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NUTRITIONAL AND ANTIOXIDANT POTENTIAL OF GREEN LEAFY VEGETABLES -A REVIEW

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Leafy green vegetables are potentially valuble and being rich in nutrients and dietary fiber, intake of these leafy vegetables should be ensured. Hence, nutritional and antioxidant potential of green leafy vegetables has been reviewed in this communication.

Keywords : Antinutritional factors; Antioxidant potential; Green leafy vegetables; Nutritional factors; Wild leafy vegetables.

Introduction

Green leafy vegetables are important part of our cultural heritage and they play unique roles in the customs, traditions and food culture of large part of the world. The nutrient content of different types of vegetables varies considerably and they are not major sources of carbohydrates compared to the starchy foods which form the bulk of food eaten, but contain vitamins, essential amino acids, as well as minerals and antioxidants. Nutrients are grouped into six classes namely carbohydrate, fats (lipids), proteins, vitamins, mineral and water. The general functions of these nutrients include fuel (energy) expressed in Kcal, building materials for body structures and regulation and control of body processes[1].The ethnic people use a wide variety of wild plants and plant products as their food. India has one of the largest concentrations of tribal population in the world and forest plays a vital role in the economy as well as daily needs of the tribals. In times of scarcity when the staple food is in short of supply tribals collect many types of wild roots and tubers to supplement their meager food available at home[2].

Green leaves or salad greens contain Vitamin A, Vitamin C, beta-carotene, calcium, folate, fiber, and phytonutrients and are a good choice for a healthy diet because they do not contain cholesterol and are naturally low in calories and sodium. Many of the health benefits that leafy greens provide come from phytonutrients, unique compounds that provide protection for plants. These compounds are becoming recognized as part of a nutritious diet that promotes long-term health. Phytonutrients can act as antioxidants, which help to prevent chronic diseases like cancer and heart disease. In Asia, several hundreds of wild/semi-wild plant species have been commonly consumed as diet and folk medicine for the treatment of diarrhea, constipation, inflammation, asthma, hypertension and as carminative agents over a long period of time[3].

With ever-increasing population pressure and fast depletion of natural resources, it has become extremely important to diversify the present day agriculture in order to meet various human needs[4]. The agricultural societies still depends on non-cultivated resources for various purposes. Today, most plant based food is limited to a small number of crops but wild plants are important in many parts of the world[5]. Diet surveys tend to ignore wild plants in comparison to cultivated ones. The nutritional value of traditional leafy vegetables is higher than several known common vegetables[6-10]. Most of these traditional leafy vegetables have a potential for income generation but fail to compete with exotic vegetables at present due to lack of awareness[11]. Consumption of traditional diets known to many societies are said to have many beneficial effects such as prevention of some age related degenerative diseases- arteriosclerosis, stroke, etc.[12]. Despite these advantages, most traditional plant foods are generally uncultivated and underutilized[13,14]. So this paper attempts to review various nutitional, antinutritional and antioxidant potential of various green leafy vegetables.

Nutritional factors- Leafy green vegetables are potentially valuable and being rich in nutrients and dietary fiber, intake of these leafy vegetables should be ensured. Most indigenous leafy vegetables were reported to be rich in protein, lipid, minerals and vitamins. Dietery fibre content reduces constipation while proteins in these vegetables are superior to those found in fruits. Fibre also adds bulk to the food and prevents the intake of excess starchy food and may therefore guard against metabolic conditions such as hypercholesterolemia and Diabetes mellitus. The presence of mucilage in some vegetables makes their soups tastier and palatable[15]. For example, when fresh leaves and tender shoots of species of *Corchorus olitorius* and *Spinacia oleracea* are mixed with soda and cooked, a soup

of slimy and slippery consistency is produced. The resultant soup is easy to take with thick pastes of locally prepared carbohydrate dishes from rice, cassava, maize or yam.

The inorganic mineral elements such as calcium, magnesium, potassium, zinc, iron, manganese and sodium found in reasonable amount in the leaves, which are nutritionally and biochemically important for proper body functioning. For instance, calcium is known to play a significant role in muscle contraction, bone and teeth formation and blood clotting[16-18]. Some of these minerals such as magnesium and zinc are needed as cofactor in enzyme catalysis in the body. Zinc present in the plant is beneficial to prevention and treatment of diarrhoea, and is also involved in normal functioning of immune system. Sodium and potassium which are present in the intracellular and extracellular fluid helps to maintain electrolyte balance and membrane fluidity[16]. It is known potassium, calcium and zinc play important roles in the maintenance of normal glucose-tolerance and in the release of insulin from beta cells of islets of Langerhans. Iron is known to be a component of some metalloenzymes, myoglobin and heamoglobin[16], which is needed in the transport of oxygen and carbon dioxide during respiration or cellular metabolism and normal functioning of central nervous system[19]. This heamoglobin (containing iron) also serve as buffer to regulate changes in blood pH[20]. Green leafy vegetables also contain iron needed in haemoglobin formation[21] and hence recommended for anaemic convalescence. Various minerals are also co-enzymes in certain biochemical reactions in the body which underscores the importance of leafy vegetables in metabolic reactions. Vitamins are a diverse group of organic molecules required in very small quantities in the diet for health, growth, and survival[22]. The absence of a vitamin from the diet or an inadequate intake results in characteristic deficiency signs and, ultimately, death[22,23]. Vitamins A, E, C, B12 and folic acid present in the plant helps to maintain nerve cell function and the deficiency leads to pernicious anaemia[24]. In addition to the antioxidant property of vitamin C and E, vitamin C strengthen the body immunity against infections, helps in collagen and thyroxin synthesis and enhance iron absorption while vitamin E play a role in immune function, cell growth, reproduction and DNA repair[24]. α-Tocopherol, the most common form of vitamin E present in nature, is the most biologically active[25] and is preferentially retained in large quantities and transported to body components[26]. Sixtytwo types of edible tropical plants are screened for R-tocopherol content by Ling and Suhaila[27].

Nutritive evaluation studies on the wild edible tubers, rhizome, corm, roots and stems consumed by the tribal people summarized that most of them are found to be a good source of protein, lipid, crude fibre, starch, vitamins and minerals[28]. Nutritional/anti-nutritional and amino acid compositions of nigerian *Melanthera scandens* was studied by Omoyeni *et al.*[29]. Nutritional potential of leaves and seeds of *Solanum nigram* was studied by Akubugwo *et al.*[30] which is a traditional food and important part of the diet of poor in Nigeria. It showed appropriate level of protein, carbohydrates, minerals like magnesium and phosphorus, vitamin C and E along with some oxalate and cyanide content which can be reduced by cooking. Dried fronds of *Diplazium esculentum* are reported to be preferred animal bedding material during winters. Several of these species have market value, but only *Diplazium esculentum* and *Megacarpaea polyandra* are actually sold or purchased as fresh vegetables.

Trace element analysis and vitamins was studied from an indian medicinal plant Nepeta hindostana (roth) haines by Deepak[31]. This plant also showed presence of ascorbic acid, riboflavin, Niacin and thiamin and mineral like Cu. Investigation on *Leucas cephalotus and Leucas martinicensis* were belonging to family Lamiaceae provide valuable information about the presence of essential amino acids and oil[32]. Nutritional and medical properties of some leafy vegetables was analysed which are consumed by Edo people of Nigeria by Menshah *et al.*[33].

Proximate composition and levels of metals in four commonly consumed species, *Sonchus eruca, Melia azadirchta, Withania coagulans* and *Fagonia indica,* were investigated by Hussain *et al.*[34]. Ash, carbohydrate, protein, fiber, fat and moisture were analyzed, while Cu, Pb, Co, Cd, Fe, Cr, Mg and Na were also investigated in metal analysis *Melia azadirachta* had the highest concentrations of the metals like Cu, Mn, Cr and Fe while *S. eruca* contain higher concentration of Na as compared to other three species[34].

The scientific evaluation of ethnomedicinally important plants has become much more common, particularly as a number of drugs discovery programs have started the regular screening of traditional herbal remedies. Plant species consumed as traditional and leafy vegetables and their ecological biodiversity in a world heritage site Nanda Devi Biosphere Reserve, India was documented by Shalini *et al.*[10]. The relatively high content of calcium in leafy vegetables like *Gryllotalpa Africana* and *Celosia* sp. suggest that they may be of therapeutic value in hypocalcaemic state like osteoporosis and in fact potentially risky in hypercalcaemia.

Phytochemical and nutrient evaluation of *Tetracarpidium conophorum* (nigerian walnut) root was reported by Ayoola *et al.*[35]. The mineral analysis revealed presence of K, Ca, Na, Mg, Fe, Zn, Mn, Cu, Cr and Vitamins like Thiamine (B1) Ascorbic acid Riboflavin (B2) Niacin, Cyanocobalamin (B12) were available in roots.

Antinutritional factors-Evaluation on the wild edible tubers, rhizome, corm, roots and stems consumed by the tribal *Valaiyans* in western Ghat region of Tamil Nadu in India summarized that most of them are found to be a good source many nutritional factors but all the investigated samples exhibited variation in the levels of total free phenolics, tannins, hydrogen cyanide, total oxalate, amylase and trypsin inhibitors. Except for phenolics, tannins, hydrogen cyanide and total oxalate these antinutritional can be inactivated by moist heat treatments. For phenolics, tannins, hydrogen cyanide and total oxalate can be eliminated by soaking and discarding water followed by cooking before consumption is recommended as a means of removing harmful effects of these antinutritional factors[36].

The antinutritional factors such as phytic acid, tannin, saponin, oxalic acid, have adverse effect on health through inhibition of protein digestion, growth, iron and zinc absorption[37]. Oxalic acid and its content have deleterious effects on human nutrition and health, mainly by decreasing calcium absorption and aiding the formation of kidney stones. The formation of oxalate crystal is said to take place in digestive tract. Phytic acid is an organic acid found in plant materials which bind minerals in the gastrointestinal tract, making dietary minerals unavailable for absorption and utilization by the body[38]. It decreases calcium bioavailability and form calcium phytate complexes that inhibit the absorption of Fe, Zn[39]. Tannins forms complexes with proteins and reduce their digestibility and palability[40]. Saponin are naturally occurring oily glycosides occurring in wide variety of plants when eaten, they are dangerous when injected into the blood stream and quickly haemolyse red blood corpuscles[41].

Antioxidant potential-Free radicals are highly reactive compounds, with an odd or unpaired electron and can be formed when oxygen interacts with certain molecules. They are neutral, short lived, unstable and highly reactive to pair with the odd electron and finally achieve stable configuration[42]. Once formed these highly reactive radicals can start a chain reaction they are capable of attacking the healthy cells of the body, causing them to lose their structure and function. Antioxidant is a molecule capable of slowing or preventing the oxidation of other molecules and thereby reduces the risk of cancer and other diseases. The major action of antioxidants in cells is to prevent damage due to the action of reactive oxygen species. Studies have suggested that antioxidant supplements have benefits for health. Antioxidants are absolutely critical for maintaining optimal cellular and systemic health and well-being. Naturally there is a dynamic balance between the amount of free radicals produced in the body and antioxidants to scavenge or quench them to protect the body against deleterious effects[43].

Generation of oxygen radicals, such as superoxide radical hydroxyl radical and non-free radical species, such as H_2O_2 and singlet oxygen is associated with cellular and metabolic injury, and accelerating aging, cancer, cardiovascular diseases, neurodegenerative diseases, and inflammation[44-46]. Epidemiological studies have consistently shown that consumption of fruits and vegetables has been associated with reduced risk of chronic diseases, such as cardiovascular diseases and cancers[47-49] and neurodegenerative diseases, including Parkinson's and Alzheimer's diseases[50] as well as inflammation and problems caused by cell and cutaneous aging[51].

Antioxidant compounds in food play an important role as a health protecting factor. Plants are major source of food antioxidants like vitamin C, vitamin E, carotenes, phenolic acids, phytate and phytoestrogens. Most of the antioxidant compounds in a typical diet are derived from plant sources and belong to various classes of compounds with a wide variety of physical and chemical properties. Some compounds, such as gallates, have strong antioxidant activity, while others, such as the mono-phenols are weak antioxidants[52]. The enzymatically potential antioxidants known are superoxide dismutase, catalase and glutathione peroxidase. In the non-enzymatic category, there are vitamin-A, vitamin-C, flavonoids, α-carotenoids, uric acid (urates), ubiquinone and other synthetic compounds *viz.* DHEA, melatonins etc[53].

The protective action of vegetables has been attributed to the presence of antioxidants, especially antioxidant vitamins including ascorbic acid, α-tocopherol and β-carotene[55]. However, numerous studies have conclusively shown that the majority of the antioxidant activity may be from compounds such as flavonoids, isoflavone, flavones, anthocyanin, catechin and isocatechin rather than from vitamins C, E and carotene[55-58]. The consumption of food and beverages rich in phenolics contents can reduce the risk of heart disease by slowing the progression of arteriosclerosis by acting as antioxidants towards low-density lipoproteins [LDL][58-60]. The

antioxidant activity of phenolics is mainly because of their redox properties, which allow them to act as reducing agents, hydrogen donors, singlet oxygen quenchers and metal chelators[57,61]. Vegetables such as root and tuberous crops (carrots, potatoes, sweet potatoes, red beets etc.), cruciferous vegetables (cabbage, Brussels sprouts, broccoli etc.), green leafy vegetables (lettuce, spinach etc.), onions, tomatoes and other vegetables have been screened for antioxidant activity using different oxidation systems. In addition to the differences in methodologies, different extraction methods used to release antioxidative constituents result in variation of the antioxidant activities reported for vegetables. Gazzani *et al.*[62] reported that when prepared at 2°C, most vegetable juices showed initial pro-oxidant activity. This pro-oxidant activity was very high for eggplant, tomato, and yellow bell pepper. In the cases of carrot, celery, garlic, mushroom, zucchini, tomato, and particularly eggplant juice, it was reported that the antioxidant activity of the vegetables was increased by boiling. This suggests that the pro-oxidant activity was due to peroxidases which were inactivated at high temperature. Sun-drying has been reported to affect the amount and biological activity of the chemical constituent present in both plant and animal food[63].

Evaluation of the antioxidant of the selected green leafy vegetables such as *Amaranthus tristis, Centella asiatica, Hibiscus sabdariffa, Moringa oleifera, Sesbania grandiflora* and *Solanum trilobatum* was reported by Jacob and Shenbagaraman[64]. Comparative study of some leafy vegetables of India like *Asteracantha longifolia* Nees, *Bacopa monnieri* (Linn.) Pennell, *Bauhinia racemosa* Lam., *Centella asiatica* (Linn.) Urban), *Chenopodium album* Linn., *Enhydra fluctuans* Lour., *Ipomoea reptans* (Linn.) Poir., *Moringa oleifera* Lam., *Nyctanthes arbortristis* Linn., *Paederia foetida* Linn. and *Trigonella foenum-graecum* Linn. were reported for their free radical-scavenging activity and ability to prevent lipid peroxidation[65]. Ten leafy vegetables were screened for antioxidant properties in Thailand by Vipaporn *et al.*[66].

According to Vinson *et al.*[67] the phenols in spinach were able to enrich the lipoproteins by binding with them and subsequently protect them from oxidation. Studies on traditional vegetables reported by Faridah *et al.*[68] described the antioxidant potential of methanolic extract of *Averhoaea bilimbi, Poortulaca oleracea, Solanum nigrum, Persicaria tenella, Cosmos caudatus, Curcuma mangga, Ocimum basilicum, Anacardium occidentale* and *Melicope ptelefolia.* In another study, Wong *et al.*[69] evaluated the antioxidant activities of aqueous extracts of tropical plants like *Centella asiatica, Piper betel, Sauropus androgyus, Coriandrums ativum, Eugenia polyantha, Polygonum hydropiper* and *Ociumum basilicum* that are widely consumed in the Southeast Asian region. Mineral composition and *in vitro* antioxidant activity of leaf and stem bark powders of *Pappea capensis* (L.) was reported by Geoffrey [70]. Alpha-tocopherol, retinol, ascorbic acid, beta-carotene, psi-carotene (lycopene), betacryptoxanthin, thiamine and nicotinamide and minerals Se, Fe, Cu, Zn, Mn, Cr, Ni, V, Mo and Co present in leaf and stem bark of *Pappea capensis* are responsible for the different nutraceutical and therapeutic uses in traditional medicine.

The amount of antioxidant principles present in our normal diet may be insufficient to neutralize free radicals generated. Therefore, it is obvious to enrich our diet with antioxidants to protect against harmful diseases. Hence there has been an increased interest in the food industry and in preventive medicine in the development of "Natural antioxidants" from plant materials because of the possible toxicity of synthetic antioxidants.

Wild leafy vegetables - Traditional knowledge is localized in a particular area because it gains only through experience and practice by a particular community environment. It is common for the households to collect wild leafy vegetables from various places such as grazing lands, forest, crop fields and watercourses. None of these leafy vegetables required any special processing for cooking or consumption. All the leafy vegetables are prepared like spinach and eaten as a form of stew or cooked in oil with salt and spices.

The core diet of most Asian and African countries includes rice, wheat, pulses and a wide variety of local wild and semi-domesticated plants. Most households grow domesticated vegetables in their kitchen gardens. Wild foods are considered by the local inhabitants as necessity rather than as a supplement and are eaten frequently[71]. Nutritional analysis of green leafy plants were reported from southern Appalchia, United States[72], Thailand[73], Rome[74], Tanzania[75], Various African countries like Kenya[76], Camaroon[77], Southern Mali[6], central Himalayas[71], Sikkim[78], Nanda Biosphere reserve in India[79], Uttaranchal hills of Indian Himalaya[80] and Western Ghats of Kerala[81].

Wild edibles which were traditionally used by people in Meghalaya were evaluated for the nutritional potential by Tapan[82]. Tested plants and leaves contain high levels of protein, ash and carbohydrate, however, other proximate composition parameters such as crude fibre and fat were low. The elemental composition showed increased levels in potassium, sodium, calcium, phosphorus and iron while zinc, copper and manganese were relatively low.

The phytate and hydrocyanide levels were very low although the oxalate level was moderately high but not considered to be lethal to man. Phytochemical screening showed the presence of alkaloids, saponins, cardiac glycosides, polyphenols, reducing sugars and tannins[83].

Bidens biternata, a wild leafy vegetable from Western ghats of kerala, was reported to nutrient rich with very low antinutritional factors[84]. Dried fronds of *Diplazium esculentum* are reported to be preferred animal bedding material during winters and only *Diplazium esculentum* and *Megacarpaea polyandra* are actually sold or purchased as fresh vegetables. *Megacarpaea polyandra, Paeonia emodi* and *Smilacina purpurea* are processed for storing to be used as vegetable during periods of non-availability in addition to their consumption as fresh vegetable[10]. The majority of wild edible herbs eaten typically contain high levels of important nutrients especially for diets usually high in starch. There is need for collecting, preserving and documenting this knowledge not only for maintaining the local cultural traditions but also to facilitate the research on new food sources elsewhere as well. Value addition through storage and commercialization could probably widen the livelihood base and thus draw attention of planners. Such strategies have been effectively used to combat vitamin and micro-nutrient deficiencies all over the world.

Plant species of traditional medicines and wild leafy vegetables should be subjected to scientific experimentation/ verification for establishing their validity before bringing them into various preparations of alternate medicines. Antioxidants play a vital role in checking oxidative stress taking place in physiological processes. Studies should be carried out to know about the details of antioxidative properties and pharmacological action of constituents in various herbs, vegetables and fruits along with evaluation of nutritional and antinutritional factors. Research for the development of inexpensive, highly available and effective naturally aesthetic antioxidants from biodiversified medicinal flora of the modern era, is in fact an utmost need of era. Identification of these underutilized wild leafy vegetables and inculcation of them in our diet could potentially address many nutritional and medicinal problems and challenges. Alternate nutritional sources should be identified from the wild and need domestication to reduce nutritional deficiency problems of the world.

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