A review on horticulture in augmenting human health metabolism and disease prevention

Yogendra Singh and Prerak Bhatnagar

Abstract
Fruit and vegetables are playing crucial role in human nutrition. Fruit and vegetables are immensely packed with goodness and often have a number of essential vitamins and minerals that cannot be found in other types of foods and they are enriched with higher levels of these mineral nutrients than other foods. Vegetables and fruit contribute a significant part of human nutrition, as they are potential sources of nutrients, dietary fiber and phytochemicals. A diet rich in vegetables and fruits can reduce blood pressure, lower risk of heart disease and stroke, ameliorate some types of cancer, lessens risk of eye and digestive problems and have a positive effect upon blood sugar which can help in controlling appetite. The higher average daily consumption of fruits and vegetables makes less possibility the chances of developing cardiovascular diseases. Fruits and vegetables keep indigestible fiber, which absorbs water and expands as it passes through the digestive system. The passage of fibre through digestive system can calm symptoms of an irritable bowel and by triggering regular and smooth bowel movements can relieve or check constipation which makes human free from several ailments and disorders. Consuming fruits and vegetables can also keep eyes healthy and may help check two common aging-related eye diseases cataracts and muscular degeneration. Fruit and vegetables especially leafy vegetables have been positively in nearly half the gastrointestinal infections caused by norovirus. These foods are commonly eaten raw and may become contaminated during their preparation by an infected food handler. Hygiene is more important when handling fruits to be eaten raw and such products require proper cleaning, handling and storing to limit contamination of microbial load to minimum as possible. The multifaceted benefits through sufficient intake of fruits and vegetables as per daily dietary recommendation along with other cereals, milk and eatables has tremendous impact on human health wellness, enhanced longevity and impart profuse health benefits in controlling several important diseases and disorders. The increasing awareness and availability in well-connected world offers a promising scope to utilize all seasonal fruits and vegetables in every part of the world. In this way, we can eat better in quality and quantity of horticultural foods and lead in healthier and happier life.

Keywords: LDL (Low density lipoprotein), antioxidant, phytochemical, human nutrition

Introduction
Several reports have shown that adequate consume of fruits and vegetables form an important part of a healthy diet and low fruit and vegetable consume constitute a risk factor for chronic diseases such as cancer, coronary heart disease (CHD), stroke and cataract formation as demonstrated by Van Duyn, Pivonka (2000) [73]. Scientific evidence indicates that frequent consumption of fruits and vegetables can prevent oesophageal, stomach, pancreatic, bladder and cervical cancers and that a diet high in fruits and vegetables could prevent 20% of most types of cancers as reported by Crawford et al (1994) [16]. Fruit and vegetable intake is influenced by gender, age, income, education and family origin as reported by Wardle et al (2000) [78], Giskes et al (2002) [29]. Fruits and vegetables play crucial a significant role in human nutrition, particularly as potential sources of vitamins (C, A, B 6, thiamine, niacin, E), minerals, and dietary fiber as reported by Quebedeaux and Bliss (1988) [56], Quebedeaux and Eisa (1990) [55] and Wargovich (2000) [79]. Their contribution as a group is estimated at 91% of vitamin C, 48% of vitamin A, 27% of vitamin B 6, 17% of thiamine, and 15% of niacin in the U. S. diet. Fruits and vegetables also provide 16% of magnesium, 19% of iron, and 9% of the calories. Another important nutrients supplied by fruits and vegetables include folacin, riboflavin, zinc, calcium, potassium, and phosphorus. Nutrition is most absolutely necessary for normal body functions. We obtain this nutrition through chemicals found in food. Just like your body, food is a combination of chemicals, some of which are essential for normal body functions. These essential chemicals are called nutrients. A nutrient is defined as a chemical...
whose absence from diet for a long enough time results in a clearly defined change in health. We require nutrients for normal body growth and development for managing cells and tissues, and as a fuel to do physical and metabolic processes. Foods provide six major classes of nutrients viz., carbohydrates, lipids, proteins, minerals, vitamins and water. The first five are called essential nutrients. Carbohydrates, protein and fats are also called macronutrients because our bodies require large quantities of them. Our body needs comparatively less amounts of vitamins and minerals, so they are called micronutrients. In addition to nutrients, there are many other chemical substances, but they do not fit the classical definition of a nutrient and plays supplemental role for smooth and vital functions of human digestive system. These include dietary fiber, enzymes and phytochemicals. The latest development in the field of nutrition is research on phytochemicals (plant chemicals), popularly called as antioxidants. They are abundantly found in fruits and vegetables and play a vital role in decreasing the risk of many chronic diseases including cardiovascular disease, cancer, and diabetes, macular and neurological degeneration. Some fruits and vegetables have been studied separately either in prospective cohort studies or randomized controlled trials.

Typically, these fruits or vegetables are of interest because of their phytochemical contents, including polyphenols, phytoestrogens, and antioxidants. Studies in berries were summarized by Basu et al (2010) [5]. Intervention studies found mixed results, with only 2 of 20 experiments indicate decreases in systolic blood pressure with berry consumption. Cranberries have been studied more extensively, particularly for their role in prevention and treatment of urinary tract infections as reported by Cote et al (2010) [13]. Grapes have also been extensively studied, mostly in response to the French paradox, the finding that the French diet is high in fat but CVD incidence is low. Consumption of red wine has been proposed as a protective mechanism, because grapes are high in antioxidants, namely flavonoids as reported by Vislocky et al (2010) [10]. Grape polyphenols can reduce atherosclerosis by inhibiting LDL oxidation and platelets aggregation, improving endothelial function, lowering blood pressure, reducing inflammation, and activating novel proteins that prevent cell senescence as revealed by Dohadwala et al (2009) [21]. Despite the promise of grapes in disease prevention, little epidemiologic evidence supports a unique role for grapes in disease prevention or health.

### Table 1: Nutritive constituents of fruits and vegetables that have a positive impact on human health and their sources

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Sources</th>
<th>Proposed effects on human-wellness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ascorbic acid (Vitamin C)</td>
<td>Broccoli, cabbage, cantaloupe, citrus fruits, guava, kiwifruit, leafy greens, pepper, pineapple, potato, strawberry, tomato, watermelon</td>
<td>Prevents scurvy, aids wound healing, healthy immune system, cardiovascular disease</td>
</tr>
<tr>
<td>Carotenoids (Vitamin A)</td>
<td>Dark-green vegetables (such as collards, spinach, and turnip greens), orange vegetables (such as carrots, pumpkin, and sweet potato), orange-flesh fruits (such as apricot, cantaloupe, mango, nectarine, orange, papaya, peach, persimmon, and pineapple), tomato</td>
<td>Night blindness prevention, chronic fatigue, psoriasis, heart disease, stroke, cataracts</td>
</tr>
<tr>
<td>Vitamin K</td>
<td>Nuts, lentils, green onions, crucifers (cabbage, broccoli, brussel sprouts), leafy greens</td>
<td>Synthesis of pro-coagulant factors, osteoporosis</td>
</tr>
<tr>
<td>Tocopherol (Vitamin E)</td>
<td>Nuts (such as almonds, cashew nuts, filberts, macadamias, pecans, pistachios, peanuts, and walnuts), corn, dry beans, lentils and chickpeas, dark green leafy vegetables</td>
<td>Heart-disease, LDL oxidation, immune system, diabetes, cancer</td>
</tr>
<tr>
<td>Fiber</td>
<td>Most fresh fruits and vegetables, nuts, cooked dry beans and peas</td>
<td>Diabetes, heart disease</td>
</tr>
<tr>
<td>Folate (folic or folic acid)</td>
<td>Dark-green leafy vegetables (such as spinach, mustard greens, butter head lettuce, broccoli, brussels sprouts, and okra), legumes (cooked dry beans, lentils, chickpeas and green peas), asparagus</td>
<td>Birth defects, cancer heart disease, nervous system</td>
</tr>
<tr>
<td>Calcium</td>
<td>Cooked vegetables (such as beans, greens, okra and tomatoes) peas, papaya, raisins, orange, almonds, snap beans, pumpkin, cauliflower, rutabaga</td>
<td>Osteoporosis, muscular/skeletal, teeth, blood pressure</td>
</tr>
<tr>
<td>Magnesium</td>
<td>Spinach, lentils, okra, potato, banana, nuts, corn, cashews</td>
<td>Osteoporosis, nervous system, teeth, immune system</td>
</tr>
<tr>
<td>Potassium</td>
<td>Baked potato or sweet potato, banana, plantain, cooked dry beans, cooked greens, dried fruits (such as apricots and prunes), winter (orange) squash, and cantaloupe</td>
<td>Hypertension (blood pressure) stroke arteriosclerosis</td>
</tr>
</tbody>
</table>

Source: Kader A. A. (2002)[137]

### Table 2: Non-nutritive plant constituents that may be beneficial to human health

<table>
<thead>
<tr>
<th>Constituent</th>
<th>Compound</th>
<th>Sources</th>
<th>Proposed effects on human-wellness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phenolic compounds</td>
<td>Tannins</td>
<td>Apple, grape, cranberry, pomegranate</td>
<td>Cancer</td>
</tr>
<tr>
<td>Anthocyanins</td>
<td>Cyaniding, malvidin, delphinidin, pelargonidin, peonidin, petunidin</td>
<td>Red, blue, and purple fruits (such as apple, blackberry, blueberry, cranberry, grape, nectarine, peach, plum, prune, pomegranate, raspberry, and strawberry)</td>
<td>Heart disease, cancer initiation, diabetes, cataracts, blood pressure, allergies</td>
</tr>
<tr>
<td>Flavan-3-ols</td>
<td>Epicatechin, epigallocatechin, catechin, gallatechin</td>
<td>Apple, apricots, blackberries, plums, raspberries, strawberries</td>
<td>Platelet aggregation, cancer,</td>
</tr>
<tr>
<td>Flavanones</td>
<td>Hesperidin, narigenin, eriodictyol</td>
<td>Citrus (oranges, grapefruit, lemons, limes, tangerine)</td>
<td>Cancer</td>
</tr>
<tr>
<td>Flavones</td>
<td>Luteolin, apigenin</td>
<td>Celeriac, celery, peppers, rutabaga, spinach, parsley, artichoke, guava, pepper</td>
<td>Cancer, allergies, heart disease</td>
</tr>
<tr>
<td>Flavonols</td>
<td>Quercetin, kaempferol, myricetin, rutin</td>
<td>Onions, snap beans, broccoli, cranberry, kale, peppers, lettuce</td>
<td>Heart disease, cancer initiation, capillary protectant</td>
</tr>
<tr>
<td>Phenolic acids</td>
<td>Caffeic acid, chlorogenic acid, coumaric acid, ellagic acid</td>
<td>Blackberry, raspberry, strawberry, apple, peach, plum, cherry</td>
<td>Cancer, cholesterol</td>
</tr>
</tbody>
</table>

Source: Kader A. A. (2002)[137]
Table 2: Con…..

<table>
<thead>
<tr>
<th>Carotenoids</th>
<th>Sources</th>
<th>Proposed effects on human-wellness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lycopene</td>
<td>Tomato, watermelon, papaya, Brazilian guava, Autumn olive, red grapefruit</td>
<td>Cancer, heart disease, male infertility</td>
</tr>
<tr>
<td>α-carotene</td>
<td>Sweet potatoes, apricots, pumpkin, cantaloupe, green beans, lime beans, broccoli, brussel sprouts, cabbage, kale, kiwifruit, lettuce, peas, spinach, prunes, peaches, mango, papaya, squash and carrots</td>
<td>Tumor growth</td>
</tr>
<tr>
<td>β-carotene</td>
<td>Cantaloupes, carrots, apricots, broccoli, leafy greens (lettuce, Swiss chard), mango, persimmon, red pepper, spinach, sweet potato</td>
<td>Cancer</td>
</tr>
</tbody>
</table>

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<thead>
<tr>
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<th>Sources</th>
<th>Proposed effects on human-wellness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Xanthophylls</td>
<td>Lutein, zeaxanthin, β-cryptoxanthin</td>
<td>Sweet corn, spinach, corn, okra, cantaloupe, summer squash, turnip greens</td>
<td>Macular degeneration</td>
</tr>
<tr>
<td>Monoterpenes</td>
<td>Limonene</td>
<td>Citrus (grapefruit, tangerine)</td>
<td>Cancer</td>
</tr>
<tr>
<td>Sulfur compounds</td>
<td>Glucosinolates, isothiocyanates, indoles, allicin, diallyl sulphide</td>
<td>Broccoli, Brussels sprouts, mustard greens, horseradish, garlic, onions, chives, leeks</td>
<td>Cancer, cholesterol, blood pressure, diabetes</td>
</tr>
</tbody>
</table>

Source: Kader A. A. (2002) [77].

**Fruits and vegetables rich sources of vitamins, minerals and antioxidants**

Fruits and vegetables play crucial role in human nutrition and health, especially as sources of vitamin C, thiamine, niacin, pyridoxine, folic acid, minerals and dietary fibre as demonstrated by Wargovich (2000) [79]. In the USA, the consumption of fruits and vegetables as a group is known to contribute to an estimated intake of 91% of vitamin C, 48% of vitamin A, 30% of folate, 27% of vitamin B6, 17% of thiamine and 15% of niacin. It is also known that fruit and vegetable intake supply 16% of magnesium, 19% of iron and 9% of the calories (United States Department of Agriculture, 2000) [72]. Another vital nutrients supplied by fruits and vegetables include riboflavin, zinc, calcium, potassium and phosphorus. Some components of fruits and vegetables (phytochemicals) are strong antioxidants and modify the metabolic activation and detoxification/disposition of carcinogens and may even influence processes that may change the course of the tumor cell as reported by Wargovich (2000) [79]. Although antioxidant capacity varies greatly among fruits and vegetables as revealed by Kalt (2002) [38], it is better to consume a pot pourri of them rather than limiting intake to a few with the highest antioxidant capacity. The United States Department of Agriculture (2000) [72] encourages consumers to take at least two servings of fruits and at least three servings of vegetables per day, choose fresh, frozen, dried or canned forms of a variety of colours, kinds and choose dark-green leafy vegetables, orange fruits, vegetables and cooked dry beans and peas regularly. However, in some countries, consumers are encouraged to eat at least 10 servings of fruits and vegetables per day. There is evidence that consumption of whole foods is better than isolated food components such as dietary supplements and nutraceuticals. Increased consumption of carotenoid-rich fruits and vegetables offer a better protective effect than carotenoid dietary supplements by increasing LDL-oxidation resistance, lowering DNA damage and inducing higher repair activity in human volunteers who participated in a study conducted in European countries such as Italy and Spain as demonstrated by Southon (2000) [64]. High consumption of tomatoes and tomato products have been related with reduced carcinogenesis, particularly of prostate cancer and is thought to be due to the presence of lycopene, which gives red tomatoes their colour as reported by Giovannucci (2002) [28]. The use of tomato powder significantly reduced prostate carcinogenesis in rats as reported by Boileau et al (2003) [8]. Examples of fruits and vegetables recommended for daily consumption include spinach, orange, mango, carrot, melon, pineapples red grapefruit etc.

**Fruit and vegetable consumption: Human health and disease prevention**

**Prevention of obesity**

Childhood and adolescent obesity have reached epidemic proportions especially in the USA and the alarming rate at which this condition continues to increase is of great concern (Muriello et al., 2006) [48]. Unfortunately, obesity among children and adolescents is also increasing in South Africa and in other Asian countries due to western influence, and since behavior-related attitudes to obesity prevention such as physical activity and fruit and vegetable consumption tend to decline with age, it is important that intervention efforts begin early in life (Muriello et al., 2006) [48]. Research has shown that the consumption of fruits and vegetables may be associated with a decreased incidence and mortality of a variety of chronic diseases which includes obesity. Fruit and vegetable intake has been shown to have positive effects in terms of weight management and obesity prevention reported by Tohill et al (2004) [71]. Duncan et al (1983) [22] conducted a study using a diet rich in fruits and vegetables and low in fats versus a diet which was higher in fats but lower in fruits and vegetables. Although both groups were eating to satiety, the group eating the diet rich in fruits and vegetables consumed on average, one half the energy intake when compared to those on high fat, low fruit and vegetable diet. He et al. (2006) carried out a study in respect of fruit and vegetable consumption and its relationship to weight management. Their study found that an increase in fruit and vegetable intake was primarily associated with a 24% lower risk of becoming obese. In a large cohort of pre-adolescents and adolescents living in the USA, body mass index (BMI) changes were relatively consistent during a three year follow-up study. At the beginning of the study, more males than females were overweight and during the follow-up, change in body mass index (BMI) was slightly higher among the boys than in the girls. Among both genders, about 75% of the adolescents did not meet the public health recommendation to consume at least five servings of fruits and vegetables per/day (Field et al., 2003) [23]. There are various benefits gained by consuming a diet rich in fruits and vegetables, but it is not clearly understood why a diet rich in fruits and vegetables would prevent obesity or excessive weight gain, suggesting that further studies are needed to elucidate and confirm possible mechanisms involved in the prevention of obesity by fruit and vegetable consumption.
Prevention of coronary heart disease
Several studies revealed the relationship between fruit and vegetable fasten onto and coronary heart disease. These studies demonstrated an inverse relationship between fasten onto of fibre from fruits and vegetables and the risk of developing coronary heart disease. Meta-analyses of previous studies showed an inverse association between fruit and vegetable fasten onto and the occurrence of stroke which supports the concept that fruit and vegetable consumption has the potential to protection against cardiovascular events as reported by Daucher et al (2005) [18] and same result finding He et al (2006) [32]. The risk of developing coronary heart disease decreased by 4% for each additional portion per day intake of fruit and vegetables and by 7% for fruit consumption, indicating that fruit intake offer a more protective effect in reducing the risk of developing coronary heart disease (CHD) as reported by Daucher et al (2006) [19]. It has been conducted that clinical and biological investigations helps to the protective effect offered by the consumption of fruit and vegetables against coronary heart disease. Interestingly, the relationship is biologically valid with many clinical and laboratory data showing that the micro- and macro-constituents of fruit and vegetables works well improve to risk factors of coronary heart disease such as hypertension, dyslipidemia and diabetes as demonstrated by Appel et al (1997) [4], Van Duyn et al (2000) [23] and Bazzano et al (2003) [46]. In various investigations and studies, adequate fruit and vegetable fasten onto have been shown to correlate with healthy lifestyles which may explain the lower coronary heart disease incidence rates among individuals who adequately intake fruits and vegetables. Usually, it is assumed that consumers of fruits and vegetables smoke less, exercise more and are better educated than non-consumers as reported by Joshipura et al (1999) [36]. However many of the clinical and biological studies adjust for lifestyle factors, basic confounders may still explain part of the favourable association with coronary heart disease. The consuming high fruit and vegetable are related to a healthy diet pattern as reported by Hu et al (1999 and Hu et al (2000) [34,33] and inversely associated with the consumption of saturated fat-rich food revealed by Tucker et al (2005) [81], which may also contribute to a lower coronary heart disease risk as envisaged by Hu et al (1999) [34], Hu et al (2000) [33], Fung et al (2001) [25]. It should be noted however, that most of the clinical and laboratory studies to date have not established a causal relationship between inadequate intake of fruits and vegetables and the risk of developing coronary heart disease. Different observational studies selected for meta-analyses, the association between vegetable consumption and coronary heart disease risk was more pronounced for cardiovascular mortality than for incident coronary heart disease as reported by Daucher et al (2006) [19]. They stated that the reason for the difference is not known but possible explanations may be related to publication bias since mortality studies have fewer outcomes than studies reporting incident coronary heart disease or that consumption of vegetables might have specific effects on mortality, a hypothesis that needs confirmation in cohorts with a large number of fatal outcomes. It is also possible that residual confounding factors such as measurement errors affected the association between fruit and /or vegetable intake and risk of developing coronary heart disease and differences in study types, including dietary assessment methods, the variety of fruits and vegetables investigated and the definition of the reference group may further explain the difference. Ness and Powles (1997) [40] reviewed evidence about fruit and vegetable intake and the development of coronary heart disease and found a significant inverse association between the amount of fruits and vegetables consumed and the incidence of coronary heart disease.

Prevention of stroke disease
A study carried out by He et al (2006) [32], found a significant lower risk of stroke development among those with the highest intake of fruits and vegetables and Lock et al (2005) [43] showed that increasing individual fruit and vegetable consumption by 600 grams per day could reduce the global burden of stroke by 19% and decrease the risk of CHD by 31% respectively.

Prevention of high blood pressure
High blood pressure promotes the risk of heart disease and stroke as reported by Chobanian et al (2003) [13]. Consumption of fruit and vegetable inadequate amount decreased blood pressure as reported by Alonso et al (2004) [2]. Adding more fruits and vegetables to a healthy diet is one feasible pathway to control blood pressure. In the Dietary Approaches to Stop Hypertension (DASH) study, Appel et al (1997) [4] conducted survey on 459 people with and without high blood pressure were randomly assigned to one of three diets: a) a typical American diet that provided about 3 servings per day of fruits and vegetables and one serving per day of a low-fat dairy product, b) a fruit and vegetable diet that provided 8 servings per day of fruits and vegetables and one serving per day of a low-fat dairy product or c) a combination diet (called the DASH diet) that provided 9 servings per day of fruits and vegetables and 3 servings per day of low-fat dairy products. After 8 weeks, the blood pressures of those on the fruit and vegetable diet were significantly lower than those on the typical American diet.

Prevention of diabetes
It is believed that the beneficial effect of a diet abundant in fruits and vegetables on diabetes is not as convincing as it is for heart disease, however the results of a few studies advise that high consumptions of fruits and vegetables are related with improved blood glucose control and lower risk of developing type-2 diabetes. In the extensive various investigations of 10, 000 adults in the USA, the risk of developing type-2 diabetes over the next 20 years was about 20% decrease in those who reported consumption of at least 5 servings per day of fruits and vegetables as compared to those who did not intake fruits and vegetables as revealed by Ford, Mokdad (2001) [24]. In a prospective cohort study that followed over 40 000 USA women for an average of nine years, fruit and vegetable consume was not related with the risk of developing type-2 diabetes, however higher intakes of green leafy and yellow vegetables were associated with a significant lowering in the risk of developing type-2 diabetes in overweight women as reported by Liu et al (2004) [42]. A cross-sectional study of over 6000 non-diabetic adults in the UK, who consume higher volumes of fruits and vegetables showed to exhibit significantly low levels of glycosylated haemoglobin and it is postulated that potential compounds in fruits and vegetables that may improve glucose control include fibre and magnesium as reported by Sargeant et al (2001) [58].

Prevention of cancers
Dietary factors are estimated to account for about 30% of cancers in developed countries, making diet second only to

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tamin C or flavonoids between fruit and vegetable characteristics as demonstrated by Brown (2000) [57]. Evidence from case-control and different investigations has indicated that the consumption of fruits and vegetables have a strong protective effect against various types of cancer like (oralpharynx, oesophagus, stomach, colon and rectum) and that people with a higher consumption may have low risk than people with less or very less fruit and vegetable consumption as reported Block et al (1992) [71] and Steinmetz and Jansen (1996) [65]. Van’t Veer and co-workers (2000) [74] indicated that people with higher consumptions of fruits and vegetables could lessen their risk of developing cancer by 19%. The relationship between fruit and vegetable consumption and the risk of cancer has been said to be associated to the quantities of fruits and vegetables consumed and it further indicates that there are three potential dose response associations. It is anticipated that an extra serving of fruit and vegetables might achieve a much greater risk reduction when the total consume is relatively less than when it is high (a vitamin-like minimal requirement) or when the total consume is relatively high (a high threshold effect) and thirdly when intake is at all levels (not higher or lower) as reported by Temple and Gladwin (2003) [69]. With reference to the relationship between fruit and vegetable consumption, two investigations showed contrasting results. An investigation carried out by Terry et al (2001) [70] demonstrated that fruit and vegetable consumption could indicate a protective association only at consumes of about two servings per day whereas Mitchells et al. (2000) [46] indicated that fewer than three servings of fruits and vegetables per week are not associated to elevated risk of colorectal cancer. However, more consumption of fruits and vegetables have been related with a modestly significant reduction in lung cancer risk in a pooled analysis of eight prospective investigations as demonstrated by Smith-Warner et al (2003) [63]. Higher consumption of cruciferous vegetables have been linked to a significant deduction in the risk of developing bladder cancer in men as reported by Micaud et al (1999) [45] and higher consumption of tomato products have been linked to a significant deduction in the risk of developing prostate cancer as reported by Giovannucci et al (2002) [28]. Joseph and coworkers (2007) [82] denoted that supplementation of the diet of rats with fruits or vegetables (blueberry, strawberry or spinach) prevented or reversed age-related changes in neuronal and behavioural function. In our opinion, the finding of Joseph and coworkers is suggestive of a possible association between the mechanisms by which health may be modified by diet in both animal and man by the consumption of fruits and vegetables. A study carried by Galeone et al. (2007) [26] indicated that a high consumption of fruits and vegetables significantly reduced the risk of lung cancer and that the reduced risk was significantly evident in smokers as well as non-smokers.

Prevention of eye disease

The incidence of cataracts has been reported to be associated to oxidative damage of proteins in the eye’s lens which is induced by long-term exposure to ultraviolet light. The cloudiness and discoloration of the lens resulting from such exposure have been known to lead to vision loss that becomes more severe with age. The results of various prospective cohort studies tend to advise that diets rich in fruits and vegetables, especially carotenoid and vitamin C-rich fruits and vegetables are related with decreased incidence and severity of cataracts as demonstrated by Brown et al (1999) [10], Jacques et al (2001) [35], Christen et al (2005) [14]. High consumption of broccoli and spinach has been revealed to be related to decrease in cataracts among USA males as reported by Brown et al (1999) [10]. Lutein and zeaxanthin are carotenoids that are found in relatively high concentrations in the retina and could play a crucial role in inhibiting damage to the retina which is caused by light or oxidants demonstrated by Mares-Perlman et al. (2002) [44]. In two case-control studies, high intakes of carotenoid-rich vegetables particularly those rich in lutein and zeaxanthin were said to be associated with a significant reduced risk of developing age-related macular degeneration as reported by Seddon et al (1994) [59], Shellen et al (2002) [62]. Another study involving more than 118,000 male and female participants found that those who consumed three or more servings of fruits and vegetables daily had their risk of developing age-associated macular degeneration decreased by 36% than those participants who consumed less fruits and vegetables as reported by Cho et al (2004) [12].

Prevention of pulmonary disease

A beneficial association between reduced risk of developing chronic obstructive pulmonary disease and fruit and vegetable intake has been documented by Romieu and Trenga (2001) [57]. Epidemiological studies in Europe and elsewhere showed that higher fruit consumption (particularly apple) can be associated with higher forced expiratory volume values, indicating a better lung function as reported by Tabak et al (2001) [68], Butland et al (2002) [11]. A European study of 2917 participants followed over twenty years with an increase in the daily intake of fruits has been related with a 24% reduce in the risk of death from chronic obstructive pulmonary disease. Although the reason for the association between increased fruit intake and reduced risk of developing chronic obstructive pulmonary disease is not known but it is suggested that antioxidants such as vitamin C or flavonoids found in fruits may be playing a protective role in reducing the risk of developing chronic obstructive pulmonary disease.

Prevention of alzheimer’s disease

Few researches have showed that an antioxidants present in the most fruits and vegetable juices could help lower a person’s risk of developing Alzheimer’s disease. This may be associated to the fact that freshly squeezed juices from fruits and vegetables are potential sources of minerals and vitamins which catalyze chemical reactions occurring in the body. Other benefit of fruits and fruit juices is their ability to encourage detoxification of the human body. Fruits help to cleanse the body and tomatoes, pineapples and citruses such as oranges, red grapefruits and lemons are well known for their detoxifying properties as revealed by Cuthbertson (2002) [17]. Increased fruit and vegetable consumption of about 3 to 9 servings per day has been shown to decrease urinary calcium loss of about 50 mg/day and lower biochemical markers of bone turnover especially bone resorption as reported by Appel et al (1997) [4], Lin et al (2003) [40].

Prevention of HIV disease

The effects of HIV infection on the nutritional status of persons living with HIV and AIDS have been documented by Oguntibeju et al (2006, 2007, 2008 and 2009) [51, 52, 53, 54]. It is good nutrition including the consumption of fruits and vegetables can contribute to the wellness and sense of well-being of people living with HIV and AIDS and may even
prolong life. Fruits and vegetables are an important part of healthy food consumption and may supply the necessary vitamins, minerals and other substances that could boost the human immune system as reported by (Department of Health, South Africa, 2001)\textsuperscript{(20)}.

Possible mechanism of action of fruits and vegetables in human health and disease prevention

It is a common knowledge in biological science that mammalian and plant cells are constantly exposed to a variety of oxidizing agents. These oxidizing agents may be present in air, food, and water or they may be produced by metabolic activity within the cells, however, it is important to maintain a balance between oxidants and antioxidants to be able to sustain optimal physiological conditions. Overproduction of oxidants can cause an imbalance, leading to oxidative stress as reported by Ames\textit{ et al} (1993)\textsuperscript{(3)} and Liu\textit{ et al} (1995)\textsuperscript{(41)}. In order to prevent or reduce the oxidative stress induced by free radicals, sufficient amounts of antioxidants require to be consumed and fruits and vegetables are known to contain a variety of antioxidant compounds such as phenolics and carotenoids which may help protect cellular systems from oxidative damage and reduce the risk of developing chronic diseases as reported by Wang \textit{et al} (1996)\textsuperscript{(77)}, Vinson \textit{et al} (2001)\textsuperscript{(73)} and Adom\textit{ et al} (2003)\textsuperscript{(1)}. It is well known that carotenoids demonstrate photo protection which originates from their ability to quench and inactivate reactive oxygen species as reported by Britton (1995)\textsuperscript{(8)}. Phenolics provide essential functions in the reproduction and the growth of plants, acting as defense mechanisms against pathogens, parasites, and predators as well as contributing to the colour of plants and may also provide health benefits related with decreased risk of chronic diseases in humans as demonstrated by Sun\textit{ et al} (2002)\textsuperscript{(1)}. Various species and varieties of fruits and vegetables have different phytochemical profiles revealed by Adom and Liu (2003)\textsuperscript{(42)}; Adom \textit{et al} (2003)\textsuperscript{(1)} The combination of orange, apple, grape, and blueberry has been shown to display a synergistic effect in antioxidant activity and obtaining antioxidants from dietary intake by consuming a wide variety of foods is of significant importance due to the fact that foods originating from plants contain many diverse types of phytochemicals in various quantities. Carcinogenesis is a multistep process and oxidative damage is linked to the formation of tumors through several mechanisms as demonstrated by Ames\textit{ et al} (1993)\textsuperscript{(3)} and Liu\textit{ et al} (1995)\textsuperscript{(41)}. Oxidative stress increased by free radicals causes DNA damage, which, when left unrepaired, can lead to base mutation, single- and double-strand breaks, DNA cross-linking, and chromosomal breakage and rearrangement as reported by Ames\textit{ et al} (1993)\textsuperscript{(3)}. This potentially cancer-inducing oxidative damage might be checked or limited by the consumption of dietary antioxidants which are found in fruits and vegetables. Studies till date have demonstrated that phytochemicals in common fruits and vegetables can keep complementary and overlapping mechanisms of action, including antioxidant activity and the scavenging of free radicals, regulation of gene expression in cell proliferation, cell differentiation, oncogenes, and tumour suppressor genes, induction of cell-cycle arrest and apoptosis, modulation of enzyme activities in detoxification, oxidation, reduction, stimulation of the immune system, regulation of hormone metabolism, and antibacterial and antiviral effects as demonstrated by Ames\textit{ et al} (1993)\textsuperscript{(3)} Liu\textit{ et al} (1995)\textsuperscript{(41)} and Adom and Liu (2002)\textsuperscript{(42)}. It is believed that fruits and vegetables are richer in precursors to bicarbonate ions which serve to buffer acids in the body, therefore if the concentration of bicarbonate ions is inadequate to maintain normal pH, the body is capable of mobilizing alkaline calcium salts from bone in order to neutralize acids consumed in the diet and those generated by metabolism, thus increased consumption of fruits and vegetables reduces the net acid content of the diet and may preserve calcium in bones which might otherwise be mobilized to maintain normal pH as reported by New (2002)\textsuperscript{(50)}. The association between fruit and vegetable consumption and obesity has also been envisaged. It is not clear how fruit and vegetable consumption prevent obesity or excessive weight gain. However, one possible mechanism could be that fruits and vegetables might serve as healthy substitutes for more calorie-dense foods as reported by Field\textit{ et al} (2003)\textsuperscript{(23)}.

Factors affecting the nutritional qualities and intake of fruits and vegetables

Climatic conditions such as temperature and light intensity have been shown to have a strong effect on the nutritional quality of fruits and vegetables as reported by Mozafar (1994)\textsuperscript{(47)}. Low temperature is believed to favour synthesis of sugar and vitamin C while short duration reduces the rate of ascorbic acid oxidation. Maximum beta-carotene content in tomatoes occurs at a temperature range of 15 to 21º C but beta-carotene content is decreased if temperatures are much higher or lower than this range, mainly due to the temperature sensitivity of lycopene, the precursor to beta-carotene and lutein. The vitamin B is crop specific with reference to temperature sensitivity. Warm season crops (beans, tomatoes, peppers, melons) produce more vitamins B at high (27 to 30 º C) versus low (10 to 15º C) temperatures. In contrast, cool season crops such as broccoli, cabbage, spinach, peas produce more vitamin B at low versus high temperature. It has been recorded that light intensity has little effect on the vitamin B but as light intensity increases, vitamin C increases and total carotenoids and chlorophyll reduce as reported by Gross (1991)\textsuperscript{(31)}. More light intensities obtain more sugars thus favouring the synthesis of vitamins and also induce plant temperatures, preventing beta-carotene production which protects chlorophyll from light bleaching. According to Goldman \textit{et al} (1999)\textsuperscript{(30)}, the type of soil, the rootstock used for fruit trees, irrigation, fertilization and other traditional practices influence the water and nutrient supply to the plant and have been shown to affect the composition and quality attributes of fruits and vegetables. Another environmental factor such as altitudes, soil pH, salinity, insects and plant diseases have also been recorded to affect composition and quality of fruits and vegetables. Also, processing and cooking methods do affect the nutritional value of fruits and vegetables as reported by Lee, Kader (2000)\textsuperscript{(37)}. For example, water-soluble vitamins such as vitamin C and folic acid are readily lost at high rates when cooking water is discarded. The level of education has been shown to be associated with fruit and vegetable intake in children and adults. It has been shown that mothers with a higher level of education tend to consumption high fruits and vegetables and also influence their children to do so as reported by Gibson \textit{et al} (1998)\textsuperscript{(27)} and that more income influences the availability of fruits, which in turn affect consumption in both adults and children.
Family origin is said to influence food choice and preparation and one study indicated that the frequency of fruit and vegetable consumption in both mothers and children differs according to origin as demonstrated by Shatenstein and Ghadirian (1998) [61].

Functions of foods
The famous proverb “do you eat to live or live to eat” deflects the life style of young generation. For most of us the first is certainly true, you must eat to live. But there may be times that it is enjoyment that is more beneficial than nourishment. Factors such as age, sex, genetic makeup, occupation, lifestyle, family and cultural background affect our daily food choices. We use food to express friendship, bond, relationship, creativity and demonstrate feelings through gifts. Preference for food begins early and is mainly determined by age. Young children prefer sweet or familiar foods, babies and toddlers are generally willing to try new things. Teenagers are strongly influenced by preferences and habits of their peers. These factors are inter mingling and are closely knitted with functions of food in terms of human enrichment.

- **Food satisfies hunger:** Hunger is a symptom indicating that the energy requirement of human is not being met. Hunger is manifested in terms of physical weakness, intermittent sensation of tension in the abdominal region (hunger pangs) and a driving urge to find food. When the person is under starvation, the body itself is used as source of energy and stored carbohydrate, fat reserves and proteins are all used for fulfilling the energy demand.

- **Food satisfies social needs:** Social factors exert a powerful influence on food choice. Eating is also a social event that brings together different people for a variety of reasons (e.g. religious or cultural celebrations, business meetings and family dinners) to share individual and collective feelings about perception of life. Foods may also help one to achieve status at several platform, particularly in these days, where eating out habits have more commonly chosen, inviting your friends, relatives and boss to dine for a party are all instruments to develop social rapport. Serving foods at social events banquets, dinners, award functions, parties and meetings have all become one’s important status symbol in modern times.

- **Cultural and religious needs:** Likewise social ambit requires cultural and religious factors also influence food choices. In different cultures, food has symbolic meaning associated to family traditions, social status, and health. Foods also form an important part of religious rites, symbols and customs as well as daily activities that are intended to promote an orderly relationship with supernatural forces.

- **Food builds body tissues and regulates body processes:** Nutrients are needed for the overall growth of the body. Proteins are needed for building tissues. Calcium and phosphorus are involved in the development of skeleton and teeth. Fat and lipids are needed for body building processes.

- **Foods are protective in function:** Fruits and vegetables are called as functional foods because apart from nutrients, which are needed to fulfill bodies physiological requires, they also keep antioxidants, which protect the body from diseases such as cancer and cardiovascular diseases. Commonly m found in fruits and vegetables are ascorbic acid, β-carotene, phenolics and flavonoids.

- **Food supplies energy:** One of the main reasons we eat foods comprising fruit and vegetables, it keeps us charged by energy renewal for maintaining basal metabolic rate. Every cellular reaction, every muscle movement and every nerve impulse needs energy. Three of the prime nutrient classes viz. carbohydrate, fat and proteins are potential sources of energy. These nutrients can be broken down completely (metabolized) to yield energy in a form that cells can use. The commonly used standard for measurement of energy value of substances is calorie.

**Fruits and vegetables**
The consumption of fruits and vegetables” is one of the tried and true recommendations for a healthy diet. Eating plenty of fruits and vegetables can help you ward off heart disease and stroke, prevent blood pressure and cholesterol, control some types of cancer, avoid a painful intestinal ailment called diverticulitis, and guard against cataract and macular degeneration, two common causes of vision loss. National Cancer Institute (NCI) has sponsored a -5 A Day for Better Health” program to encourage public to include high fruits and vegetables in their diet. Fruits and vegetables keep wealth of nutrient and non-nutrient substances called as phytochemicals that keep protective, disease controlling compounds. More than 900 different phytochemicals have been identified as components of food, and many more phytochemicals continue to be discovered today. It is estimated that there may be more than 100 different phytochemicals in just one serving of vegetables. These popularly known as antioxidants can scavenge or mop off the harmful free radicals produced in the body. Free radicals damage cellular membranes, proteins and DNA and cells and produce a range of diseases in body. Phenols, flavonoids, anthocyanins and carotenoids are some of the important antioxidant found in fruits and vegetables. In this section we will study the nutrient and non-nutrient components of fruits and vegetables. The edible portion of most types of fruits contains 75-95% of water. Fruits usually are low in calories and with the exception of avocados and olives, contain practically contain no fat. Fruits contain substantial carbohydrates such as fructose, sucrose and starch and are also low in proteins except for tree nuts (walnuts, pecan, pistachio and walnuts). Nutritionally fruits are significant source of vitamin A and C. The vitamin precursor carotene, which is converted in the body to vitamin A, is abundant in mango, papaya, apricots, peaches, cantaloupes and bananas. For vitamin C, gooseberry citrus fruits guava, papaya, and small berry fruits are good sources. Fruits are plentiful in potassium and low in sodium and hence eating fruits helps to maintain blood pressure in heart patients. More amounts of calcium are present in dried fruits and moderate quantities in oranges, raspberries and strawberries. Iron is significant amounts in dates, figs bananas, apricots and raisins. Usually fruits are low in vitamin B, however orange juice is a well source of thiamine and folate. Bananas and watermelon are well source of vitamin B6. Vegetables are commercially well source of mineral substances in comparison to fruits, which are rich in vitamins. In general vegetables are low in calories except soybean, lima beans, cow peas, potato and taro, which are abundant in carbohydrates. They are also low in protein except legumes (peas, beans) and low in fat except soybean. Vegetables are abundant in vitamin A, ascorbic acid, protein (legumes) and fiber. Carrots, sweet potatoes, green leafy vegetables and tomato are best sources of vitamin A among vegetables. Hot chili peppers, squash, turnip greens and spinach are also good sources. Recent research has shown...
phenolics, flavonoids and anthocyanins are among the most potent antioxidants found in fruits and vegetables. Red or purple colour of some fruits and vegetables is due to presence of anthocyanin pigment. Lycopene is a carotenoid pigment found in tomatoes, grapefruit, guava and water melon is believed to be protective against heart disease and prostate cancer. Lutein, a yellow pigment found in marigold petals and green leafy vegetables reduces the risk of age related macular degeneration and cataract. Onions and citrus fruits are good for our bones and reduce the risk of osteoporosis in elderly women.

**Enzymes and pigments**

Fruits and vegetables apart from being rich in vitamin and minerals are rich in colour imparting pigments and enzymes. The chief pigments of fruits and vegetables are carotenoids, chlorophyll and anthocyanin. Carotenoids are naturally taking place compounds that give the deep yellow, orange and red colours to fruits and vegetables such as apricots, carrots and tomatoes, orange, capsicum, mango and papaya. Carotenoids also are plentifully found in in dark green vegetables, such as spinach, but the dense chlorophyll marks the carotenoid colours. The major carotenoids found in fruits and vegetables include alpha-carotene, beta-carotene, lutein, lycopene and zeaxanthin. The body can convert alpha-carotene, beta-carotene and cryptoxanthin to retinol so they are called pro-vitamin A carotenoids. Lycopene, lutein and zeaxanthin do not have pro-vitamin A activity. Lycopene is the orange- red pigment of tomatoes. Chlorophyll is the green pigment of stem and leaves of plants. Two types of chlorophyll occur in plants, namely chlorophyll a and chlorophyll b in ratio of 3a:1b. Fruits and vegetables also contain certain specialized chemicals called enzymes. These enzymes are more important in fruits because of the chemical changes that they initiate. Ficin in figs and papain in papaya are the major proteolytic enzymes. These enzymes can react with proteins of the human skin and cause dermatitis. Phenol oxidases in potatoes, apples, pears, grapes, strawberries, and figs are responsible for the discoloration of cut surfaces when exposed to air. Other enzymes responsible for color changes in fruits and vegetables are chlorophyllases, anthocyaninases and peroxidase. Lipooxygenase and lipase are the enzymes linked with off-flavour in frozen peas and beans. Citrus fruits and tomatoes are rich in pectin esterase, and pears and tomatoes in polygalacturonase, both being pectolytic enzymes responsible for softening of fruit texture during ripening.

**Processed fruits and vegetables**

Fruits and vegetables are highly perishable in nature because of their high moisture content. They cannot be stored for long times and thus there is a require to process them. Processed fruits and vegetables available as canned, frozen, dried and juices are beneficial, are available all year round and have a longer shelf life. It is commercially believed that fresh fruits and vegetables are always the most nutritious and processed products are inferior. However this is a misconception and fruits and vegetables if processed within hours of harvesting are equally nutritious and healthier than their raw counterparts. Post harvest handling, storage and processing by canning, dehydration, freezing and fermentation do alter the nutrient composition of fruits and vegetables to some extent. Particularly, vitamin C and carotenoids are highly inclined to oxidation and thermal abuse during processing. Losses in nutrients also occur during handling, transportation, storage and retail display, in fact fruits and vegetables, which we consider fresh, reach us after many days after their harvest. However these losses can be minimized if processing takes place immediately after harvest. Canned and frozen fruits and vegetables are good as their fresh counterparts and in some cases even better. Canned produce prepared from freshly harvested produce, maintains majority of the nutrients even though the heating process destroys some vitamins. Similarly frozen vegetables are equally good as fresh vegetables.

**Factors affecting the nutritional qualities**

Climatic conditions, particularly temperature and light intensity, have strong effect on the nutritional quality of fruits and vegetables. Soil type, the rootstock used for fruit trees, mulching, irrigation, fertilization, and other cultural practices influence the water and nutrient supply to the plant, which can affect the composition and quality attributes (appearance, texture, taste and aroma) of the harvested plant parts as reported by Goldman et al (1999) [30]. Maturity at harvest and harvesting method influence the commodity’s quality and extent of physical injuries. Delays between harvest and consumption or processing can result in losses of flavor and nutritional quality. The magnitude of these losses increases with exposure to temperatures, relative humidities, and/or concentrations of oxygen, carbon dioxide, and ethylene outside the ranges that are optimum for each commodity during the entire post harvest handling system (Lee and Kader, 2000) [37]. Climatic conditions such as temperature and light intensity have been shown to have a strong effect on the nutritional quality of fruits and vegetables as reported by Mozafar (1994) [47]. Low temperature is believed to favour synthesis of sugar and vitamin C while short duration reduces the rate of ascorbic acid oxidation. Maximum beta-carotene content in tomatoes occurs at a temperature range of 15 to 21°C but beta-carotene content is decrees if temperatures are higher or lower than this range, mainly due to the temperature sensitivity of lycopene, the precursor to beta-carotene and lutein. The B vitamins are crop specific with reference to temperature sensitivity. Warm season crops (beans, tomatoes, peppers, melons) produce more B vitamins at high (27 to 30 degree C versus low (10º to 15ºC) temperatures. In contrast, cool season crops such as broccoli, cabbage, spinach, peas produce more B vitamins at low temperature versus high temperature. It has been reported that light intensity has little effect on the B vitamins but as light intensity increases, vitamin C increases and total carotenoids and chlorophyll decreases as reported by Gross (1991) [31].

**Conclusion**

There is increasing confirmation and awareness that intake of whole foods is better than isolated food components. For example, increased intake of carotenoid rich fruits and vegetables was more fruitful than carotenoid supplements in increasing LDL oxidation resistance, lowering DNA damage and inducing higher repair activity in human metabolism. Future line of work on nutrition metabolism studies are required to be carried out on other constituents of fruits and vegetables to harness the potential benefits of phytochemicals as well as bioavailability of nutrients to be taken as dietary supplements or as foods which imparts beneficial nutrients in the human gut. Regular consumption of a vegetable rich diet has beneficial effects on health since phytonutraceuticals of fruits and vegetables can supply safety to the human body from different types of chronic diseases. The process by which vegetables decrease risk of disease is complex and largely unknown. Several elements of the whole food are likely to
contribute to the overall health benefit. Several phytotherapeutics engulfed in fruits and vegetables possessing antioxidant properties may work as quenching free radicals directly or indirectly by participating in cell signaling pathways sensitive to maintain redox balance. Nutrients such as potassium contribute to blood pressure regulation. The dietary fiber content and type of different vegetables may also contribute to the overall health benefit, such as improving bowel transit, lowering cholesterol, helping manage blood glucose concentrations, and by transporting a sufficiently great amount of minerals and phytochemicals linked to the fibre matrix through the human gut. Finally, increasing vegetables in the diet may lessen the consumption of saturated fats, trans fats and foods with higher caloric density, all of which may be associated to contribute a healthier diet. For an adequate supply of vitamins, minerals and other compounds from fruits and vegetables, it is very important to buy fresh fruits and vegetables without bruises, soft spots, mold, decay or broken skins. It is very important to clean all fruits and vegetables with water before cutting and is also advisable to store fruit and vegetables in the refrigerator but once cut or sliced, fruits and vegetables should be placed in a refrigerator in tightly fastened plastic bags and should be consumed within two to three days. There is a requirement for more controlled, clinical intervention trials in order to confirm findings that approve the view that consumption of fruits and vegetables promotes health and decrease the risk of developing chronic diseases. Accurate preventing of dietary consumption remains difficult and cost-efficient methods for estimating fruit and vegetable consumption are required to be able to confirm the association between fruit and vegetable consumption. Although research evidence supports the collaboration between fruit and vegetable consumption and decreased incidence and mortality of chronic diseases such as obesity, different cancers and cardiovascular diseases, disagreements still exist in the science community with reference to their association, therefore further studies with large population groups over long periods of time in relation to dietsics is recommended. The plethora of fruits and vegetables availability in this global world offers a better scope for reduction of disease and disorders by their regular intake as per recommended dietary schedule according to human age and availability in the vicinity of the population domain.

References


