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A Review on Nutritional Quality of Green Leafy Vegetables

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ABSTRACT

Vegetables play an important role in food and nutrition conservation. Green leafy vegetables, in particular, are known as a high-quality source of vitamins, minerals, and phenolic compounds. Leafy vegetables have higher levels of mineral nutrients like iron and calcium than staple foods like grains. Leafy vegetables are among the most potent herbal assets and the only available sources of folic acid, this paper examines the nutritional and anti-nutritional properties of some common green leafy vegetables, which are significantly higher in *Moringa oleifera* plant leaves than in other leafy and non-leafy vegetables. There are several different forms and compositions of nutritional and anti-nutritional factors in edible leafy vegetable plants.Anti-nutritional elements are chemical compounds found in plant tissues that prevent humans from absorbing nutrients. Their results can be direct or indirect and they can vary from mild reactions to death. Antinutrients such as nitrates, phytates, tannins, oxalates, and cyanogenic glycosides have been linked to several health problems. Anti-nutritional factors can be minimized using one-of-a-kind processing techniques such as boiling and blanching. The various analytical methods for the willpower of the various dietary and anti-nutritional factors in a few green leafy vegetables were also briefly discussed below.

***Key words**: Green leafy vegetables, Nutritional factors, Anti-nutritional factors*

Introduction

Green Leafy Vegetables are extremely important for human health and nutrition levels. They are composed of the substances such as cellulose, hemicellulose and pectin, which give them their texture and firmness (Mohammed and Sharif, 2011). They provide people in developing countries with adequate amounts of dietary fibres, minerals, vitamins, and other nutrients(Asaolu *et al.,* 2012). As a result of their low energy density, leafy vegetables are recommended for weight loss (Nwanekezie and Obiakor, 2014). Excessive production of field crops has resulted in a major decrease in the supply of indigenous vegetables. There is also an increasing lack of understanding among young people about the nature of these nutritionally dense food plants that are readily accessible (Odhav *et al.,* 2007). Phytochemicals are a group of bioactive compounds found in plants that are directly beneficial to one's health. Researchers also discovered that phytochemical composition is very distinct and varies greatly between plants. Some important green leafy vegetable and their botanical names are shown below in Table 1.

Nutritional factors in green leafy vegetables

Proteins: Proteins are large, complex molecules made up of a variety of amino acid combinations. Proteins are needed for all living organisms' cellular functions, structure, and metabolic control. As a result, proteins are an essential part of most people's diets. Green leafy vegetables are the best and cheapest sources of protein.This is due to their ability to

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Table 1. Some important green leafy vegetables

S.No.	Common name	Botanical name	Family	References
1	Amaranthus	*Amaranthus spp.*	Amaranthaceae	Maurya *et al.* (2018)
2	Spinach beet	*Beta vulgaris var. bengalensis Roxb.*	Chenopodiaceae	Jabeen *et al.* (2017)
3	Spinach	*Spinacia oleracea*	Chenopodiaceae	Jiraungkoorskul*et al.*(2016)
4	Fenugreek	*Trigonella foenum*	Fabaceae	Pal *et al.* (2020).
5	Indian Spinach	*Basella rubra var. alba*	Basellaceae	Singh *et al.* (2018)
6	Drumstick	*Moringa oleifera*	Moringaceae	Seshadri *et al.* (2003)
7	Curry leaf	*Murraya koenigii*	Rutaceae	Bhusal *et al.* (2021)
8	Lettuce	*Latuca sativa*	Asteraceae	Dias *et al.* (2019)

Source: Vegetable Crops Production Technology (M.S. Fageria 2013)

synthesise and accumulate amino acids with the aid of a plentiful supply of sunlight, water, oxygen, and nitrogen from the atmosphere (Alector *et al.,* 2002). Ribulose-1,5-bisphosphate carboxylase/oxygenase (RUBISCO), which can be found in leaf chloroplasts, accounts for around half of total leaf cell protein. During photosynthesis, it is important for the fixation of atmospheric carbon (Ducat *et al.* 2012). RUBISCO is a related protein found in all green leafy vegetables, with some differences in amino acid groups.Green leafy vegetables including spinach *(Spinacia oleracea)*, broccoli *(Brassica oleracea var. Italic)*, and duckweed *(Lemna perpusilla)* have recently been shown to provide all of the essential amino acids needed by the FAO nutrition standards.

Dietary fiber: Dietary fiber is a component of the cell wall of plants (Buttriss *et al.,* 2008). Soluble dietary fibre (SDF) and insoluble dietary fibre (IDF) are two types of dietary fibre that make up total dietary fibre (TDF). Green leafy vegetables have long been considered to be healthy sources of dietary fiber (Gopalan *et al.,* 2000). Literature information showed that Indian green leafy vegetables like basella (*Basella rubra*), fenugreek (*Trigonella foenum graecum*), hibiscus (*Hibiscus cannabinus*), coriander (*Coriandrum sativum*), cabbage (*Brassica oleracea*), and spinach (*Spinacia oleracea*) are rich in soluble dietary fibre. Higher levels of vegetable fibre intake were related to a lower risk of cardiovascular disease and probably colon cancer (Jenkins *et al.,* 2001). It was more important in addressing constipation, diabetes, diverticulosis, and obesity problems.

Vitamins: Green leafy vegetables contain β-carotene and leafy vegetables also a very good source of β-carotene. In leaves, vitamin A is present as provitamin A carotenoids such as β-carotene (ca. 25-30%), α-carotene, γ-carotene, β-cryptoxanthin and non-provitamin A carotenoids lutein (ca. 45%), violaxanthin 2(ca. 15%) and neoxanthin (ca. 15%) (Britton, 1996), the content of vitamin A is expressed in retinol equivalents (RE) with one (1) RE being equivalent to 6 µg of β-carotene and 12µg of the other pro vitamin carotenoids. The recommended daily allowance (RDA) for vitamin A is also expressed in RE, but the United States has recently changed its mind. The term RE has been replaced by the term ''retinol activity equivalent" by the Institute of Medicine (RAE; IOM, 2001). The Institute of Medicine recommends 900 and 700 g RAE of vitamin A for an adult male and female, respectively, in the dietary reference intake (Trumbo *et al.,* 2001). Cooking, boiling, and steaming methods have an important impact on the abundance of carotenoids in green leafy vegetables. A nutritional analysis of 30 widely eaten green leafy vegetables showed that they contain a decent amount of lutein and are rich in different vitamins.

Minerals: According to WHO (1996) "overall malnutrition must no longer be considered without reference to micronutrient status, as the two are inextricably linked". Attempting to improve protein-energy status without addressing micronutrient deficiencies will not result in optimal growth and function"(Baudoin and Fresco, 2002). Metal ions are important for human health and well-being because they serve as cofactors in enzymatic reactions and help to preserve protein structures. Anaemia occurs as a result of iron deficiency in women and infants (Galloway, 2003). Zinc deficiency causes gastrointestinal and immune system problems.Green leafy vegetables are a good source of mineral nutrients, according to the results. Spinach has the highest calcium content as shown in (Table 2). The atomic absorption spectrophotometry (AAS) process, as well as inductively coupled plasma optical emission spectroscopy, can be used to determine the minerals in leafy vegetables (ICP-OES).

Table 2. Mineral concentration in Spinach

Mineral concentration (mg)	Spinach
Calcium (mg)	1036
Magnesium (mg)	827
Iron (mg)	28.4
Phosphorus (mg)	513
Potassium (mg)	5840
Sodium (mg)	827
Zinc mg)	5.5

Sources: Edelman and Colt (2016)

Essential fatty acids: Omega-3 fatty acids are essential for healthy growth and development, as well as the prevention and treatment of coronary artery disease, hypertension, diabetes, arthritis, cancer, and other inflammatory and autoimmune diseases (Hmazaki and Okuyama, 2001). α-linolenic acid, an omega-3 fatty acid precursor, has been discovered in green leafy vegetables and has been shown to have health benefits (Simopoulous, 2002). Some important fatty acids which are present in leafy vegetables are also known to assist in the treatment of many chronic diseases. Evidence suggests that wild plants have higher levels of omega-3 fatty acids than cultivated vegetables. Purslane (*Portulaca oleracea*), a wild plant and weed in most instances, is a strong non-aquatic source of α-linolenic acid, with 4 mg/g fresh weight, according to the US Department of Agriculture (USDA). α-Linolenic acid was also found in other leafy green vegetables, including 1.7 mg/g in spinach, 1.1 mg/g in mustard greens, 0.7 mg/g in red leaf lettuce, and 0.6 mg/g in butter crunch lettuce, according to the same report. Gas chromatography can be used to evaluate fatty acids in leaves.

Anti-nutritional factors in green leafy vegetables

Anti-nutrients, or harmful chemical compounds, are found in both cultivated and wild plant species. Allelochemicals are another term for these anti-nutrients (Thakur *et al.,* 2019). Plant genera and species have varying quantities and distributions of these chemical compounds. According to Cheek and Shull (Cheeke and Shull, 1985), being an anti-nutritional element is not an innate property of a compound, but depends on the digestive process of the ingesting animal. The degree of adversity is primarily determined by the diet pattern and method of processing used before the plant food is eaten. Nitrates, oxalates, tannins, phytates, and cyanogenic glycosides are some of the anti-nutrients typically present in leafy vegetables.

Nitrate: Nitrate is a natural compound found in vegetables that is responsible for assessing the quality of the vegetables. Nitrate concentrations in leafy vegetables are typically higher than in other vegetable types, such as root and fruit vegetables (Tamme *et al.,* 2010). The number, timing, and type of nitrogen fertilizer used, as well as environmental and genetic factors, may all have a major impact on nitrate levels in raw green leafy vegetables. An evaluation of 10 leafy vegetables harvested at two different light intensities (200 and 400 mol m-2 s-1) found that harvesting at low light intensity (200 mol m-2 s-1) resulted in higher nitrate accumulation. The amount of nitrate in any vegetable per serving is non-toxic, but its metabolites and bi-products, such as nitrite,

Table 3. Nutritional quality of some leafy vegetables

	Kale	Spinach	Chinese cabbage	Brussel sprout
Dietary fibres	85 mg	2.2 g	1.2 g	3.8 g
Protein	4.3 g	2.9 g	1.2 g	3.4 g
Vitamin A	9990 IU	9377 IU	318 IU	754 IU
Vitamin C	120 mg	28.1 mg	27 mg	85 mg
Vitamin K	704.8 ug	482.9 ug	43 ug	177 ug
Calcium	150 mg	99 mg	77 mg	42 mg
Folates	141 ug	194 ug	79 ug	61 ug
Iron	1.47 mg	2.7 mg	0.31 mg	1.4 mg
Potassium	491 mg	558 mg	238 mg	389 mg
Magnesium	47 mg	79 mg	13 mg	23 mg
Phosphorus	92 mg	0 mg	29 mg	69 mg
Zinc	0,56 mg	0.53 mg	0.23 mg	0.42 mg

Source: (USDA Nutrient Data Base)

nitric oxide, and N-nitrous compounds, are the major health concerns (Parks *et al.,* 2008). Total nitrate in the diet circulates into the enterosalivary system, where it is converted to nitrites by oral bacteria and salivary enzymes. This conversion rate is about 5-7% in healthy adults but considerably higher in infants and patients with gastroenteritis.

Oxalates: Oxalates are made up of oxalic acid [(COOH)2] and its salts or minerals. Many green leafy vegetables contain oxalic acid in their cell sap (Champ, 2002). Oxalates can appear as insoluble calcium, magnesium, and iron salts, soluble potassium and sodium salts, or a mixture of these two types, depending on the plant species.Oxalic acid, on the other hand, does not affect zinc absorption or metabolism. Insoluble oxalates are excreted in the skin. Soluble oxalates, on the other hand, affect the human body by forming a solid chelate with dietary calcium and other minerals, making the complex inaccessible for absorption and assimilation. This insoluble calcium oxalate crystallizes in the kidney, resulting in a severe health condition known as kidney stone. When the oxalate:calcium ratio is greater than 9:4, the detrimental effect of calcium absorption is greater. Oxalates are produced in the human body as a by-product of ascorbic acid and glyoxylate metabolism in addition to dietary intake. The distribution of oxalic acid varies among plants and species.

Tannins: Seguin (1976) coined the term tannin to describe substances contained in vegetable extracts that are responsible for turning animal skin into leather products (Natesh *et al.*, 2017). Vegetable tannins are polyphenols with a high molecular weight (up to 20,000 Da) that can form complexes in aqueous solutions with carbohydrates and proteins (Khanbabaee and Van Ree, 2001). Plant tannins can be found in the bark, wood, fruits, fruit pods, leaves, roots, and galls of various plants. Vegetable tannins, according to Gupta and Haslam, are naturally metabolic products, not the result of chemical or other in vitro transformations. Based on structural forms, Freudenberg divided tannins into two groups: hydrolyzable tannins and non-hydrolyzable or condensed tannins. Condensed tannins are more common in higher plants than the other two types (e.g., proanthocyanidins). The hydrolysable tannins are made up of glucose that is surrounded by phenolic acids and can be easily broken down by acids, bases, and enzymes. These oligomers of condensed tannins are immune to hydrolysis. Vegetable tannins are phenolic compounds that are water soluble and found in the plant kingdom.

Phytic acid: Phytic acid (myo-inositol hexaphosphoric acid) is a naturally occurring phosphorus storage compound found in all leafy vegetables (Nissar *et al.*, 2017). Phytic acid is present in plant tissues as potassium, magnesium, and calcium cation salts. Since phytic acid contains a large number of negatively charged phosphate groups, it chelates important mineral nutrients in the human body, rendering them less accessible for absorption (Reddy and Sathe, 2001). All leafy vegetables contain phytic acid (Myo-inositol hexaphosphoric acid), a naturally occurring phosphorus storage compound. Plant tissues contain potassium, magnesium, and calcium cation salts of phytic acid.

Conclusion

Green leafy vegetables are rich in nutrients that are important for human health and happiness. Amino acids, vitamins, essential fatty acids, minerals, and dietary fibre are among them. It has major socioeconomic advantages as well. Green leafy vegetables, for example, are grown and harvested by women farmers in the tropics and subtropics to supplement household income. Traditional leafy vegetables play an important role as a food source in rural areas, and they are available all year. Green leafy vegetables are commonly thought to be the cheapest source of food for supplementing vitamins and micronutrients to reduce nutrient deficiencies. It's also used as a herbal and medicinal plant for a variety of ailments in various cultural and traditional settings. Anti-nutritional factors in green leafy vegetables, mainly nitrates, oxalates, phytates, cyanogenic glycosides, and tannins, may interfere with micronutrient absorption and makes them inaccessible. Pre-consumption thermal processing of leafy vegetables, such as boiling, frying, and blanching, helps to minimize anti-nutrient levels.

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