

## Health Benefits and Therapeutic importance of green leafy vegetables (GLVs)

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### Abstract

*Green leafy vegetable have excellent nutritional value and can be used for medicinal benefits. Different photochemicals are present in green leafy vegetables including phenolic acids, flavonoids, carotenoids, polyphenols, glucosinolates, isothiocyanate, allylic sulfides, phytosterols, and monoterpenes. Green leafy vegetables mostly contain antioxidants, dietary fibers, minerals,  $\alpha$ -linoleic acid, and vitamins. It has different health benefits such as anti-diabetic properties, prevents CVD, anti-hypertensive, anti-carcinogenic, anti-anemic, and improves gut health.*

**Keywords:** Green leafy vegetables, health benefits, dietary fiber, antioxidant, flavonoids

### INTRODUCTION:

GLVs (Green Leafy Vegetables) are vegetables whose young shoots, leaves and flowers are edible<sup>1</sup>. They have excellent nutritional value

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and can be used for medicinal benefits<sup>2</sup>. Concentration of functional compounds vary according to the climate season, their growth phase and their existence in particular plant part <sup>3</sup>

### Phytochemicals in Green leafy vegetables:

The phytochemicals present in green leafy vegetables includes phenolic acids, flavonoids, carotenoids, polyphenols, glucosinolates, isothiocyanate, allylic sulfides, phytosterols, and monoterpenes<sup>4</sup>

### Components of green leafy vegetables:

Green leafy vegetables mostly contain antioxidants, dietary fibers, minerals,  $\alpha$ -linoleic acid, and vitamins. Antioxidants reduce ferric ions and mitigate oxidative stress. Dietary fiber delay absorption of carbohydrates and improve insulin secretion. Minerals such as magnesium and phosphorous protect against gestational diabetes.  $\alpha$ -linoleic acid determines composition of phospholipid bilayer and insulin sensitivity within skeleton muscles. Vitamins such as  $\alpha$ -tocopherol (Vit. E),  $\beta$ -carotene (Vit. A), ascorbic acid (Vit. C) reduces oxidative stress.<sup>5</sup>

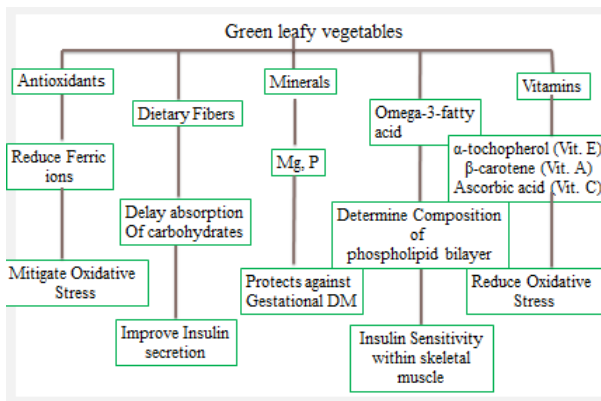


Figure 1

### Health benefits:

Green leafy vegetables with phytochemicals and enormous antioxidants have potential to work as: anti-diabetic prevents CVD, anti-hypertensive, anti-carcinogenic, anti-anemic, improves gut health<sup>6,7,8</sup>

### **Green leafy vegetables and anti-diabetic properties:**

Diabetes Mellitus is spreading everywhere in the world and it is categorized as a non-communicable disease. By 2025, it has been proposed that approximately 300,000,000 people would be affected by this disease.<sup>9</sup> GLVs (Green leafy vegetables) contain decent quantity of minerals, alpha tocopherols, vitamins, flavonoids,  $\alpha$ -linoleic acid, phytochemicals.<sup>10</sup>

It has been seen in one of the studies that females who consume leafy green vegetables are at low risk to develop type 2 diabetes. Green leafy vegetables can decrease the chance of developing type 2 diabetes because of magnesium present in these vegetables as one of the researches has proved that magnesium can decrease the risk of type 2 diabetes development.<sup>11</sup>

### **Green leafy vegetables and its cardio protective effects:**

CVD includes the diseases related to heart and blood vessels like stroke, hemorrhage, heart failure.<sup>12</sup> It has been reported that about 80% of males and 75% of females died annually due to cardio vascular diseases.<sup>12</sup> In Pakistan, 30 to 40 per cent of all deaths are due to CVD.<sup>15</sup> The risk factors for CVD includes smoking, age, physical inactivity, alcohol consumption, obesity, family history, diabetes mellitus, high blood cholesterol level, poverty and inadequate vegetables and fruits consumption.

There is very low data available on the effect of vegetables and fruits in lowering the risk of heart diseases. One of the researches conducted to observe the effect of consumption of fruits and vegetables in lowering risk of heart diseases. It was observed that people who consume fruits and vegetables especially leafy green vegetables have low risk to develop CVD as compare to those who does not consume them.<sup>16</sup>

In another study researchers studied the mechanism of green leafy vegetables related to the protection against heart diseases. Researchers noticed that inorganic nitrate present in green leafy vegetables was converted to nitric oxide and nitrite in oral cavity which were seen to have vasodilation property and tissue protective effect, thus lowers the risk of CVD.<sup>17</sup>

In different Indian areas, a clear difference has been seen in the prevalence and mortality due to cardiovascular disease. An

investigation was done to examine the importance and numerous dietary factors and other variables in everyday life to describe the variation death rate of cardiovascular disease. Survey results showed that death due to cardiovascular disease was linked with literacy level, smoking, prevalence of overweight and obesity, prevalence of stunted growth at 3-years, dietary consumption of calories, adult mean body mass index, green leafy vegetables, cereals and pulses, roots, milk and milk products, tubers and other vegetables, sugar, jaggery and fats and oils. A noteworthy negative link of cardiovascular disease mortality with green leafy vegetable intake was seen. On the contrary, a positive link between cardiovascular disease mortality with intake of milk and milk products, sugar and prevalence of obesity was observed.<sup>18</sup>

A meta-analysis was done to see that intake of GLVs (green leafy vegetables) as well as cruciferous vegetables considerably decreases the incidence of CVD (cardiovascular disease). 8 studies examined the positive correlation between the intake of GLVs (green leafy vegetables) and occurrence of CVD (cardiovascular disease) and met the encompassing criteria.<sup>19</sup>

With different constituents of minerals, vitamins, dietary fiber, bio-active phytochemicals and carotenoids, vegetables and fruits make a heterogenous food group. A research was done to study the association between stroke risk in Swedish men and women and specific intake of fruits and vegetables subdivisions. This study was restricted to persons without High blood pressure (hypertension). Results concluded that risk of stroke is negatively associated with intake of fruits and vegetables especially intake of green leafy vegetables and pears and apples was negatively linked with stroke.<sup>20</sup>

### **Components that prevent CVD**

The components that prevents from CVD are flavonoids<sup>21</sup>, Dietary Fiber<sup>22</sup>, Niacin<sup>23</sup>

#### **Role of flavonoids:**

Flavonoids provide protection against low density lipoprotein oxidation by two mean firstly by free radical scavenging effects and secondly by activates cellular antioxidants.<sup>(21,24)</sup> Gel like substance present in dietary fiber (soluble) helps in decreasing dietary fiber absorption and also help in fecal secretion of cholesterol.<sup>(25)</sup> Niacin present in green

leafy vegetables produces reactive oxygen species and decrease the LDL oxidation and also low the monocyte adhesion to endothelial cell which lowers the chances of atherosclerosis.

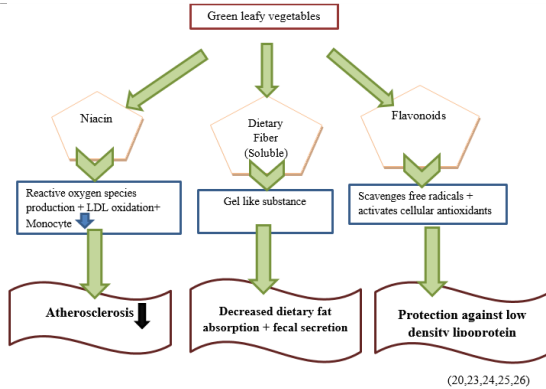
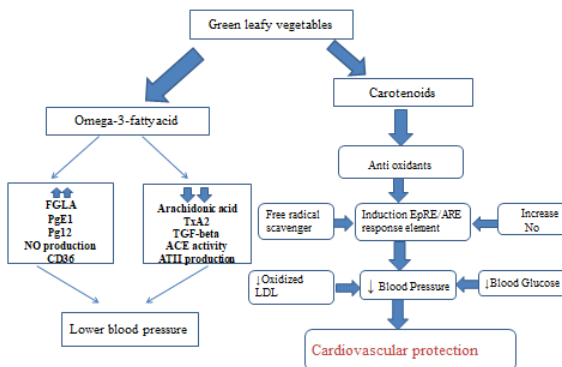


Figure 2

**Green Leafy vegetables and anti- hypertension effect:**

Bioactive component of green leafy vegetables that prevent from hypertension includes alpha-tocopherol<sup>27</sup>, Carotenoids<sup>27,28</sup>, coumarins<sup>27,29</sup>, omega-3-fatty acids<sup>27,30</sup>. The antioxidants present in green leafy vegetables helps in protection against cardiovascular diseases by free radical scavenger, Induction EpRE/ARE response element, and increasing NO which helps in lowering oxidize LDL, lowering blood pressure, and lowering blood glucose level. (27,28)



(27,28)

Figure 3

Green leafy vegetable, that are rich source of dietary nitrate and defensive against stroke and cardiovascular diseases are suggested by Epidemiological studies. The major risk factor of stroke is High blood pressure (BP) and the use of inorganic nitrate has shown to lessen the blood reassure. Analysis of the theory that vegetables containing high nitrate diets would enhance plasma nitrate and concentrations of nitrate whereas in healthy women reduce blood pressure was aim of the study.<sup>29</sup>

The high omega-6: omega-3 fatty acid ratio (FAR) in typical Western dietary pattern may aggravate the possibility of chronic disease. Contrarily, disease risk has been reducing by the intake of green leafy vegetable (GLVs). The study explores special effects of orange flesh, collard greens (CG), sweet potato greens (SPG), purslane (PL) of disease risk measure in rats fed. The results suggest that possibilities of cardiovascular disease (CVD) have been reduce by SPG, CG and PL that are linked with the intake of foods that have high omega-6: omega-3 fatty acid ratios.<sup>30</sup>

Nitric oxide and nitrite circulation is boost by an increase nitrate intake. This may attend to improved vascular function and lower blood pressure. The rich source of nitrate containing green leafy vegetable is spinach. In order to evaluate severe sound effects on arterial stiffness and blood pressure in healthy male and females of a nitrate rich meal containing spinach a study was conducted. Spinach ensure in a sevenfold enhance in nitrate in saliva and an eightfold enhance in nitrate in saliva levels from pre-meal to 120 min post meal. Therefore, utilization of a nitrate-rich food can reduce systolic pulse pressure and systolic blood pressure and enhance large artery conformity intensely in well women and men. Only if encourage, these sound effects could provide to improved heart condition.<sup>31</sup>

The risk of undesirable cardiovascular measures has been reducing by diets that are rich in vegetables and fruits. On the other hand, the component accountable for this consequence has not been finely demonstrated. Lately, with evidence vegetables with high nitrate content may signify a resource of vasoprotective nitric oxide. The limited use of spinach has been assumed; a high dietary nitrate content containing vegetables can influence the central and peripheral blood pressure (BP) and arterial waveform analytical of arterial stiffness. 27 healthy candidate were erratically allocate to obtain either a low-

nitrate or high-nitrate soup, by using a placebo-controlled, crossover design. The result show that vegetable-rich diet may contribute beneficial hemodynamic effects of dietary nitrate from spinach and underline the elevated BP the mangement.<sup>32</sup>

Through the nitrite - nitrate – NO pathway, evidence for the positive attribute of nitrate is accumulating in dealing with function of heat in people with good health. Increased intake of nitrate from green leafy vegetables has the same vascular effect as those at risk for high blood pressure, this is not clear. The aim is to assess the effects of short-term regular consumption of nitrate from greens on hypertension and arterial stiffness in people with high-blood pressure. High-nitrate dietary intervention led to at least a fourfold increase in saliva and plasma nitrate and nitrate. There is no difference between high-nitrate diet and diet low in nitrate in slight active, home-based and workplace arterial vision and blood pressure. Nitrate intake and increased risk of hypertension in people may not be an effective short-term strategy to reduce blood pressure.<sup>33</sup>

### Green leafy vegetables and anti-cancerous properties

Bioactive component of green leafy vegetables that prevent from cancer includes beta carotene<sup>27</sup>, phenyl isothiocyanate<sup>28</sup>, sulphoraphane<sup>34</sup>, selenium<sup>35</sup>. The mechanism through which it works is explain in the figure as below

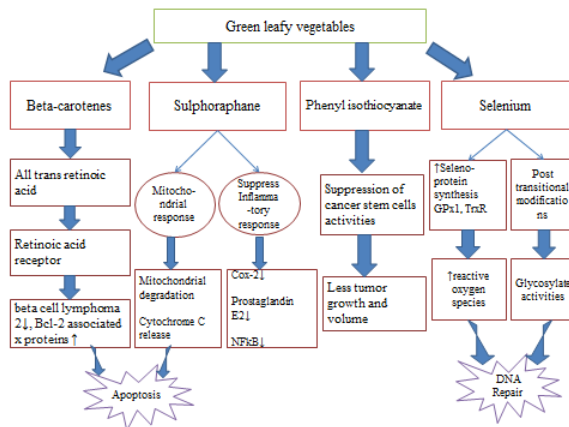


Figure 4

The low incidence of many long-lasting illnesses, for example cardiovascular diseases and cancer, has been linked to the intake of vegetable-rich diets and has been confirmed by in vitro, clinical and pre-clinical research. Crucified family members are planted and consumed worldwide on regular bases. The main vegetables include banana, broccoli, radish, cauliflower, cabbage, Brussels sprouts and watercress which can be fresh (salad), steamed or cooked. In addition to nutrients, these vegetables also have health-beneficial secondary metabolites, including S-methylcysteine sulfoxide and sulfur-containing flavonoids, glucosinolates, anthocyanin, coumarin, carotenoids, and other antioxidant enzymes. Some specific mechanisms of cancer prevention include NRF2, anti-inflammatory, polymorphism, inhibition of histone deacetylase activity, and effects on estrogen metabolism.<sup>36</sup>

"Bioactive compounds" are extra-nutritional components that usually happen in minor amounts in food. Their benefits on health are studied comprehensively. The epidemiology of this scientific research has resulted in numerous epidemiological studies showing the heart healthy benefits of a plant based diet on cancer and heart disease. Several bio active compounds have been found. These bio active compounds don't have same functional and structural activities and can be characterized correspondingly.

A research was conducted to study the phenolic compounds, their subtypes, flavonoids and other components of all plants that are present in legumes, grains, vegetables, nuts, fruits, olive oil, red wine and teas. Most of phenolic compounds contain antioxidant potentials, and few studies have shown positive impact on promotion, coagulation and tumor genesis. While few epidemiological studies have reported positive link between bioactive compounds and heart diseases and cancer, results of other studies have not shown these links. Soy contains numerous phytoestrogens, but also in linseed oil, cereals, vegetables and fruits. Some studies have shown positive effects on other comorbidity factors of heart disease and in cancer as they have antioxidant properties. The potential impact of phytoestrogen on cancer is complex as it acts as partial estrogen and antagonists. The phenolic which is present in olive oil and olive, hydroxytyrosol is a effective antioxidant. The wine and nuts contain resveratrol which inhibits



carcinogenesis and have anti-oxidative, antithrombotic and anti-inflammatory properties.

A powerful carotenoid, lycopene which is present in tomatoes and other fruits inhibits the growth of tumor cells in animals and also protect from prostate and other cancers. In experimental models, onion and garlic contain organosulfur compounds, monoterpenes in citrus fruits, isothiocyanates in cruciferous vegetables, cherries and monoterpenes have cardioprotective effects as well as anti-cancer activity. In short, on health many bioactive compounds have beneficial effects. In order to make science-based dietary recommendations many scientific researches need to be conducted. However, there is ample proof that bioactive compounds are rich in dietary sources. So it is best to recommend whole grains, legumes, oils, nuts, fruits and vegetables rich diets. <sup>37</sup>

The minimum carcinogen threat and low toxins levels of fruits and vegetables recommended that precise amount of antioxidants agents from these food sources can cause anticancerous effects without producing significant toxins. This review provides a comprehensive overview on major findings from studies on the effects of dietary antioxidants on lungs, skin, breast, prostate, and liver cancers for example curcumin, resveratrol, tea polyphenols, lycopene, genistein, lupole and pomegranate. <sup>38</sup>

### **Green leafy vegetables as anti-anemic:**

In anaemia body have not the adequate amount of healthy red blood cells which carry appropriate amount of oxygen to the tissues of body. The very common or induced types of anaemia are included megaloblastic anaemia and Iron deficient anaemia. <sup>(40)</sup>

### **Iron Deficiency Anemia and green leafy vegetables:**

A study was conducted in 2016 by Linnewiel- Hermoni K et,al. this study was conducted to detect the Iron rich sources frequency (non-vegetarian diet and green leafy vegetables), order of birth, food habits, reading and writing ability level and anaemia interception understanding are main factors on which anaemia prevalence depends. For this purpose the groups of 317 adolescent female ages of 10-19 years were taken. It was observed that the general prevalence was established to be 58.4 %. <sup>(42)</sup>

**Table 1**

Iron rich green vegetables	Amount/ 100g
Feenugeek	30.41mg
Spinach	26.54mg
Asparagus	2mg
Broccoli	1mg
Leeks	2mg
Parsely	4mg

Another study was conducted to study the prevalence rate of mild, moderate and severe anaemia was observed. For this purpose the adolescent girls were taken for mild, moderate and severe anaemia correspondingly and the all -inclusive prevalence rate was 28%, 24% and 43%. WHO recommends 8mg-10mg/day iron consumption for this age but those girls dietary expenditure for iron was much underneath the suggested amount. <sup>(43)</sup>

Among children iron deficiency anemia is widely prevalent and more than 2 billion people globally affecting by malnutrition. Food-based approach of Food multi-mix (FMM) idea involves nearby accessible untreated resources in dissimilar extent and converting them into ethnically suitable foodstuffs by means of usual methods of preparations. For this reason, blending diverse amount of spinach, fenugreek and multi-legumes flour were prepared by six food multi-mix formulations along with control. Consequences about sensory valuation showed that maximum number for breakability, appearance, flavor, chewiness and generally suitability were obtained by T3 and T4. Based on product acceptability, these best formulations i.e. T3 and T4 along with control were selected for further efficacy studies in school aged children, containing 8.93 mg/100g iron. Hence, in school nutrition programs to decrease the severity of various problems foodstuffs ready from legumes supplemented with parched green leafy vegetables .<sup>44</sup>

Today high prevalence of anemia has been seen in many countries in many developing countries, mostly in women who are vegetarian. In vegetarian diet low bioavailability of nonheme iron is a major cause. Forty-eight meals with combinations of roti is one of four normally used green leafy vegetables (GLV) and one of the 6 cereals along with 35 meals with cereal, roti, vegetable/legume and fruits were experienced for standardized protocol with <sup>59</sup>Fe as a tracer and their in vitro dialysability of iron using simulated gastrointestinal

conditions. In GLV-based meals their average bioavailability of iron was extensively elevated as adjacent to the worth in current cereal-legume vegetable combination or cereal-fruit eating patterns. Bioavailable iron density was identified having higher amount in 31 GLV-based meals. Green leafy vegetable based meal/day will enhance the bioavailable iron intake in women who are vegetarian especially in reproductive age which will help in meeting daily requirement of iron.

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On the risk of developing anemia the control of vegetarian diet among Indian women was tested and suggests advantages for addressing diet-related iron-deficiency anemia. Daily consumption of fish, meat, and egg for severely or moderately anemia was related after controlling for household level socioeconomic characteristics and individual-level factors, the chances of having iron-deficiency anemia in Indian women can be reduced after studying the economic characteristics such as having higher wealth, being in paid employment and rural residence. The major public health problem in India is vegetarian diets poor in iron for economic, cultural and religious reasons supplementations and fortification of commonly used vegetarian diet is not associable for all due to cost –effective strategy. The promotion of consumption of cheap iron-rich foodstuffs should be encouraged. Urgently to control vegetarianism in India on iron deficiency anemia large-scale cohort and intervention studies are necessary. <sup>46</sup>

In recent cross-sectional study shows that 240 women of reproductive age from slum areas were carried out as the study population, In Community Medicine department the field practice area, to evaluate load of nutritional anemia and study its epidemiological correlates. The early stage of iron deficiency anemia as shown by study subjects normocytic hypochromic picture and had microcytic hypochromic picture, indicate the dipmorphic/macrocytic hypochromic anemia, iron deficiency anemia, implying folate/B12 vitamin deficiency and iron deficiency correspondingly. Epidemiological factors made known statistically shows that anemia is associated with socioeconomic status, education of respondents, age, inadequate intake of green leafy vegetables and pulses and history of excessive menstrual bleeding. <sup>47</sup>

In India seasonally various types of unconsumed foods are available but are not utilized to the amount they should actually use in

high nutritive value. The level of micronutrient malnutrition among vulnerable section has been explored to overcome the nutritional disorders. Practically, there is not significant intake of nutritious food due to the lack of information available on underutilized foods in rural areas. Therefore, from chosen areas of south Karnataka an attempt has been made to categorize and evaluate various different unconsumed vegetables for their nutrient content. In total 38 green leafy vegetables iron content of same ranged between 3.68 to 37.34mg/100g has been identified, Calcium content is highest in Oxalis acetosella, Chilikere greens (400g). Knol khol green, Brassica oleracea have the highest content of ascorbic acid. Portulaca oleracea (37.34mg), Nelabasale green has highest iron content. In chilikere greens calcium content ranged Calcium content ranged from 73 to 400mg/100g. <sup>48</sup>.

### **Folate and prevention of anemia:**

The risk of chronic disease increases due to the deficiency of folate, megaloblastic anemia. A study that is conducted in China shows the link between the green leafy vegetables and their contribution in the intake of folate. Similar results show that population that consume green leafy vegetables have better source of folate than those who consumes fruits and root vegetables. <sup>(49)</sup>

**Table 2**

Folate rich vegetables	Amount/100g
Turnip green	170mg
Collard	177mg
Mustard Green	103mg
Lettuce	76mg
Celery	36mg
Spinach	263mg

### **Megaloblastic Anemia and green leafy vegetables:**

70 out of 100 patients with megaloblastic anemia significantly were delivered with green leafy vegetables in the 6 months more than in the other half of the year. So the study showed that the higher incidence of onset in winter and spring may be related to an inadequate intake of folic acid due to seasonal low consumption of fresh green vegetable. <sup>(50)</sup>

### **Green leafy vegetables and gut health:**

Dietary fiber is a major component of vegetables, coming in the form of cellulose (polysaccharides and lignin).<sup>46</sup> Two types of dietary fibers are soluble and insoluble.

### **Insoluble dietary fiber and Constipation:**

Insoluble fiber does not dissolve in water and is left intact as food moves through the gastrointestinal tract.<sup>41</sup> The insoluble dietary fiber has long been known to relieve constipation. Insoluble fiber adds bulk to the diet and performs the role of cleansing the digestive tract<sup>40</sup>

### **Soluble dietary fiber:**

Soluble dietary fibre absorbs water from the digestive tract and become viscous and gelatinous in nature, thereby improves stool consistency<sup>51</sup>. Because of these properties of GLV helps to relief constipation and hemorrhoids.<sup>52</sup> Inulin is now also included in this class. 30-40% dietary fibers come from green leafy vegetables.<sup>53</sup>

### **Green leafy vegetables and dietary fiber:**

Gut health has been influenced by the dietary fiber comes from green leafy vegetables, effecting the spread of disease causing bacteria. GLV can protect against or else improve enteric infections, balance and upheld with the metabolism and immune system and fermentation of non-digestible dietary components in the large intestine.<sup>54</sup>

### **Benefits of dietary fibers:**

A good intake of dietary fibers provides us benefits such as improves the serum lipid concentration, blood glucose control, regularity gets promote, lower the blood pressure, helps in losing the weight moreover improves the immunity.<sup>55</sup>

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