a lignan compounds mixture of V. negundo (Verbenaceae) has excellent broad-spectrum cytotoxic activity specially against SMMC-7721 (liver cancer) and MDA-MB-435 (breast cancer) cell lines [85]. There are some trademarks common in every type of cancer i.e. self-sufficiency in growth signals and uncontrolled cell proliferations, growth inhibitory signal resistance capability, evasion of apoptosis, unrestricted replication capacity, sustained angiogenesis, metastatic activity and invasion. The complicated mechanism of actions requires strong multi-targeted treatment [90]. Bioactive multi-components plant extract involves in modulating various mechanism by interfering cellular transportations, activating pro-drugs to alter metabolites, inhibiting binding to target proteins etc. It has been observed that natural therapeutics exert significant additive or synergistic mode of action at the signalling cascade by which severe toxic side effects associated with conventional cancer therapies can be avoided. In this scenario, we should...
focus on preclinical studies i.e. quality control, drug designing, delivery strategy, drug safety and therapeutic efficacy as well as clinical studies to overcome the problem of data insufficiency about majority of plant derived drugs. Considering the findings of these ethnopharmacological researches on medicinal plants of Bengal, it is possible to formulate effective anticancer drugs either using single or in combination with other phytochemicals through an extensive scientific analysis.

**CONCLUDING REMARKS**

Science has long acknowledged the value of natural phytochemical based remedies. These traditional therapeutic-inspired approaches to drug discovery attract considerable attention in cancer therapy due to presence of diverse range of active ingredients. But the effectiveness of any herbal product is dependent upon molecular recognition, rational designing, proper standardization, smart delivery strategy during clinical trials. While some natural formulations have shown to exert promising cytotoxicity against cancer cell lines, many remedies aren’t supported by research. Our article highlighted twenty most common Bengal plants having strong anti-cancer properties by promoting anti-tumour or anti carcinogenic activities and boosting up the immunity machineries. Our review helps to make a potent data base on those medicinal plants from different plant families with antiproliferative and anti-carcinogenic effect on some specific cancer types and pave the way for the development and utilization of new phytotherapeutic agents in medical applications.

**DECLARATION OF INTEREST**

There are no conflicts to declare.

**Funding**

The research work is not assisted by any kind of funding agencies or research fund.

**ACKNOWLEDGEMENTS**

The authors would like to thank Biophysics department of Jadavpur University, National Medicinal Plant Board (NMPB), West Bengal State Medicinal Plant Board (WBSPMB) Government of India’s Department of AYUSH. We are thankful to everyone who provided valuable information and guidance during research of this review. We are also grateful to Dr. Ashesh Nandy for careful reading of our article.

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