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Review

Pharmacological and other beneficial effects of anti-nutritional factors in plants - A review

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The health and other benefits of plant's secondary metabolites, also known as antinutritional factors are reviewed. Examples of these natural compounds of plant origin are saponins, flavonoids, alkaloids, tannins, oxalates, phytates, trypsin (protease) inhibitors, phytohaemagglutinins (lectins), just to mention a few. Emphasis has always been laid on the toxic and anti-nutrient effects of these compounds in the natural state even though many of them are detoxified by several processing methods such as soaking, germination, boiling, autoclaving, fermentation, genetic manipulation and other processing methods. In recent years, there has been an increasing interest by researchers in the use of naturally occurring biologically active compounds of medicinal value (phytomedicines). The plant kingdom still contains many species of plant-containing substances of pharmacological and other benefits. In the search for new drugs to combat the problem of drug resistance, natural products of plant origin play a vital role. This review is an attempt to redefine the importance of these natural compounds as a possible solution to the problem of drug resistance and to explore their potentials for the benefit of humans and animals.

Key words: Pharmacological, beneficial effects, anti-nutritional factors, plants.

INTRODUCTION

Anti-nutritional factors (ANF) are compounds which act to reduce nutrient utilization and or food intake (Osagie, 1998). These antinutritional factors play a great role in limiting the wider use of many plants. They are natural compounds capable of precipitating deleterious effects in man and animals (Osagie, 1998). The levels of toxic substances in plants vary with the specie of plant, cultivar and post-harvest treatment such as soaking, drying, autoclaving and seed germination. These anti-nutritional factors are also known as 'secondary metabolites' in plants and they have been shown to be highly biologically active (Zank, 1991). Although most of these secondary metabolites elicit very deleterious biological responses, some of them have found a wide application in nutrition and as pharmacologically active agents (Oakenfull and Sidhu, 1989).

Saponins and flavonoids, for example, have found wide applications in the fields of medicine, pharmacy and food industries as pharmacologically active principles (Schopke and Hiller, 1990); in food, drink and beverage industries as foaming agents (Fenwick et al., 1983; Oakenfull and Sidhu, 1989); as antioxidants, preservatives and flavouring agents (You et al., 1993; Fenwick et al., 1983) and in agriculture especially as allelochemicals (Oleszec et al., 1992; Waller et al., 1993).

In the native African traditional medicine and folk medicine, concoctions prepared from plant materials using water or local alcohol may contain a complex mixture of hundreds of bioactive plant secondary metabolic constituents (Igile, 1995). The mode of action of these compounds has been described in detail by other reviewers and this will not be discussed here. The nutritional, biochemical and physiopathological effects of these antinutritional factors have been reviewed by Aletor (1993). The significance of these compounds in humans, animals and the plant kingdom has been discussed.

The aim of this review is to highlight the pharmacological and other applications of these secondary plant metabolites and to emphasize on the need for them to be phytochemically exploited as phytomedicines and functional foods.

ANTICARCINOGENIC ACTIVITY

Tannins are reported to have possible anticarcinogenic effects (Butler, 1989) and are also suggested to play a major role in plant's defense against fungi and insects. Haemagglutinins are reported to cause agglutination of malignant cells and induction of mitosis in lymphocytes, and precipitation of polysaccharides and glycoproteins (Sharon and Lis, 1972). Saponins are also reported to have anticancer properties, inhibiting about two-thirds the development of azoxymethane-induced preneoplastic lesions in the colon (Koratkar and Rao, 1997). Saponins have long been established as cytotoxic agents (Das and Mahato, 1983) and that their cytotoxic potency is structure dependent (Agarwal and Rastogi, 1974). Many anti-tumour drug preparations used for the chemotherapeutic management of various types of cancer contain saponins in their chemical formulations. Examples are ginseng, quillaia and gypsophila saponins (Oteake et al., 1987). These saponins have been reported to inhibit the growth of both benign and malignant tumours (Agarwal and Rastogi, 1974; Schopke and Hiller, 1990; Wakabayashi et al., 1997). Studies at the University of Toronto, Department of Nutritional Science, Toronto, Canada reported that dietary sources of saponins offer preferential chemopreventive strategy in lowering the risk of human cancers. Saponins can inhibit or kill cancer cells without killing normal cells (Rao, 1996).

Isoflavones are being studied for their potential role in the prevention and treatment of cancer (Messina, 1999). Apart from isoflavones, there are a number of phytochemicals in soyabeans with demonstrated anticarcinogenic activity. These include phytates, saponins, phytosterols, protease inhibitors and many phenolic acids (Messina and Barnes, 1991). However, most data reported isoflavones as being responsible for the hypothesized anticancer effects of soy (Messina, 1999).

The primary isoflavones in soybeans are genistein (4,5,7-trihydroxyisoflavone) and daidzein (4,7-dihydroxyisoflavone) and their respective β-glycones, genistin and daidzein (sugars are attached at the 7 position of the A ring) (Messina, 1999). Daidzein exhibits anticancer effects. This was seen in the inhibition of the growth of HL-60 cells implanted in the sub-renal capsules of mice (Jing et al., 1993). However, genistein attracted a lot of interest. There are several reports of *in vitro* studies showing that genistein inhibits the growth of a wide range of both hormone-dependent and hormone independent cancer cells including breast (Peterson and Barnes, 1991, 1996; Pegliacci et al., 1994; Peterson et al., 1996; So et al., 1996; Clark et al., 1996; Zava and Duwe, 1997) and prostate cells (Peterson and Barnes, 1993; Naik et al., 1994; Kyle et al., 1997), colon (Kuo, 1996; Kuo et al., 1997) and skin (Rauth et al., 1997) (reviewed by Akiyama and Ogawara, 1991; Constantinou and Huberman, 1995; Adler Creutz and Mazur, 1997). Also, *in vitro* genistein inhibits the metastatic activity of both breast (Scholar and Toewa, 1994) and prostate (Santibanez et al., 1997) cancer cells independent of the effects on cell growth.

There are speculations that isoflavones may promote bone health based on the similarity in structure between isoflavones and oestrogen and the findings that isoflavones possess weak oestrogenic properties (Messina, 1999). Some flavonoids have been shown to prevent liver cancer (hepatoma) and to prevent the liver from lipid peroxidative effects in experimental hyperlipidaemia (Blazovics et al., 1993).

PESTICIDAL/INSECTICIDAL ACTIVITIES

Rodents are generally known to be depressed following the ingestion of foods containing high levels of hydrolysable tannins. Apart from the inhibition of digestion, tannins are breakdown to produce fatty liver and gallic acid in the presence of esterases (Freeland et al., 1985), which in turn suppress growth in animals such as rats (Joslyn and Glick, 1969). As a result of this, tannins may be used as a component of biological rodenticide, in the control of rodents which invade and destroy food plants, thus reducing the economic and nutritional value of human foods and animal feeds.

Several plant chemical components are known to have insecticidal properties either as whole leaves, powders or water and or oil extracts (Aletor, 1999). According to Sharma and Norris (1991), some of the chemical groups used for insecticidal activities include tannins, flavonoids, alkaloids, terpenoids among others. As a result of this, a lot of highly polyphagous insects which are known to tolerate many different compounds do not feed on plants that accumulate such compounds. This results in the protection of such plants against a wide range of insect pests (Nahrstedt, 1988). Soyabean is known to be resistant to many insects and several insecticidal compounds have been isolated from it (Jones and Sullivan, 1979; Sharma and Norris, 1991). Gatehouse et al. (1991) identified lectins (haemagglutinins) as the active principle involved in the insecticidal activity of the winged bean (*Psophocarpus tetragonolobus*) against the larvae of the seed beetle (*Callosobrochus masculatus*). Several other leguminous seeds are known to contain a wide range of secondary compounds that protect them against insect attacks (Gatehouse et al., 1989). A lectin isolated from *Phaseolus vulgaris* has been demonstrated as being insecticidal to *C. masculatus* (Janzen et al., 1976; Gatehouse et al., 1984).

Trypsin (protease) inhibitors are also reported to have insecticidal properties. The protease inhibitors from cowpea (*Vigna unguiculata*) were shown to be antimetabolic to *C. masculatus* by Gatehouse et al. (1979).

Sharma and Norris (1991) isolated two flavonoids and glyceolins with antinutritional effects against the larvae of the cabbage looper, *Trichoplusia ni*, from soyabeans.

In the chemical industry, flavonoids are used in the manufacture of insecticides using the isoflavonoid, rottenone (Harborne, 1967) and in the preparation of various cosmetic products, where they are used as natural stabilizers and preservatives and are synergistically used to enhance the antimicrobial activities of many skin lotions and their products. The oviposition and ovicidal activities of alkaloidal extract from *Murraya koenigii* were reported against two important vector mosquitoes, *Culex quinquefasciatus* and *C. tritae* by Rajkumar and Jebanesan (2003).

ANTIMICROBIAL ACTIVITY

Saponins are reported to have antibiotic activities (Tchesche and Wulff, 1963; Zimber et al., 1965; Cucu and Grecu, 1971; Gestetner et al., 1971; Asa et al., 1972; Soetan et al., 2006), antifungal activities (Jun et al., 1989) and antiviral activity (Okubo et al., 1994). Prowers (1964) reported that several flavonoids including phenolic acids showed inhibitory activity towards one or more of the bacteria studied. Krammer et al. (1984) reported the fungicidal activity of isoflavones from soybeans and chickpeas on three food-containing fungi, *Aspergillus ochracens*, *Penicillium digitatum* and *Fusarium culmorum.*

Oleszek et al. (1990); Shimoyamada et al. (1990) reported that plants often defend themselves against microorganisms through the production and or accumulation of antinutritional factors. An example is the presence of the triterpene glycoside, a saponin in all parts of the alfalfa plant which is widely reported to have antifungal activities (Olesek et al., 1990). Other saponins possessing antifungal properties have also been reported. Some other plant secondary metabolites are also known to inhibit the germination of some fungal spores. Mehansho et al. (1987) reported that a number of phenolic compounds including tannins are able to inhibit the germination of spores of *Colletorichun germinicola*. Van Etten, (1976) showed that the ptero-carpans and related isoflavonoids significantly inhibited the activity of *Fusarium solani* and *Aphanomycetes euteiches.* Mori et al. (1987) demonstrated the antibacterial activity of the flavonoid, epigallocatechin against *Proteus vulgaris* and *Staphylococcus aureus* and showed that this flavonoid and the others tested were strongly inhibitory to these fungi. Tannins are involved in the protection of plants against fungi and micro-organisms (Ayres et al., 1997). Tannins are also able to affect microbial activity in the soil (Lewis and Starkey, 1968). The effects of tannins on soil microbes are used to play a role in succession in plant communities (Schimel et al., 1996).

ANTHELMINTIC ACTIVITY

Molan et al. (1999, 2000, 2000a,b, 2002) reported the inhibitory effects of tannins against gastrointestinal nematodes and deer lungworms. They reported that condensed tannins (CT) extracted from forages have the ability to inhibit the development of *Trichostrongylus colubriformis* eggs (L1) to infective larvae (L3) and to reduce larval motility. They suggested that these CT-containing forages may have the ability to break the life cycle of sheep nematodes and reduce the contamination of pasture with infective larvae and that this may reduce dependence on anthelmintic drugs as the main method of controlling parasites. This shows the anthelmintic effects of tannins and the potential of using them as an anthelmintic agent.

Triterpenoid saponins from *Zygophylum* species are used in traditional medicine as an anthelmintic agent (Elgamal et al., 1995). Lasisi et al. (2003) reported the effects of condensed saponins on hatching of eggs of bovine gastrointestinal nematodes *in vitro*. At high concentrations of the saponin extract, the percentages of the nematode eggs that hatched were reduced.

Dietary proanthocyanidins (tannins) can contribute to improved animal health by reducing the detrimental effects of internal parasites in sheep (Niezen et al., 1995). Philipson et al. (1993) reported tropical plant extracts as sources of anti-protozoal agents.

HYPOCHOLESTEROLAEMIC ACTIVITY

The beneficial effects of saponins are largely due to their hypocholesterolaemic action, leading to the belief that they may prove useful in the control of human cardiovascular disease (Oakenfull and Sidhu, 1983). The hypocholesterolaemic activity of dietary saponins may be due to the formation of some complexes with dietary cholesterol or their bile salt precursors which can then be made unavailable for absorption. Most saponins form insoluble complexes with 3-β-hydroxysteroids and are known to interact and form large, mixed micelles with bile acids and cholesterol (Messina, 1999).

Johnson et al. (1986) reported that besides lowering serum cholesterol, saponins also readily increasing the permeability of the mucosal cells of the small intestine, thereby facilitating the uptake of materials to which the gastrointestinal tract would not normally be permeable. In human nutrition, saponins are reported to assist in the prevention of cardiovascular diseases (Malinow et al., 1977; Topping et al., 1980; Malinow et al., 1985) by lowering plasma cholesterol concentrations through the excretion of cholesterol directly or indirectly as bile acids. Saponins cause a depletion of body cholesterol by preventing its reabsorption, thus increasing its excretion in much the same way as other cholesterol-lowering drugs, such as cholestyramine.

APPLICATIONS IN THE FOOD INDUSTRY

Certain plant extracts which contain saponins are used as flavourings in food (Merck Index, 1960) and as foam-producing agents. Purified saponins or their concentrated extracts are used as food additives in the manufacture of food and drinks primarily as foaming agents or as emulsion stabilizers. Saponins are also used as an anti-oxidant for food use (Takashi et al., 1986). Saponins are used in the preparation of spray dried powders containing vitamin E for the enrichment of foods, drinks and animal feeds. Interest in the beneficial effects of isoflavones is due to their oestrogenic activity and their possible use as growth promoters in the animal feed industry (Bradbury and White, 1954). In the food processing industries, flavornoids have been shown to inhibit heat or chemical initiated lipid peroxidation as well as chelating metallic and super oxide ions (Kim et al., 1990). Flavones and leucoanthocyanidins are known to impart very pleasant flavours in foods after processing (Harborne, 1967). Flavones also impart a bitter taste in many soft drinks and bitter lemon brands.

ANTI-INFLAMMATORY ACTIVITY

Although alkaloids are known to be the most potent anti-inflammatory agents of the naturally-occurring products of secondary metabolism, the same activity is shown to be attributed to flavonoids and saponins (Igile, 1995). Handa et al. (1992) reported that Ternatin, a flavonoid from *Egletes viscosa*, has been shown to have CNS activity and also exhibits antipyretic effect on Brewer's yeast-induced pyrexia in rats.

A flavonoid mixture from *Sempervivum tectorum* was shown to possess highly-potent typical and oral-inflammatory activity dose dependently (Blazovics et al., 1993). An extensive study of the antiarthritic and anti-inflammatory activity of flavonoids has been documented by Hanada et al. (1992).

Anti-inflammatory activities of quercetin, luteolin and 3-methyl quercetin were demonstrated to be effective against oedema in rats induced by carageenan (Simoes et al., 1988). The anti-inflammatory effects of 5, 7-dimethoxy flavone were found to be comparable to aspirin effects on the rat paw oedema model (Panthong et al., 1989). Braide (1993) showed the anti-inflammatory effects of kolaviron, a biflavonoid from *Gercinia kola*. He reported that kolaviron significantly inhibited turpentine-induced joint oedema, carrageenan-induced paw oedema and pleurisy, and also brewer's yeast-induced pyrexia in rats.

Saponins are reported to have several pharmacological properties. Their wide range of chemical and physical properties contributes to their wide range of pharmacological as well as biochemical and physiological effects (Oakenfull, 1981; Cheeke, 1983; Price and Fenwick, 1990; Just et al., 1998; Chao et al., 1998). *Bupleurum fruitcescens* saponins have been shown to exhibit anti-inflammatory activity (Just et al., 1998). Saponins are also reported to have analgesic properties (Gomes et al., 1987).

Flavonoids from amaranth and plants of the amaranthus family had been reported to be effective against dermatitis (Al-Saleh et al., 1993). These authors also reported that flavonoids from *Chenopodium murale* L. had inhibitory effects on fungal-induced dental caries, although not all flavonoids have antimicrobial activity.

Isoflavones are being studied for their potential role in the prevention and treatment of many chronic diseases, including certain forms of cancer, osteoporosis and heart disease and also for their ability to relieve menopausal symptoms (Messina, 1999). Saponins from the roots of *Peuraria lobata* showed hepato-protective action *in vitro* (Arao et al., 1998).

DIURETIC, ANTI-DIABETIC AND ANTI-ULCER ACTIVITIES

Saponins from *Vigna radiate*, *Vigna mungo* and *Vigna sinensis* were all shown to have diuretic activities (Chowdhurry et al., 1987). The triterpenoids of *Artidesma menasu* were also shown to be diuretic (Rizvi et al., 1980). Saponins are also reported to have anti-diabetic activity (Yamaguchi, 1993), anti-ulcer activity (Zhang and Hu, 1985; Aguwa and Okonji, 1986; and Marhuenda et al., 1993).

ANTI-OXIDANT/ANTI-AGEING ACTIVITY

Tkayama et al. (1984) reported that flavonoids are potent inhibitors of molecular oxygen (O_2), thus acting as free radical scavengers (anti-oxidant). Flavonoids also scavenge other free radicals as OH and N_3 (Bors et al., 1990). Flavonoids suppress the effects of active oxygen species (H_2O_2 and O_2^-) in many other vulnerable biological systems (Nakayama et al., 1993). Flavonoids are used as natural anti-oxidants in food, medicinal and non-nutritive plant materials due to their ability to inhibit and scavenge reactive oxygen species (Kim et al., 1990; Larson, 1988). Isoflavones are also known to act as anti-oxidants in the test tube (Ruiz-Larrea et al., 1997). Saponins are reported to have anti-ageing activity which is related to their free radical scavenging action (Jun et al., 1986; Hongping et al., 1993). Saponins are also reported to improve learning processes and memory retention in experimental animals (Zang and Hu, 1985). Saponins also inhibited lipid peroxide formation in tissues and elevated the blood and brain superoxide dismutase activity. Yoshiki and Okubo (1995) reported the active oxygen-scavenging activity of saponins. Huong et al. (1998) reported the protective action of Vietnamese ginseng saponins against free radical-induced injury.

IMPORTANCE IN AGRICULTURE

The allelopathic effects of saponins are very important in agriculture. Oleszek et al. (1992); Waller et al. (1993) and Igile (1995) reported the allelopathic effects of saponins from alfalfa and *Vernonia amygdalina* (Compositae) leaves respectively. Flavonoids are also used as regulators of seed germination and plant growth (Igile, 1995).

Aerts et al. (1999) reported the beneficial effects of proanthocyanidins (tannins) in forages. They stated that forages containing moderate concentrations of proanthocyanidins (2 - 4% digestible matter) can exert beneficial effects on protein metabolism in sheep, slowing down the degradation of dietary protein to ammonia by rumen micro-organisms and increasing protein outflow from the rumen, thus increasing the absorption of amino acids in the small intestine of the animal. This was reported to result in increases in lactation, wool growth and weight gain without changing voluntary feed intake. Min et al. (2003) also reported the effects of condensed tannins (CT) on the nutrition and health of ruminants fed with fresh temperate forages. They stated that condensed tannins can be used to reduce the degradation of forage proteins in the rumen, without reducing the amount of microbial protein synthesized. CT in several forage plants such as *Lotus corniculatus* and *Hedysarum coronarium* have been shown to offer advantages for ruminants and have resulted in increased milk production, wool growth, ovulation rate and lambing percentage as well as reducing bloat risk and reducing internal parasite burdens. This is probably related to the action of condensed tannins in increasing essential amino acid absorption from the small intestine. In the case of internal parasites, their inactivation by condensed tannins is also involved.

Dietary proanthocyanidins can also reduce the risk of bloat in cattle (Tanner et al., 1997). Proanthocyanidins offer a natural and ecologically sound means of solving problems in animal husbandry (Aerts et al., 1999).

PHARMACEUTICAL APPLICATIONS

Tannins are constituents of several drugs because of their astringent property. They are used in the treatment of haemorrhoids, diarrhoea, dysentery, leucorrhoea and as a useful medicine for the throat (Allport, 1970). The fact that saponins can increase the permeability of intestinal mucosa raises the possibility of interesting nutritional and pharmacological uses (Cheeke, 1971).

Saponins have been found useful in the preparation of atherosclerosis agents (Grininger and Fisher, 1958; Shibata, 1977), hypocholesterolaemic agents (George, 1965), the central nervous system (CNS) depressants and in the treatment of ulcers (Shibata, 1977). Saponins are useful in the treatment of hypocholesterolaemia. They bind to cholesterol, making it unable to be reabsorbed into the system and are excreted from the body (Rao, 1996).

Flavonoid drugs have been widely used in medical practice for many years in the management of circulatory disorders involving capillary dysfunction. They were also effective in preventing or alleviating capillary fragility and permeability (Fahey and Jung, 1989). Flavonoids are currently used to potentiate the *in vivo* and *in vitro* activity of other drugs and vice-versa (Hoffman et al., 1988). Their synergistic use with vitamin E as anti-oxidants is more potent than when either of them is used singly (Ferriola et al., 1989). De Eds (1968), Robbins (1973) and Srinivasan et al. (1973) reported the beneficial physiological and pharmacological effects of flavonoids on blood capillaries as:

i. Chelating metals, thus sparing ascorbate from oxidation,
ii. Prolonging epinephrine action by the inhibition of O-methyltransferase
iii. Stimulating the pituitary-adrenal axis and
iv. Acting on the aggregation of erythrocytes.

The action of flavonoids on erythrocyte aggregation is consistent with their beneficial effects on capillaries and in disease states because the aggregation impairs micro-circulation and also induces pathology. Flavonoids reduce aggregation by membrane surface effects especially those with multiple methoxyl and ethoxyl groups (Harborne et al., 1975). Shampoos and other hair preparations and various cleansing agents are manufactured using saponins (Lion, 1985 a, b, c).

Legumes produce primary and secondary metabolites and other phytochemicals such as nutraceuticals, pharmaceuticals, pesticides and industrial products (Morris, Brad, 2003). Kievitone, the potential breast cancer fighting chemical is found in hyacinth bean. Agmatine and isovitexin are potential chemicals that combat microbial organisms in mammals including humans. They are found in winged bean. Visoltricin, a novel metabolite of *Fusarium tricinctum*, was reported to be toxic to *Artemia salina* leaves and cytotoxic human tumour cells (Visconti and Solfrizzo, 1994). Work is in progress to test visoltricin or its derivatives for their potential application in medicine for the treatment of glaucoma or other diseases which can be treated with anticholinesterase agents. Visoltricin is reported to have anticholinesterase activity (Visconti and Solfrizzo, 1994).

The use of natural products, especially plants for the treatment of different ailments is as old as mankind (Ogbona et al., 2007). Several workers have reported that secondary plant metabolites such as saponins, tannins, alkaloids, flavonoids, quinines and phenolic compounds have antimicrobial action (Sofowora, 1982; Ekong, 1989; Ebana et al., 1991). Alkaloids have been used in the treatment of skin infections (Sofowora, 1982; Finar, 1987). The diuretic and laxative actions of flavonoids from *Pulicaria crispa*, *Euphorbia densa* Schrenk and several other plant flavonoids have been reported (Al-Saleh et al., 1993).

IMMUNOSTIMULATORY EFFECTS

Saponins are reported to be suitable immunostimulators and they are used as adjuvants in the preparation of vaccines against several types of fungal, bacterial and protozoal infections (James and Pearce, 1988; Campbell, 1993). Since saponins are part of the active immune system of plants, research appears promising that the effects from saponins are indeed being transferred to the human body when ingested (Saponins Research Information.htm). Saponins also function as 'natural antibiotics' for plants. They help boost the effectiveness of certain vaccines. Saponins are also believed to boost energy (Saponins Research Information,htm).

Tannins in general are considered to be part of the plant chemical defenses against pathogens and herbivores (Bernays et al., 1989).

MANAGEMENT OF ARTHEROSCLEROSIS

Saponins have been shown to exhibit various cardiovascular activities. The ability of saponins to penetrate cell and plasma membranes in order to cause positive inotropic effects in isolated cardiac muscles (Yamasaki et al., 1987; Enomoto et al., 1986), qualified them to be included in numerous pharmaceutical formulations for the management of artherosclerosis (Schopke and Hitler, 1990), myocardial infarction (Yang et al.,1986), aging pectoris (Li et al.,1988) and hypertension (Gu et al.,1987; Sokolov, 1986). Ginseng leaf saponins are reported to protect the ultrastructure of the myocardium (Wang et al., 1985). Flavonoids have also been shown to be capable of modifying low density lipoproteins (LDL) in order to greatly increase its uptake by macrophages, thereby reducing the level of low density lipoproteins (LDL) in the body (Rankin et al., 1993). As such, flavonoids can be applied in the management of atherosclerosis.

Soy isoflavones assist in the prevention of cardiovascular diseases (heart disease and stroke). Numerous controlled clinical trials suggest that increasing soy isoflavone intake, especially by substituting soy protein for animal protein, can result in a more favourable cardiovascular disease risk profile (Crouse et al., 1999; Jenkins et al., 2002; Sandars et al., 2002; Lichtenstein et al., 2002; Dalais et al., 2003; Sagara et al., 2004).

OESTROGENIC EFFECTS

Soy isoflavones are known to have weak oestrogenic activity. Scientists are interested in the tissue-selective activities of phytooestrogens because anti-oestrogenic effects in reproductive tissue could help reduce the risk of hormone associated cancers (breast, uterine and prostate) while oestrogenic effects in other tissues could help maintain bone density and improve blood lipid profiles/ cholesterol levels (Micronutrient Information Center).

CONCLUSION

Although many different and potentially dangerous compounds have been isolated from many of the potentially useful plants, little emphasis is placed on their beneficial effects as compared to their toxic and antinutritive effects. As plant breeders and nutritionists are looking for ways to reduce the concentration of these antinutrients in plant foods, efforts should also be geared towards exploiting the pharmacological and medicinal potentials of these secondary plant compounds. Chemically synthesized drugs are very expensive and micro-organisms are developing resistance to them. This calls for the need to explore the natural compounds of plants to solve the problem of drug resistance encountered in the management of diseases. Plant Biotechnology techniques like tissue culture, genetic manipulation and other modern plant breeding methods will play a vital role in optimising the pharmacological and other beneficial effects of these anti-nutritional factors in plants.

REFERENCES

Aerts RJ, Barry TN, McNabb WC (1999). Polyphenols and Agriculture: Beneficial effects of proanthocyanidins in forages. Agriculture, Ecosyst. Environ. 75: 1-2.

Agarwal SK, Rastogi RP (1974). Triterpenoid saponins and their genins: Phytochemistry 13: 2623.

Aguwa CN, Okonji CO (1986). Antifungal effects of extracts of some Nigerian herbal plants. J. Ethnopharmacol. 15: 45.

Akiyama T, Ogawara H. (1991). Use and specificity of genistein as inhibitor of protein-tyrosine kinases. Methods Enzymol. 201: 362-370.

Aletor VA (1993). Allelochemicals in Plant Food and Feedingstuffs I. Nutritional, Biochemical and Physiopathological aspects in Animal Production. J. Vet. Hum. Toxicol. 35(1): 57-67.

Aletor VA (1999). Antinutritional factors as nature's paradox in Food and Nutrition securities. Inaugural lecture series 15 Delivered at the Federal University of Technology, Akure on Thur, August 12, 1999.

Allport Noel (1970). Drugs containing tannins,. In: Chemistry and Pharmacy of vegetable drugs.

Al-Saleh AHH, Mira M (1993). Chemical constituents of some medical plants growing in Britain LXIV 3: 251.

Arao T, Udayama M, Kinjo J, Nohara T (1998). Preventive effects of saponins from the *Peureria lobata* root on in-vitro immunological liver injury of rat primary hepatocyte culture. Plant. Med. 64(5): 413-416.

Ayres MP, Clausen TP, MacLean S, Redman AM, Reichardt PB (1997). Diversity of structure and antiherbivore activity in condensed tannins. Ecology 78: 1696-1712.

Bernays EA, Cooper DG, Bilgener M (1989). Herbivores and plant tannins. In: Begon, M, Fitter AH, Ford ED, MacFadyen A (Eds): Advances in Ecological Research, 19, Academic Press, London, pp. 263-302.

Blazovics A, Pronai L, Feher J, Kery A, Petri G (1993). A natural antioxidant extract from Sempervivum tectorum. Phytother. Res. 7: 95-97.

Bors W, Heller W, Michel C, Saron M (1990). Flavonoids as antioxidants: Determination of radical scavenging effeciencies. Methods. Enzymol. 186: 343.

Bradbury RB, White DE (1954). Oestrogens and related substances in plants. Vitam. Horm. 12: 207-212.

Butler LG (1989). Effects of condensed tannin on animal nutrition. In: "Chemistry and significance of condensed tannins'' R.W. Hemingway and J.J.Karchesy Eds. Plenum Press, New York, pp. 391-402.

Campbell JB (1993). Saponins-Adjuvants: Theory and Practical Applications, Edited by DES Stewart-Tull, Chapter 4, (In press). Butterworth-Heinemann Inc. Toronto, London, New York.

Chao AO, Nguyen JV, Broughall M, Recchia J, Kensil CR, Daddona PE, Fix JA (1998). Enhancement of intestin al model compound transport by DS-1,a modified *Quillaia saponin*. J. Pharm. Sci. 87(11): 1395-1399.

Cheeke PR (1971). Nutritional and physiological implications of saponins. A Review. Can. J. Anim. Sci. 51: 621-632.

Cheeke PR (1983). Nutritional and Physiological properties of saponins Nutr. Rep. Intn'l. 13: 315.

Cheeke PR, Fenwick GR (1990). The Chemistry and Biological significance of saponins in foods and feeding stuffs. Int. Rev. Food. Sci. Nutr. 157: 62.

Chowdhurry AKA, Jahirullah IJ, Tabukder SA, Khan AKA (1987). Diuretic activities of saponins of *Vigna spp*. J. Bangladesh Acad. Sci. 11: 75.

Clark JW, Santos-Moore A, Stevenson LE, Frackelton AR (1996). Effects of tyrosine kinase inhibitors on the proliferation of human breast cancer lines and proteins important in the RAS signaling pathway. Int. J. Cancer 65: 186-191.

Constantinou A, Huberman E (1995). Genistein as an inducer of tumour cell differentiation: Possible mechanisms of action. Proc. Soc. Exp. Biol. Med. 208: 109-115.

Crouse JR, Morgan T, Terry JG, Ellis J, Vitolins M, Burke GL (1999). A randomized trial comparing the effect of casein with that of soy protein containing varying amounts of isoflavones on plasma concentrations of lipids and lipoproteins. Arch. Int. Med. 159(17): 2070-2076.

Dalais FS, Ebeling PR, Kotsopoulos D, McGrath BP, Teede HJ (2003). The effects of soy protein containing isoflavones on lipids and indices of bone resorption in post menopausal women. Clin. Endocrinol. (Oxf) 58(6): 704-709.

Das MC, Mahato SB (1983). Triterpenoids (Review): Phytochemistry 22: 1071.

DeEds F (1968). In Comprehensive Biochemistry (M. Florkin and E.H. Storz eds) Elsevier Publishing Co. Amsterdam. 20: 127-177.

Ebana RUB, Madunagu BE, Ekpe ED, Otung IN (1991). Microbiological exploitation of cardiac glycosides and alkaloids from *Garcinia kola*, *Boreria ocynoides*, *Kola nitida* and *Citrus aurantifolia*. J. Appl. Bacteriol. 71: 398-401.

Ekong E (1989). Medicinal plants research in Nigeria. Retrospects and prospects,. In: The state of medicinal plants research in Nigeria (SMPRN Sofowora (Ed), Ibadan University Press, pp. 1-10.

Elgamal MHA, Shaker KH, Pollman K, Seifert K (1995). Phytochemistry 40(4): 1233-1236.

Enomoto Y, Ito K, Kawagoe Y, Morio Y, Yamasaki Y (1986). Inotropic effects of *Acanthopanax gracilistylus* saponins on guinea pig cardiac muscle. Br. J. Pharmacol. 88: 259.

Fahey GC, Jung HJG (1989). Phenolic compounds in forages and fibrous feedstuffs. In: Toxicants of Plant Origin,CRC Press;Boca Raton,FL, pp. 123-190.

Fenwick GR, Heaney RK, Mullin WJ (1983). Glucosinolates and their breakdown products in foods and food plants. CRC Crit. Rev. Food. Sci. Nutri. 18: 123-201.

Finar I (1987). Organic Chemistry: Vol II, Stereochemistry and Chemistry of Natural Products (5th Ed). Longman Scientific Technical. England. pp 415-417.

Fotsis T, Pepper M, Adlercreutz H (1993). Genistein, a dietary-derived inhibitor of *in-vitro* angiogenesis. Proc. Natl. Acad. sci. 90: 2690-2694.

Ferriola PC, Cody V, Middleton E (1989). Protein kinase C inhibition by plant flavonoids: Kinetic mechanisms and structure-activity relationships. Biochem. Pharmacol. 38: 1617.

Freeland WJ, Calcott PH, Geiss DP (1985). Allelochemicals, minerals and herbivore population size. Biochem. Syst. Ecol. 13: 195-206.

Gatehouse AMR, Deurey FM, Dove J, Fenton KA, Puszai A (1984). Effect of seed lectins from *Phaseolus vulgaris* on the development of Cacallosobruchus maculates mechanism of toxicity. J. Sci. Food Agric 25: 373-380.

Gatehouse AMR, Gatehouse JA, Bodie P, Kilmnoster AM, Boulter D (1979). Biochemical basis of insect resistance in *Vigna unguiculata*. J. Sci. Food. Agric.30: 948-958.

Gatehouse AMR, Home DS, Elemming JE, Hilder UA, Gatehouse JA (1991). Biochemical basis of insect resistance in winged bean (*Phosphocarpus tetragonolobus*) seeds. J. Sci. Food. Agric. 55: 63-74.

Gatehouse AMR, Shackky SJ, Fenton KA, Bryden J, Pustai A (1989). Mechanism of seed lectin tolerance by a major insect storage pests of *Phaseolus vulgaris*, *Acanthoccelides obtectus*. J. Sci. Food. Agric. 47: 269-280.

George AJ (1965). Legal status and toxicity of saponins. Unilever Research Laboratories, Guest Reviews. Food Cosmetol. Toxicol. 3: 85-91.

Gomes A, Charma RM, Ghatak BJR (1987). Analgesic effects of Olean-12-ene-3β-16,228,28,Tetrol in the rat.

Griminger P, Fisher H (1958). Dietary saponin and plasma cholesterol in the chicken. Proc. Soc. Exp. Biol. Med. 99: 424-426.

Gu W, Liu J, Zhang J, Liu X (1987). Pharmaceutical applications of saponins. J. Med. Coll. PLA 2: 315.

Hanada R, Abe F, Yamauchi T (1992). Steroid glycosides from Nerium odorium. Phytochemistry 31(9): 3183.

Handa SS, Chawla AS, Sharma AK (1992). Plants with anti-inflammatory activity. Fitoterapia LXIII,1,3.

Harborne JB (1967). Comparative biochemistry of the flavonoids., Academic Press, London. 9: 80-303.

Harborne JB, Marbry TJ, Marbry H (1975). The flavonoids. Chapman and Hall, London. 4: 1022.

Hoffman J, Droppler W, Jakob A, Maley K. (1988). Effects of Quercetin on Protein Kinase C. Inlem J. Cancer 42: 382.

Hongping P, Ling H, Zhan Z, Gang L, Xijun, H, Zhiming H (1993). Experimental studies on anti-aging effect of total saponin from stalk and leaf sanchi (*Panax natoginseng*). Chem. Abs. 120(11): 95.

Huong NT, Matsumoto K, Kasai R, Yamasaki K, Watanabe H (1998). In-vitro anti-oxidant activity of Vietnamese Ginseng saponin and its components. Biol. Pharm. Bull. 21(9): 978-981.

Igile GO (1995). Phytochemical and Biological studies on some constituents of Vernonia amygdalina (Compositae) leaves. P.hD Thesis, Department of Biochemistry, University of Ibadan, Nigeria.

James SL, Pearce EJ (1988). The influence of adjuvant on induction of protective immunity by a nonliving vaccine against Schistosomiasis. J. Immunol.140: 2753.

Janzen DH, Juster HB, Liener IE (1976). Insecticidal action of the phytohaemagglutinins in black beans on a bruchid beetle. Science 192: 795-796.

Jenkins DJ, Kendall CW, Jackson CJ (2002). Effects of high- and low-isoflavone soyfoods on blood lipids, oxidized LDL, homocysteine and blood pressure in hyperlipidaemic men and women. Am. J. Clin. Nutr. 76(2): 365-372.

Johnson IT, Gee JM, Price K, Curl C, Fenwick GR (1986). Influence of saponin on gut permeability and active nutrient transport in-vitro.116: 2270-2277.

Jones WA, Sullivan MJ (1979). Soybean resistance to the southern green stink bug *Nezera viridula*. J. Econ. Entomol. 72: 628-632.

Joslyn MA, Glic Z (1969). Comparative effects of gallotanic acid and related phenolics on the growth of rats. J. Nutr. 98: 119-126.

Jun HK, Park KY, Jo JB (1989). Inhibitory effects of ginseng saponins on aflatoxin production in culture. Chem. Abstr. 106: 116-199.

Just MJ, Recsio MC, Giner RM, Cuellar Mj, Marez S, Bilia AR, Rios J (1998). Anti-inflammatory activity of usual Lupane saponins from Bulerum fruiticescens. Planta Med. 64(5): 404-407.

Kim JY, Germolec DR, Luster MI (1990). Panax ginseng as a potential immunomodulator, studies in mice. Immunopharmacol. Immunotoxicol. 12: 257.

Koratkar R, Rao AV (1997). Effect of soyabean saponins on azoxymethane-induced preneoplastic lesions in the colon of mice. Nutr. Cancer 27: 206-209.

Krammer RP, Hindorf H, Jha HC, Kallage J, Zilliken F (1984). Antifungal activity of soyabean and cowpea isoflavones and their reduced derivatives. Phytochemistry. 23(10): 2203.

Kuo SM (1996). Antiproliferative potency of structurally distinct dietary flavonoids on human colon cancer cells. Cancer Lett. 110: 41-48.

Kuo SM, Morehouse HF, Lin CP (1997). Effect of antiproliferative flavonoids on ascorbic acid accumulation in human colon adenocarcinoma cells. Cancer Lett. 16: 31-137.

Kupchan SM, Bauerschmidt E (1971). *In vitro* effects of soy flavonoids on malignant cell cultures II. Phytochemistry. 10: 664

Kupchan SM, Sigel CW, Knox JR, Udayamurthy MS (1969). Effect of flavonoids on malignant cell cultures I. J. Org. Chem. 34: 1460.

Kyle E, Neckers L, Takimoto C, Curt G, Bergan R (1997). Genistein-induced apoptosis of prostate cancer cells is preceded by a specific decrease in focal adhesion kinase activity. Mol. Pharmacol. 51: 193-200.

Larson RA (1988). The anti-oxidants of higher plants. Review article No.30. Phytochemistry 27 (4),969.

Lasisi OT, Soetan KO, Fafunso MA, Aiyelaagbe OO (2003). Effects of

condensed saponins on hatching of bovine gastrointestinal nematodes *in vitro.* Niger. Vet. J. 24(3): 30-34.
Lewis JA, Starkey RL (1968). Vegetable tannins, their composition and effects on decomposition of some organic compounds. Soil Sci. 106: 241-247.
Li J, Tao R, Ma KC, Zhang QJ (1988). Effect of red ginseng saponins on serum corticosterone levels in mice. Shenyang Yaozveyuam xvebao 4,249. Chem. Abstr.108: 49310.
Lion C (1985a). Shampoos and cleaning solution containing acylamino acid salts. Saponins. Abstr. 102: 119421.
Lion C (1985b). Hair preparations containing surfactants, alcohols, fatty acids, esters and saponins. Chem. Abstr. 102: 209145.
Lion C (1985c). Shampoos containing sugar alcohol, esters and saponins. Chem. Abstr. 102: 1191122.
Lichtenstein AH, Jalbert SM, Adlercreutz H (2002). Lipoprotein response to diets high in soy or animal protein with and without isoflavones in moderately hypercholesterolaemic subjects. Arterioscler. Thromb. Vasc. Biol. 22(11): 1852-1858.
Malinow MR, McLaughlin P, Stafford C (1977). Effects of alfalfa saponins on intestinal cholesterol absorption in rats. Am. J. Clin. Nutr. 30: 2061-2067.
Malinow MR, McNaughty AL, Kohler GO (1985). Effects of synthetic glycosides on cholesterol absorption. Ann. N.Y. Acad. Sci. 23: 454.
Marhuenda E, Marbin MJ, delaCastra CA (1993). Anti-ulcerogenic activity of Aescine in different experimental models. Phytother. Res. 7: 13.
Mehansho H, Butler KG, Carlson DM (1987). Dietary tannins and salivary praline-rich proteins: Interaction,induction and defence mechanisms. Ann. Rev. Nutr. 7: 423-440.
Merck Index (1960). Prevention of dietary hypercholesterolaemia in the rat by soyabean and Quillaja saponins. Nutr. Rep. Int. 29: 1039.
Messina MJ (1999). Legumes and soybeans: Overview of their nutritional profiles and health effects. Am. J. Clin. Nutr. 70(3): 439-450.
Messina MJ, Barnes S (1991). The role of soy products in reducing risk of cancer. J. Natl. Cancer Inst. 83: 541-546.
Molan AL, Duncan A, Barry TN, McNabb WC (2000a). Effects of condensed tannins and sesquiterpen lactones extracted from chicory on the viability of deer lungworm larvae. Proc. New Zealand Soc. Anim. Prod. 60: 25-29.
Molan AL, Hoskin SO, Barry TN, McNabb WC (2000b). Effect of condensed tannins extracted from four forages on the viability of the deer lungworms and gastrointestinal nematodes. Vet. Rec. 147: 44-48.
Molan AL, Waghorn GC, McNabb WC (2002). Effect of condensed tannins on egg hatching and larval development of *Trichostrongylus colubriformis in vitro*. Vet. Rec. 150: 65-69.
Mori A, Mishimo C, Enoki N, Tawata S (1987). Antibacterial activity and mode of action of plant flavonoids against *Proteus vulgaris* and *Staphylococcus aureus*. Phytochemistry. 26(8): 2231.
Morris B (2003). Biofunctional legumes with nutraceutical, pharmaceutical and industrial uses. Econ. Bot. (57): 254-261.
Nahrstedt A (1988). The significance of secondary metabolites for interaction between plants and insects. Plant Med. 35: 333-338.
Naik HR, Lehr JE, Pienta KJ (1994). An in-vitro and in-vivo study of antitumour effects of genistein on hormone refractory prostate cancer. Anticancer Res. 14: 2617-2620.
Nakayama T, Yamada M, Osava T, Kawakishi S (1993). Suppression of active oxygen-induced cytotoxicity by flavonoids. Biochem. Pharmacol. 45(1): 265-267.
Negre-Salvayre A, Salvayre R (1992). Quercetin prevents the cytotoxicity of oxidized LDL on lymphoid cell lines. Free Rad. Biol. Med. 12: 101-106.
Niezen JH, Waghorn TS, Charleston WAG, Waghorn GC (1995). Growth and gastrointestinal nematode parasitism in lambs grazing either Lucerne (*Medicago sativa*) or sulla (*Hedysarum coronarium*) which contains condensed tannins. J. Agric. Sci. (Cam) 125: 281-289.
Oakenfull DG (1981). Saponins in Food - A Review. Food chem. 6(19): 21-23.
Oakenfull DG, Sidhu GS (1983). A physico-chemical explanation for the effects of dietary saponins on cholesterol and bile salt metabolism. sm. Nutr. Rep. Int. 27: 1253-1259.
Oakenfull DG, Sidhu GS (1989). Saponins. In: Toxicants of plant origin. 2, Glycosides, edited by P. R. Cheeke, CRC Press. Inc. Florida. 4: 97.
Ogbonna AI, Makut MD, Gyar SD, Adamu EU (2007). Antimicrobial activity of ethanolic extract of the seeds of *Ricinus communis* L. Niger. J. Biotechnol. 18(1-2): 40-43.
Okubo K, Kudou S, Uchida T, Yoshiki Y, Yoshikoshi M, Tonomura M (1994). Soybean saponin and isoflavonoids: Structure and antiviral activity against Human Immunodeficiency virus in-vitro. A Cs.Symp.Ser.1994, Food Phytochem. Cancer Prevent. I. 330-339.
Oleszec W, Jurzysta M, Gorski PM (1992). Alfalfa saponins - The allelopathic agents. In: Allelopathy, Basic and Aspects, Chapter 2, pg 151. Eds. Rizvi SJH and Rizvi V. From *Allium vineale*. Bioact. Nat. Prod. 1993, 349-403.
Oleszec W, Price KP, Colquhoun IJ, Jurzysta M, Ploszynski M, Fenwick GR (1990). Isolation and identification of alfalfa (Medicago sativa L) root saponins,their activity in relation to a fungal bioassay. J. Agric. Food. Chem. 38: 1810-1817.
Osagie AU (1998). Antinutritional factors. In: Nat. Qual. Plant Foods. pp 221-244.
Oteake N, Seto H, Ra S, Zeni F, Kobayashi E (1987). Cytotoxic preparations from *Glycyrrhiza glabra*. Japans Patent 62240696. Chem. Abstr. 109: 11715.
Pagliacci MC, Smacchia M, Migliorati G, Grignana F, Riccardio C, Nicoletti I (1994). Growth-inhibitory effects of the natural phytoestrogen genistein in MCF-7 human breast cancer cells. Eur. J. Cancer 30A: 1675-1682.
Panthong A, Tasseneeyakul W, Reutrakul P (1989).Comparative studies on the anti-inflammatory activity of 5,7-dimethoxyflavone on rat oedema model. Planta Med. 55: 133.
Peterson G, Barnes S (1991). Genistein inhibition of the growth of human breast cancer cells: Independence from oestrogen receptors and the multi-drug resistance gene. Biochem. Biophys. Res. Comm. 179: 661-667.
Peterson G, Barnes S (1993). Genistein and biochanin A inhibit the growth of human prostate cancer cells but not epidermal growth factor receptor autophosphorylation. Proatate 22: 335-345.
Peterson G, Barnes S (1996). Genistein inhibits both estrogen and growth factor-stimulated proliferation of human breast cancer cells. Cell Growth Differ 7: 1345-1351.
Peterson G, Coward L, Kirk M, Falany C, Barnes S (1996). The role of metabolism in mammary epithelial growth inhibition by the isoflavones genistein and biochanin A. Carcinogenesis 17: 1861-1869.
Philipson JD, Wright CW, Kirby GC, Warhust DC (1993). Tropical plants as sources of antiprotozoal agents. Recent Adv. Phytochem. 27: 1-40.
Powers JJ (1964). Proc. Fourth Intn'l Symposium on Food Microbiology (Gateborg, Sweden). pp5795.
Price KR, Fenwick GR (1990). The Chemistry and Biological significance of saponins in foods and feedingstuffs. Int. Rev. Food. Sci. Nutr.157: 62.
Rajkumar S, Jebanesan A (2003). Oviposition and ovicidal activities of alkaloidal extract from *Murraya koenigii* against vector mosquitoes. Nig. J. Nat. Prod. Med. (7): 16-19.
Rankin SM, DeWhalley CV, Hoult S, Jessup W, Willins GM, Collard J, Leake DS (1993). The modification of low density lipoprotein by the flavonoids Myricentin and Gossypetin. Biochem. Pharmacol. 45(1): 67-75.
Rao AV (1996). Anticarcinogenic properties of plant saponins. Second Intn'l Symp. on the role of soy in preventing and treating chronic disease, Sept.15-18,1996, Brussells, Belgium.
Rauth S, Kichina J, Green A (1997). Inhibition of growth and induction of differentiation of metastatic melanoma cells *in vitro* by genistein: Chemosensitivity is regulated by cellular p53. Br. J. Cancer 75: 1559-1566.
Robbins RC (1973). Physiological effects of plant flavonoids. J. Chem. Pharm. 4: 271.
Ruiz-Larrea MB, Mohan AR, Raganga G, Miller NJ, Bolwell GR, Rice-Evans CA (1997). Anti-oxidant activity of phytoestrogenic isoflavones. Free Radic. Res. 26(1): 63-70.

Sagara M, Kanda TM (2004). Effects of dietary intake of soy protein and isoflavones on cardiovascular disease risk factors in high risk, middle-aged men in Scotland. J. Am. Clin. Nutr. 23(1): 85-91.

Sanders TA, Dean TS, Grainger D, Miller GJ, Wiseman H (2002). Moderate intakes of intact soy protein rich in isoflavones compared with ethanol-extracted soy protein increase HDL but do not influence transforming growth factor beta (I) concentrations and haemostatic risk factors for coronary heart disease in healthy subjects. Am. J. Clin. Nutr. 76(2): 373-377.

Santibanez JF, Navarro A, Martinez J (1997). Genistein inhibits proliferation and *in-vitro* invasive potential of human prostatic cancer cell lines. Anticancer Res. 17: 1199-1204.

Saponins Research Information.htm file//A:/.online access.

Schimel JP, Van Cleve K, Cates RG, Clausen TP, Reichardt PB (1996). Effects of balsam poplar (*Populus balsamifera*) tannins and low molecular weight phenolics on antimicrobial activity in taiga floodplain soil. Implications for changes in N cycling during succession. Can. J. Bot. 74: 84-90.

Scholar EM, Toewa ML (1994). Inhibition of invasion of murine mammary carcinoma cells by the tyrosine kinase inhibitor genistein. Cancer Lett. 87: 159-162.

Schopke TH, Hiller K (1990). Triterpenoid saponins, Part 6. Die Pharamazie. 45: 313-342.

Sharma HC, Norris DM (1991). Chemical basis of resistance in soybean to cabbage looper, *Trichoplusia ni*. J. Sci. Food. Agric. 55: 353-364.

Sharon W, Lis H (1970). Lectin: Cell-agglutinating and sugar-specific proteins. Science 1777: 949-959.

Shibata H (1977). Saponins with biological and pharmaceutical activity. In: New Natural Products and Plant Drugs with Pharmacological, Biological and Therapeutical Activity, Wagner and Wulff, Eds, Berlin, 177.

Shimoyamada A, Susulki M, Sonta H, Maruyama M, Okubo K (1990). Antifungal activity of the saponin fraction obtained from *Asparagus officinale L*. and its active principle. Agric. Biol. Chem. 54(10): 2553-2557.

Simoes CMO, Shenkel EP, Baver L, Lageloh A (1988). Anti-inflammatory activity of flavonoids. J. Ethnopharmacol. 23: 281.

Soetan KO, Oyekunle MA, Aiyelaagbe OO, Fafunso MA (2006). Evaluation of the antimicrobial activity of saponins extract of *Sorghum bicolor* L. Moench. Afr. J. Biotechnol. 5(23): 2405-2407.

Sofowora A (1982). Medicinal plants and traditional medicine in Africa. Spectrum Books Ltd, Ibadan, Nigeria. pp 26-32.

Sokolov S (1986). Psychotropic and anti-inflammatory effects of Aralosides A, B and C in mice Adv. Med. Phytochem. (Ed. Proc. Intn'l. Symp. 1985).

So FV, Guthrie N, Chambers AF, Moussa M, Carroll KK (1996). Inhibition of human breast cell proliferation by flavonoids and citrus juice. Nutr. Cancer. 26: 167-181.

Soy Isoflavones: Micronutrient Information Center: The Linus Pauling Institute, Oregon State University. http://lpi.oregon state.edu/infocenter/phytochemicals/soyiso/index.html.

Srinivasan S, Lucas T, Burrowes CB, Saroyer PW (1973). Effects of flavonoids on micro-circulation. European Conference Microcirculation 6,394. Chem. Abstr. 76: 121485.

Takashi I, Keiichi U,Hisayuki R (1986). Gourd saponins as antioxidants in oils, foods, cosmetics and pharmaceuticals. Chem. Abstr. 105: 151815.

Tanner GJ, Joseph RG, Li YG, Larkin PJ (1997). Towards bloat safe pastures, Feedmix.

Tkahama U, Youngman RJ, Elatner EF (1984). Flavonoids: Quenches molecular oxygen species. Phytobiochem. Phytobiophys. 17: 175.

Topping DL, Storer GB, Calvert GG (1980). Effects of dietary saponins on faecal bile acids and neutral sterols, plasma lipid and lipid turnover in the pig. Am. J. Clin. Nutr. 33: 783.

VanEtten HD (1976). Antifungal activity of Pterocarpans and other selected isoflavonoids. Phytochemistry 15: 656-659.

Visconti A, Solfrizzo M (1994). Isolation, Characterization and Biological activity of Visoltricin, a novel metabolite of *Fusarum tricinctum*. J. Agric. Food Chem. 42: 195-199.

Wakabayashi C, Hasegawa H, Murata T, Ichiyama M, Saiki I (1997). Expression of *in-vivo* antimetastatic effect of ginseng protopanaxtriol saponins is mediated by their intestinal bacterial metabolites after oral administration. Chem. Abstr. 129(7): 44.

Waller GR, Jurzysta M, Thorne ZLR (1993). Allelopathic activity of root saponins from alfalfa on weeds and wheat. Bot. Bull. Acad. Sci. 34: 1-11.

Wang B, Chui J, Liu A (1985). Mice myocardium protective effects of ginseng leaf saponins. Adv. Clin. Med. Mater. Res. Int. Symp. p. 519.

Yamaguchi A (1993). Antidiabetics containing aqueous extract of *Pittosporum* plants. Jpn. Kokai. Tokyo. Koho. JP 05,271,086. Chem. Abst. 129.

Yamasaki Y, Ito K, Enomoto Y, Sutko JL (1987). Inotropic effects of panax quinqueflium saponins on guineapig cardiac muscles. Biochem. Biophys. Acta. 897: 481.

Yang T, Huang X, Wang W (1986). Anti-inflammatory effects of ginseng saponins in mice Zhongyao tongbao, II, III. Chem. 104: 178-184.

Yoshiki Y, Okubo K (1995). Active Oxygen Scavenging Activity of DDMP (2,3-Dihydro-2,5-dihydroxy-6-methyl-4H-pyran-4-one) Saponin in soybean seed. Biosci. Biotechnol. Biochem. 59(8): 1556 1557.

You J, Wang X, Yan Y, Jin F, Huang B (1993). Effects of active constituents of Chinese herbal medicine on HMG-CA Reductase. Chem. Abs. 120(7): 70.

Zank HM (1991). Chasing the enzymes of secondary metabolism: Plant Cell Cultures as a point of goal. Phytochemistry, 309 (12): 3861-3863.

Zava DT, Duwe G (1997). Estrogenic and antiproliferative properties of genistein and other flavonoids in human breast cancer cells *in-vitro*. Nutr. Cancer. 27: 31-40.

Zhang S, Hu Z (1985). Anti-ulcerogenic effects of Ginseng flower saponins in the rat. Zhongyao. Tongbao, 10: 331. Chem. Abstr. 104: 512.

Zimber DE, Redersen MW, Mcquire CF (1965). A bioassay for alfalfa saponins using the fungus, *Trichoderma viridae* pers. Ex. Fr. Crop. Sci. 7: 223-224.