

## PHYTOCHEMICALS OF MEDICINAL IMPORTANCE IN FOODS (A REVIEW)

<sup>1</sup>Bello, B.A and <sup>2</sup>Dandago, M. A.

<sup>1</sup>Department of Biochemistry, Kano University of Science and Technology, Wudil. P.M.B 3244, Kano State, Nigeria

<sup>2</sup>Department of Food Science and Technology, Kano University of Science and Technology Wudil, P.M.B 3244, Kano State, Nigeria.

### ABSTRACT

*Phytochemicals are biologically active compounds found in plants in small amount which are not established as nutrient but nevertheless seem to contribute significantly to protection against degenerative diseases. Plants produce these chemicals to protect themselves, but recent researches demonstrate that they can protect human being against degenerative diseases. They are classified based on chemistry as; Terpenoid isoprenoids, polyphenolic acids, Glucosinolates, Thiosulfonates, Phytosterols, Anthraquinones, Capsaicin, and other classes includes; Piperine, Chlorophyll, Betaine, Pectin and Oxalic acid. Modern Food processing has been found to greatly reduce or even lost them. These active chemicals were found to acts either as; antioxidants, by hormonal action, by enzyme stimulation, interference with DNA replication, as antibacterial and by physical means.*

**KEYWORDS:** *Phytochemicals, Food processing, Mechanism of actions*

### INTRODUCTION

Phytochemicals are biologically active compounds, found in plants in small amounts which are not established nutrients but which nevertheless seem to contribute significantly to protection against degenerative diseases. There are more than 1000 phytochemicals found in plant food sources. These chemicals acts as antioxidants, phytoestrogens, enzyme aids, and serves antibacterial functions (Ivor, 2002).

According to both the American heart association and the National Cancer Institute (NCI), it is important to eat whole foods to get the maximum benefit of phytochemicals. It is well known that plant produce these chemicals to protect itself, but recent researches demonstrated that they can protect Humans against diseases (Dena, 2006).

Foods containing phytochemicals are already part of our daily diet. Most foods contain phytochemicals except for some refined foods such as sugar or alcohol. Some foods such as whole grains, vegetables, beans, fruits and herbs contain many phytochemicals. The easiest way to get more phytochemicals is to eat more fruits (bush mango, guava, blue berries, cranberries, cherries, apple etc) and vegetables (cauliflower, cabbage, carrots, broccoli etc)(Phytochemicals, 2008). This paper aimed at reviewing some phytochemicals of medicinal importance that are always consumed in foods of plants origin.

### Classification of phytochemicals

Phytochemicals are classified on the basis of chemistry and some recognized relationship to metabolic functions. Many of these compounds are universal in plant foods and their digestibility, absorption, utilization and interaction with other nutritional factors in human is largely unknown. Specific mechanisms for an observed metabolic effect may not be fully understood and much of the work is confined to

invitro or animal experiments (Arts and Hollman, 2005).

The phytochemicals that are found in Cereals (grain), pulses (legumes), vegetables and fruits are now referred to as phytoprotectants and are generally classified as;

#### 1. Terpenoids isoprenoids

Terpenes are numerous natural products other than alkaloids which show medicinal properties or biological activities. Among these are compounds which fall in the general class of terpenes, compounds made up of 5- carbon units, often called isoprenoid units put together in a regular pattern usually head to tail in terpenes up to 25 carbons. Terpenes containing 30 carbons or more are usually formed by the fusion of two similar terpene precursors such that the head and tail rule appears to be violated (Phytochemicals, 2008).

Types of isoterpenoids include:

#### (A)Carotenoids Terpenoids

Carotenoids are organic pigments that are naturally occurring in chloroplasts of plants and some other photosynthetic organisms like algae, some types of fungus and bacteria. Carotenoids belong to the category of tetraterpenoids (i.e. they contain 40 carbon atoms). Structurally they are in the form of a polyene chain which is sometime terminated by ring. The carotenoids with molecules containing oxygen, such as lutein and zeaxanthin, are known as xanthophylls. The unoxxygenated (oxygen free) carotenoids such as  $\alpha$ - $\beta$  carotene and lycopene are known as carotenes. In the photosynthetic reaction centre, they either participate in the energy-transfer process, or protect the reaction center from auto-oxidation.

In non photosynthesizing organisms, carotenoids have been linked to oxidation - preventing mechanism. They are efficient free-radical scavengers and they enhance the vertebrate immune system (Unlu *et al.*, 2005).

Carotenoids Terpenoids are found universally in vascular plants, the carotenoids, steroids and terpenes such as limonene and menthol which have characteristic flavours and aromas are all formed from the condensation of simple isoprenoid units which include:

**(i)Lycopene:** Lycopene is a bright red carotenoid pigment found in tomatoes and other red fruits. Lycopene may be the most powerful carotenoid quencher of singlet oxygen (Dimascio *et al.*, 1989). Being 100 times the queching action of glutathione (water soluble). Singlet oxygen produced during exposure to UV lights is a primary cause of skin aging (Berbeburg *et al.*, 1999). Early research suggested that consumption of lycopene can ameliorate cardiovascular disease, cancer, diabetes, osteoporesis and even male-infertility (Khan *et al.*, 2008).

**(ii)  $\beta$ -Carotene:** The most common carotenoids include lycopene and vitamin A precursor  $\beta$ -carotene. In plants, the xanthophyll lutein is the most abundant carotenoid and its role in preventing age-related eye disease is currently under investigation. Epidemiological studies have shown that people with high- $\beta$ -carotene intake have shown a significantly reduced risk of lung cancer (Alija *et al.*, 2004).

**(iii) Lutein:** Lutein is among the over 600 known naturally occurring carotenoids, found in green leafy vegetables, egg yolks, animal fats and the corpus luteum and also present in a concentrated area of the macula, a small area of the retina responsible for central vision (Malinow *et al.*, 1980). Various research studies have shown that a direct relationship exists between lutein intake and pigmentation in the eye. Several studies also show that an increase in macula pigmentation decreases the risk for eye diseases such as age-related macular degeneration. Lutein was employed by organisms as an antioxidant and for blue light absorption. (Richers *et al.*, 2004; ARTD, 2001).

**(iv) Zeaxanthin:** Zeaxanthin is one of the two carotenoids contained within the retina of the eye. Within the central macula, zeaxanthin is the dominant component, whereas in the peripheral retina lutein predominate. There is epidemiological evidence of a relationship between low plasma concentrations of lutein and zeaxanthin on the one hand, and the risk of developing age-related macular degeneration (AMD) on the other. Some studies support the view that supplemental lutein and/or zeaxanthin help protect against age-related macular degeneration. There is also epidemiological evidence that increasing lutein and zeaxanthin intake lowers the risk of cataract development (Sangiovanni *et al.*, 2007).

**(v)Cryptoxanthin:** Cryptoxanthin is a natural carotenoid pigment that has been isolated from a variety of sources including the petals and flowers of plants in the genus *Physalis*, orange rind, papaya, egg yolk, butter, apples and bovine blood serum. In the Human body, Cryptoxanthin

is converted to vitamin A (Retinol) and is therefore considered a pro Vitamin A. As with other Carotenoids, Cryptoxanthin is an antioxidant and may help prevent free radical damage to cells and DNA. There is an inverse association between  $\beta$ -Cryptoxanthin and lung cancer risk in several observational epidemiological studies suggest that  $\beta$ -Cryptoxanthin could potentially act as a chemo preventive agent against lung cancer (Lian *et al.*, 2006).

#### **(B)Non Carotenoids Terpenoids**

Many natural products other than alkaloids show biological activities. Among these are compounds which fall in the general class of terpenes and are made up of 5-carbon units, often called isoprenoid units put together in a regular pattern, usually head to tail in terpenes up to 25 carbons. Terpenes containing 30 carbons or more are usually formed by the fusion of two similar terpene precursors such that the head of tail rule appears to be violated. The various types of non carotenoid terpenoids include:

**(i)Menthol:** Menthol, a monoterpene (10 carbons) isolated from various mints, is a topical pain reliever and antipruritic (relieves itching). Plants in the mints family have been used for medicinal purposes since before 2000BC, but menthol was not isolated until 1771. Thujone another monoterpene, is the toxic agent found in *Artemisia absinthium* (worm wood) from which liqueur, absinthe, is made. Borneol and camphor are two common monoterpenes. Borneol, derived from pine oil, is used as a disinfectant and deodorant while camphor is used as a counter irritant, anesthetic, expectorant and antipruritic, among many other uses (People, 2008).

**(ii)Limonene:** Limonene is a hydrocarbon, classified as a cyclic terpene which is colourless liquid at room temperatures with an extremely strong smell of orange. It takes its name from the lemon. Limonene and its oxidation products are skin and respiratory irritants, and limonene-1, 2-oxide (formed by aerial oxidation) is a known skin sensitizer. Most reported cases of irritation have involved long term. Industrial exposure to the pure compound e.g. during degreasing or the preparation of paints. However, a study of patient presenting dermatitis showed that 3% were sensitized to limonene (Crowell, 1999).

Although once thought to cause renal cancer in rats, limonene now is considered by some researchers to be a significant chemo preventive agent with potential value as a dietary anti-cancer tool in human by inducing the glutathione transferase group of enzymes which conjugate various carcinogens and xenobiotic prior to excretion (Tsuda *et al.*, 2004; Manni *et al.*, 1999).

#### **(2)Polyphenols:**

Polyphenols are a group of chemical substances found in plants, characterized by the presence of more than one phenol unit or building block per molecule.

Polyphenols are generally divided into hydrolysable tannins (garlic acid esters of glucose and other sugars) and phenyl propanoids such as lignins, flavonoids and condensed tannins. The division of polyphenols into tannins, lignans and flavonoids is derived from the variety of simple polyphenolic units derived from secondary metabolism of the shikimate pathway as well as classical divisions based upon the relative importance of each base component of different field of study.

The most abundant polyphenols are the condensed tannins, found in virtually all families of plants and comprising up to 50% of the dry weight of leaves. The phenolic unit can often be esterified or methylated. It can also be found dimerized or further polymerized, creating a new class of polyphenol for example, ellagic acid is a dimer of gallic acid and forms the class of ellagic, tannins, or a catechin and a galocatechin can combine to form the red compound theaflavin, a process which also results in the large class of brown thearubigins in tea.

Notable sources of polyphenols include berries, tea, bear, grape/wine, olive oil, chocolate/cocoa, peanuts, pomegranates, yerba mate and other fruits and vegetables. High levels of polyphenols can generally be found in the fruit skins. Polyphenols were once briefly known as Vitamin P. However they were quickly found out to be non-essential and reclassified. The health benefits of specific polyphenols such as quercetin are well-established, and there are less-well established claims of health benefits from all types of polyphenols (Nutrition perspective, 2005).

Research indicates that polyphenols may have anti oxidant characteristics with potential health benefit. They may reduce the risk of cardiovascular disease and cancer (Nutrition perspective, 2005).

#### **(a)Flavonoid polyphenolics**

Flavonoids and other phenolic compounds are found in fruits, vegetables, coffee, tea and alcoholic beverages. Over 2000 individual flavonoids have been described. The class includes flavones, flavonols and flavonones, most occur naturally as glycosides. Quercetin, Kaempferol and myricetin are flavonols widely distributed in vegetables and fruits. The richest source of quercetin are berries, tomatoes, broccoli, squash and onion while radishes, kale and endive are rich in kaempferol. Flavonoids function as potent antioxidants and metal chelators by protecting LDL cholesterol from oxidation and by inhibiting platelet aggregation, flavonoids may protect against heart diseases. Phenolic compounds are also involved in the induction of detoxification systems and some inhibit N-nitrosation reactions by trapping nitrate to C-nitrosophenolic compound. The most common flavonoids includes; anthocyanin, catechins, isoflavones, quercetin, silibinin and tannin (Arts and Hollman, 2005).

#### **(b)Phenolics**

**(i)Ellagic acid:** Ellagic acid is a polyphenol antioxidant in numerous fruits and vegetables including raspberries, straw berries, cranberries, walnuts, pecans, pomegranates and other plant foods. The anti proliferative and antioxidant properties of ellagic acid have spurred preliminary research into the potential health benefit of ellagic acid consumption. Plants produce Ellagic acid and convert it to a form of tannin known as Ellagotannins. These are Glucosides which are readily hydrolyzed by water to generate Ellagic acid when the plants are eaten (Vatter and Shetty, 2005).

Ellagic acid is also a primary constituent of several tannin bearing plant which produce the category of tannins known as Gallotannins. These, when hydrolyzed by water give rise to Ellagic acid and Gallic acid. Many such plants include terminalia chebulas, terminalia belerica, two related species which are ingredients of the ayurvedic medicine known as triphala. The highest levels of ellagic acid are found in strawberries, cranberries and grape (Vatter and Shetty, 2005).

Ellagic acid has anti proliferative and antioxidant properties in a number of invitro and small-animal models. The anti proliferative properties of ellagic acid are due to its ability to directly inhibit the DNA binding to certain carcinogens, including nitrosamines and polycyclic aromatic hydrocarbons (Mandal and Stoner, 1990). As with other polyphenol antioxidants, ellagic acid has a chemoprotective effect in cellular models by reducing oxidative stress (Vatter and Shetty, 2005). Small randomized controlled trials involving 19 patients with carotid artery stenosis found that pomegranate juice, which is high in ellagic acid, appeared to reduce blood pressure and carotid artery wall thickness (Arts and Hollman, 2005).

A 2005 controlled study of 48 patients undergoing chemotherapy for prostate cancer found that ellagic acid supplementation reduced the rate of chemotherapy-associated neutropenia (though there were no cases of severe neutropenia in either the ellagic acid or control groups. Ellagic acid supplementation did not improve overall or progression-free-survival of patients with prostate cancer in this trial (Falsaperla *et al.*, 2005). Despite the very preliminary state of evidence supporting health benefit in humans, ellagic acid has been marked as a dietary supplement with a range of claimed benefit against cancer, heart disease and other medical problems (FDA, 2008).

#### **(ii)Cholorogenic acid**

Caffeic acid is a naturally occurring phenolic compound (formerly called a carboxylic acid), which is found in many fruits, vegetables and herbs, including coffee, although varying in amounts depending on the plant. Caffeic acid has been shown to act as a carcinogenic inhibitor. It is also known as an antioxidant in vitro and also in vivo.

Caffeic acid is a yellow crystalline acid that is soluble in hot water and alcohol. It is related to cinnamic acid, but it has two hydroxyl groups not found in cinnamic acid. Both are part of the carbocyclic carboxylic acid group (Hirose *et al.*, 1998). Caffeic acid can be esterified with quinic acid to form chlorogenic acid. Both caffeic acid and chlorogenic acid are found in coffee beans. Caffeine is a different compound than caffeic acid. A derivative of caffeic acid is caffeic acid phenethyl ester (CAPE) (Margreet *et al.*, 2010). Caffeic acid and its derivatives, caffeic acid phenethyl ester (cape) have shown tumor-shrinking properties. When an anti-cancer drug was being sought, caffeic acid and cape were derived from burning Bush (Natarajan *et al.*, 1996).

**(vii) Ferulic acid:** Ferulic acid is an organic compound that is an abundant phenolic phytochemical found in plant cell walls. It is a derivative of trans-cinnamic acid. As a component of lignin, ferulic acid is a precursor in the manufacture of other aromatic compounds. Ferulic acid together with dihydroferulic acid is a component of lignocellulose, serving to crosslink the lignin and polysaccharides, thereby conferring rigidity to the cell walls. It is found in seeds of plants such as rice, wheat, and oats as well as in coffee, apple, artichoke, peanut, orange and pineapple. It can be extracted from wheat bran and maize bran using concentrated alkali (Liyama *et al.*, 1994).

Ferulic acid, like many phenols, is an anti oxidant in the sense that it is reactive toward free radicals such as reactive oxygen species (ROS). ROS and free radicals are implicated in DNA damage, cancer, accelerated cell aging. Animal studies and invitro studies suggest that ferulic acid may have direct antitumor activity against breast cancer and liver cancer (Shadadi and Naczki, 2004).

Ferulic acid may be effective at preventing cancer included by exposure to the carcinogenic compounds benzopyrene and 4-nitroquinoline-1-oxide. (Note that these are not randomized controlled trials done with human participants and therefore, the results of these studies may not be directly applicable to human use). If added to a topical preparation of ascorbic acid and vitamin E, ferulic acid may reduce oxidative stress and formation of thymine dimer in skin (Shadadi and Naczki, 2004).

Caffeic, ellagic and ferulic acids are the most commonly found phenolics in fresh vegetables, fruits and tea. They were shown to prevent chemical induction of lung tumours. Caffeic and ellagic acids were also found to inhibit chemically induced tumours of the tongue and the oesophagus and to inhibit skin tumours when applied topically. Ellagic acid may interact with benzo (a) pyrene in the GIT thereby reducing its bioavailability and to inhibit mutagenicity.

### **C. Others Non flavonoids polyphenolic**

**i) Curcumin:** Curcumin is a phytochemical in the spice turmeric which is used to make curry (the

spice "cumin" contains no curcumin, despite the similar name). Curcumin inhibits gene that makes inflammatory cox-2 enzymes, preventing their production (celebrex simply inhibit cox-2 enzymes). Curcumin inhibits release of the pro-inflammatory cytokine TNF-alpha. Curcumin is a more effective anti-clotting agent than aspirin, without the ulcer-inducing stomach irritation caused by aspirin.

**ii) Resveratrol:** Resveratrol is a phytoalexin produced naturally by several plants when under attack by pathogens such as bacteria or fungi. Resveratrol has also been produced by chemical synthesis (Farina *et al.*, 2006), and is sold as a nutritional supplement derived primarily from Japanese knotweed. Resveratrol extends the life span of several short living species of animals. However, this effect has not yet been demonstrated in mammals. In mouse and rat experiments, anti-cancer, anti-inflammatory, blood sugar-lowering and other beneficial cardiovascular effects of resveratrol have been reported. Most of these results have yet to be replicated in humans. In the only positive human trial, extremely high doses (3 - 5g) of resveratrol in a special proprietary formulation have been significantly lower blood sugar (Elliott and Jirousek, 2008).

It was reported that topical resveratrol applications prevented the skin cancer development in mice treated with carcinogen. There have since been dozen of studies of the anticancer activity of resveratrol in animal models (Jang *et al.*, 2007). No results of human clinical trials for cancer have been reported. However, clinical trials investigate the effects on colon cancer and melanoma (skin cancer) are currently recruiting patients (Clinical trials, 2008).

**(iii) Lignans:** Lignans are a group of chemical compounds found in plants particularly in flax seed. Lignans are one of the major classes of phytoestrogens, which are estrogen-like chemicals and also act as anti oxidant. Plant lignans are polyphenolic substances derived from phenylalanine via dimerization of substituted annamic alcohol, known as monolignols, to a dibenzylbutane skeleton.

Lignans come from whole grain products, seeds, fruits and berries. In cereals, lignan precursors meta-resinol and secoisolaricetinol occur in the bran. Enterolactone and enterodiol are synthesized in the colon by bacteria from the precursors. The main effect is anti-estrogenic. Heart disease, osteoporosis, breast cancer, prostate cancer and menopausal cancer are rare in far eastern populations eating traditional diets containing soy bean products (Milder *et al.*, 2005).

**3. Glucosinolates:** Brassica vegetables include Cabbage, Cauliflower, broccoli, Brussels sprouts, and kohlrabi contain Glucosinolates. Glucobrassicin contain about 30% of the Glucosinolate found in vegetables.

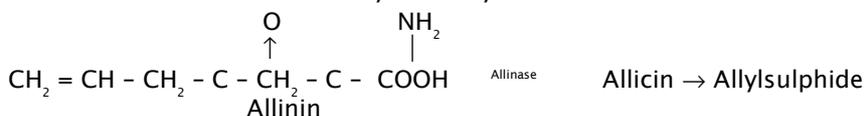
Glucosinolates is converted to isothionates (contain sulfur) and indoles (contain no sulfur) when vegetables containing them are cut. They are high in cruciferous vegetables, particularly cauliflower and cabbage and to a lesser extent in broccoli and brussel sprouts. They act against cancer by phase 2 enzyme induction. Broccoli and cabbage show the greatest protection against bladder cancer (Arts and Hollman, 2005).

**i) Indole-3-carbinol:** During cooking and chewing, Glucosinolates are metabolized by the plant enzyme Myrosinase to produce Isothiocyanates and Indole. Indole-3-carbinol may increase Microsomal mixed function oxidase activities which can both activate and detoxify a variety of carcinogens depending on the carcinogen involved and the specific enzyme induced. Indoles increase hepatic-2-hydroxylation of Oestradiol, a shift from the 16-hydroxylation which represents a reduction in Oestrogen activity and may be protective against Oestrogen related cancers (Dashwood, 2007).

Investigation of mechanisms by which consumption of indole-3-carbinol might influence cancer incidence focus on its ability to alter estrogen metabolism and other cellular effects. Controlled studies have been performed on such animal as rats, mice etc, introducing various controlled levels of carcinogens and levels of indole-3-carbinol into their diet - Results showed dose-related decreases in tumor susceptibility due to indole-3-carbinol (interred by decreases in aflatoxin-DNA binding). The first direct evidence of pure anti-initiating activity by a natural anti-carcinogen (indole-3-carbinol) found in human diet (Dashwood, 2007).

**ii) Isothiocyanates:** Isothiocyanates are commonly found in other vegetables and spices and can be synthesized industrially. However, some isothiocyanates have goitrogenic effects (Michnovicz and Brad, 1990)

**a)Sulforaphane:** Sulforaphane is an anticancer, anti diabetic and antimicrobial compound that can be obtained by eating cruciferous vegetables such as brussel sprouts, broccoli, cabbages, cauliflower etc. The enzyme myrosinase



Allyl sulphide has the following medicinal function:

i) Allyl sulphides may have an antibacterial effect particularly against *Helicobacter Phylori* and inhibit the bacterial conversion of nitrate in the stomach.

ii) Nitrosation of amines, amides and proteins can give rise to N-nitroso compounds some of which are carcinogenic, inhibiting nitrosation is one rationale for the apparent protection of allyl sulphides against stomach cancer.

iii) Twenty five (25) controlled trails have shown that intakes of garlic powder (600 -

transforms glucoraphanin (aglucoisolate) into sulforaphane upon damage to the plant (such as from chewing). The young sprouts of broccoli and cauliflower are particularly rich in glucoraphanin. The anticancer activity of sulforaphane is thought to be related to the induction of phase II enzymes of xenobiotic transformation (such as quinine reductase and glutathione-s-transferase) and enhancing the transcription of tumor suppressor proteins. Researchers have first identified sulforaphane in broccoli sprouts which, of the cruciferous vegetables have the highest concentration of sulforaphane (Zhang *et al.*, 1992). Consumption of broccoli sprouts has been shown to be effective in inhibiting *Helicobacter phylori* growth with sulforaphane being atleast one of the active agents (Galan *et al.*, 2004). Sulforaphane seem to protect skin against ultra violet radiation damage and thus potentially against cancer when applied topically (Talalay *et al.*, 2007).

**b) Phenyl isocyanate:** Phenyl isocyanates gives bitter test to watercress and also inhibit tumorigenesis by polycyclic aromatic hydrocarbons. It also induces apoptosis by caspase-8 activation and is particularly good against nitrosamines in tobacco smokes.

#### 4) Thiosulfonates (Allylsulphides)

Allium vegetables includes onions, garlic, leaks, and chives and contain allylsulphides which give these plant family their characteristic taste and smell. For long, garlic has been recognized to posses antiseptic and cardioprotective qualities.

Garlic (*Allium sativum*) like other plants has an exquisite depense system composed of as many different components as human immune system in order to protect itself from insects and fungi, Garlic enzymatically produce Allicin when it is injured and thus, Allicin is mother nature's insecticide. When garlic cloves are crushed the amino acid allinin is enzymatically converted to allicin by allcinase. Allicin is unstable and converted rapidly to sulphide compounds (Cavallito, 1944).

900mg/day) produce a 12% reduction in total serum cholesterol and a 13% reduction in Triacylglycerols but with little impact on HDL cholesterol levels. Effects were attributed to sulphur-containing compounds (Amagase *et al.*, 2001).

**5) Phytosterols:** Phytosterols are group of steroids alcohols, phytochemicals naturally occurring in plant e.g.  $\beta$ -sitosterol is one of the several pytosterols with chemical structures similar to that of cholesterol. It is white in colour and waxy in nature.

It is widely distributed in the plant kingdom and found in avacados, curcubita pepo, pygeum africanum, cashew fruit, rice bran, wheat germ, corn oils and soy beans. Alone and in combination with similar phytosterols,  $\beta$ -sitosterol reduces blood levels of cholesterol, and in sometimes used in treating hypercholesterolemia (Arts and Hollman, 2005).

#### **6) Anthraquinones**

**a) Senna:** senna side are dianthrones from dried leaves of leguminous herbs or shrubs of the pulse family and have purgative for the lower bowel. It also increases peristaltic movement in colon and have nauseating taste. It was also contraindicated for hemorrhoids or inflammation (Arts and Hollman, 2005).

**b) Barbalon:** Aloin from aloe vera plant (lily an onion family), used as laxative (lower bowel) and uterine stimulant. Use by Galen to heal skin burns, ulcer, and helminthic. It can also cause gastritis and nephritis (Arts and Hollman, 2005).

**c) Capsaicin:** Capsaicin cause burning sensation for mammals not birds and also stimulate neurons for burning and abrasion sensation. Capsaicin is soluble in fat and alcohol but not in water and can also cool mouths with cold milk alcohol or ice cream. The potency of Capsaicin is not reduced by cooking or freezing. Capsaicin also promote apoptosis in pancreatic cancer cells but no effect on normal pancreatic cells and may relieve chemotherapy induced neuropathy. Capsaicin inhibits NF-KB transcription of proinflammatory and antiapoptotic genes (Arts and Hollman, 2005).

**7) Other** classes such as piperine (found in black pepper, generate heat and sneezing. It increases intestinal absorption of food and act as insecticide. Use historically as a spice make the taste of spoiling meat), chlorophyll (most abundant in plant with principle light harvesting pigment in photosynthesis), betaine (trimethylglycine found in beets and capable of removing pro-atherosclerotic protein homocystine from the body), pectin (soluble fibres in apples binds to sugar releasing them slowly and keeping blood sugar levels steady and lowest cholesterol) and oxalic acid (especially high in rhubarb and also found in raw spinach, beat, cocconut, parsley and tea. Oxalic acid bind to calcium reduce its availability and excreted in urine or forms kidney stones) (Arts and Hollman, 2005).

#### **Phytochemicals as Therapeutics**

There is evidence from laboratory studies that phytochemicals in fruits and vegetables may reduce the risk of cancer possibly due to dietary fibers, polyphenol, antioxidant and anti-inflammatory effects. Specific phytochemicals, such as fermentable dietary fibres, meet significant scientific agreement to be allowed limited health claims by the United State food and Drug Administration (FDA, 2004)

Phytochemicals have been used as drugs for millennia, for example, Hippocrates have

prescribed willow tree leaves to abate fever. Salicin have anti-inflammatory and pain relieving properties and was originally extracted from the white willow tree and later synthetically produced to become the staple over - the counter drug called Aspirin (Benbest, 2008). An important cancer drug, Taxol (paclitaxel), is a phytochemical initially extracted and purified from the pacific yew tree.

Among edible plants with health promoting phytochemicals, Di-indolylmethane, from Brassica vegetables (Broccoli, Cauliflower, Cabbage, kale, Brussels sprouts) may be useful for receiving respiratory papillomatosis tumors. (caused by the human papilloma virus), is in phase III clinical trials for cervical dysplasia (a precancerous condition caused by the human papilloma virus) and is in clinical trials sponsored by the national cancer institute of the United States for a variety of cancers (breast, prostate, lung, colon and cervical) (Arts and Hollman, 2005).

The compound is being studied for anti-viral, anti-bacterial and anti-cancer properties, through a variety of pathways and has been shown to synergize with taxol in its anti-cancer properties, making it a possible anti-cancer phytochemicals as taxol resistance is a major problem for cancer patients (Arts and Hollman, 2005). Some phytochemicals with medicinal properties may be elements rather than complex organic molecules. Selenium for example is abundant in Brassica vegetables which may have anti-viral and anti-cancer properties. Selenium is a cofactor element for synthesis of glutathione, a potent and important anti oxidant synthesized primarily in the liver (Arts and Hollman, 2005).

#### **Clinical Trials and Health Claim Status**

There are currently many phytochemicals possibly having medicinal properties in clinical trials for a variety of diseases. Lycopene, for example, from tomatoes has been tested in clinical trials for cardiovascular diseases and prostate cancer, these studies, however, did not attain sufficient scientific agreement to conclude an effect on any disease. According to FDA report, that very limited and preliminary scientific research suggest that, eating one-half to one cup of tomatoes and/or tomato sauce a week may reduced the risk of prostate cancer, the FDA concludes that there is little scientific evidence supporting this claim. Likewise, although lutein and zeaxanthins may affects visual performance and inhibit macular degeneration and cataracts, there was insufficient scientific evidence from clinical trials for such as specific effects or health claim (FDA, 2004)

Many phytochemicals have anti-inflammatory properties invitro, including turmeric and chia. Inflammation is a factor in many diseases of aging including Alzheimer's and arthritis. Turmeric is also reported to be active against skin cancer (Melanoma) (FDA, 2004).

### Phytochemicals and Food Processing

Phytochemicals in freshly harvested plant foods may be destroyed or removed by modern processing techniques possibly including cooking. For this reason, industrially processed foods likely contain fewer phytochemicals and may thus be less beneficial than unprocessed food. Absence or deficiency of phytochemicals in processed food is believed to have contributed to the increased prevalence of the above-cited preventable or treatable causes of death in contemporary society. Interestingly a converse example exists in which lycopene, a phytochemical present in tomatoes, is concentrated in processed foods such as spaghetti sauce and ketchup in manner that make the processed version of the tomatoes better sources of lycopene than fresh tomatoes (Rao *et al.*, 2006).

### Mechanism of Action of Phytochemicals

Phytochemicals are many and each works differently, the following are their possible mechanisms of actions:

- i) Antioxidants: Most phytochemicals have anti-oxidant activity and protect cells against oxidative damage and reduce the risk of developing certain types of cancer. Phytochemicals with anti oxidant activity e.g. allylsulfides (onions, leeks, garlic), carotenoids (fruits carrots), flavonoids (fruits, vegetables), polyphenols (tea, grapes).
- ii) Hormonal action: Isoflavones found in soy, initiate human estrogens and help to reduce menopausal symptoms and osteoporosis.
- iii) Stimulation of enzymes: Indoles which are found in cabbages stimulate enzymes that make the estrogen less effective and could reduce the risk for

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breast cancer. Other phytochemicals, which interfere with enzymes are protease inhibitors (soy and beans), terpenes (citrus fruits and cherries).

- iv) Interference with DNA replication: Saponins found in beans interfere with the replication of cell DNA, thereby preventing the multiplication of cancer cells. Capsaicin found in hot peppers, protects DNA from carcinogens.
- v) Anti-bacterial effects: The phytochemical allicin from garlic has anti-bacterial properties.
- vi) Physical action: Some phytochemicals bind physically to cell walls thereby preventing the adhesion of pathogens to human cell walls. Pro anthocyanidins are responsible for the anti-adhesion properties of cranberry.

### CONCLUSION AND RECOMMENDATION

Most phytochemicals have been found to be produced by plant as a means of protecting itself but through research, clinical trials have shown to have protective roles against diseases that affect mankind.

It is therefore recommended that consumption of fresh fruits and vegetables be encouraged for the populace to benefit from these nature's endowment. Preservation methods also should be geared towards methods that preserve the fresh fruits or vegetables like fresh cut methods. More research should also be done on the precise mechanism of action of important phytochemicals present in fruits and vegetables particularly locally available ones. Because of clinical significances of numerous phytochemicals, I recommend the determination of precise mechanisms of action of all the phytochemicals in order to get more of their medicinal importance.

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