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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, rotenone (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 microcirculation 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.

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