

Review Article

Potential Health Benefits of Fruits and Vegetables : EPIC Inspite Glycemia

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Fruits and vegetables are richest source of micronutrients among all the food groups. Many persons with diabetes assume that most fruits and vegetables should be restricted for them. However, most of the fruits and vegetables have low to moderate glycemic index and other health benefits. Adequate amount of their servings every day provides many nutritional advantages beyond micronutrients and fiber. The aim of this review is to discuss potential beneficial properties of fruits and vegetables in persons with diabetes.

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Key words : Diabetes, Fruits, Vegetables, Nutrition, Recommendations, Health benefits.

With prevailing dual burden, the prevalence of chronic energy deficiency ranges from 33.2%-49% and the prevalence of chronic diseases due to over nutrition ranges from 4.8-40.0% in India^{1,2}. As a triple burden, it is reported that almost one third population is suffering from vitamin and micronutrient deficiency². There is no mention regarding fruit availability or consumption (per caput/g/day), in India, as per Indian Council of Medical Research (ICMR). Most people with diabetes eat fruits and vegetables selectively assuming it may elevate blood glucose levels, specifically fruits. Their restricted consumption may affect diet quality and inadequacy in nutrients requirement especially micronutrients.

Nutritional Composition :

Fruits and vegetables are generally low in energy density with varying nutritional contribution. They are relatively low in calories and fat; have no cholesterol and are rich in carbohydrates³. The consumption of different fruits play basic roles in human health care and exhibit beneficial effects owing to the presence of

Editor's Comment :

- Fruits and vegetables are the rich source of micronutrients.
- Their restricted consumption among people with diabetes may affect diet quality.
- Most of the fruits and vegetables have low to moderate glycemic index and other health benefits.
- Owing to the potent effectors of biological systems, fruits and vegetables are glycemic-friendly hub of beneficial healthful nutrients.

vitamins, trace minerals, fructose, dietary fibre and chemical compounds called phytochemicals^{4,5}. They have biologically active compounds that can have complementary and overlapping mechanisms of action, including detoxification, enzyme modulation and antioxidant effect⁴. Hence, they may prove to be a promising tool for the prevention and/or amelioration of a wide range of diseases.

Recommended Dietary Allowances (RDA) :

World Health Organization (WHO) recommends an intake of five to eight portions (400–600 g) daily of fruits and vegetables to reduce risk of cardiovascular disease, cancer, poor cognitive performance, other diet-related diseases as well as for the prevention of micronutrient deficiencies³.

Aeronautical Development Agency (ADA), 2019 recommends carbohydrates and fibre-containing foods, such as whole grains, legumes, fruits, and vegetables etc instead of refined carbohydrates and added sugars among both children and adults with diabetes⁶.

The National Institute of Nutrition (NIN) (ICMR, 2017) formulated the dietary goals and guidelines for the consumption of plenty of vegetables and fruits¹. The Expert Committee of the ICMR, taking into consideration the nutrient requirements, has recommended that every individual, with or without diabetes, should consume at least 300 g of vegetables

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(Green leafy vegetables: 50 g; Other vegetables: 200g; Roots & Tubers: 50g) in a day with a minimum consumption of 100g fresh fruits per day for Indian adult population. These guidelines recommend increase consumption for the elderly and increase RDA of 100g of leafy vegetables to meet additional requirements of iron and folic acid among pregnant women^{1,5,7}.

Such recommendations and nutritional requirements are same for both people with or without diabetes considering potential health benefits. Furthermore, the insulin-to-carbohydrate ratios for meal planning can be effectively used to modify insulin dosing from meal composition per day and improve glycemic control⁶. Fructose consumed as “free fructose” from naturally occurring fruits may result in better glycemic control compared with isocaloric intake of sucrose without detrimental effects on triglycerides as long as intake is not excessive (>12% energy) among the people with diabetes.

However, the people with poor glycemic control (fasting blood glucose >300mg/dl) must be mindful of total caloric intake, portion size, frequency and glycemic load while consuming fruits and root vegetables. Table 1 discusses apt ways for consuming fruits and vegetables among people with diabetes⁴⁻⁷.

Beneficial Effects :

(1) Health Benefits :

Fruits and vegetables, being rich sources of vitamins such as vitamins C and E, fibre, minerals, folic acid,

a-tocopherol, vitamin A precursor b-carotene, zinc and selenium, strongly reduce the risk for cancers of the mouth and pharynx, esophagus, lung, stomach and colon while moderately reduce cancers of the breast, pancreas, and bladder⁸. They function to modify the metabolic activation and detoxification/ disposition of carcinogens, or even influence processes that alter the course of the tumor cell⁹⁻¹⁵. β-Carotene is an excellent dietary antioxidant which may prevent lung cancer⁸. Substantial intake may cause subsequent favorable changes in anthropometry, insulin levels and improved HDL cholesterol in combination with improved nutritional markers and health benefits in the long term¹⁶⁻²⁰.

(2) Alkaline Properties :

The metabolic, enzymatic, immunologic, and repair mechanisms function at their best when an alkaline environment is maintained in the body. Most vegetables and fruits act as mineral-buffering reserves containing higher proportions of alkaline-forming elements that are essential to the maintenance of sustained health. Increased fruits and vegetables may improve the K/Na ratio, help prevent plaque formation in blood vessels, stop calcium from accumulating in urine, prevent kidney stones, build stronger bones, and boost the immune system. It helps to balance body pH, reduce morbidity and mortality from numerous chronic diseases or ailments such as hypertension, diabetes, arthritis, vitamin D deficiency and low bone density. It

Table 1 — Mindful ways for eating fruits and vegetables in persons with diabetes⁴⁻⁷

Food categories	Examples	How much to eat	Ways to make all fruits and vegetables glycemic-friendly
Low glycemic index (have a GI of 55 or less)			
Fruits	Apple, Apricot, Berries, Orange, Peach, Guava, Pear, Cherry, Plum, Strawberry	Eat plenty	<ul style="list-style-type: none"> ■ Fresh fruits and vegetables are better than juice, high fructose syrup and sucrose. ■ Whole is better than small cuts/puree. ■ Raw is better than cooked. ■ Unprocessed is better than processed. ■ With peel is better than without peel.
Vegetables	Peas, Carrot, Avocado, Broccoli, Cabbage, Cauliflower, Cucumber, Green leafy vegetables, Lettuce, Mushrooms, Tomatoes, Lady finger, Onions, Turnips.		
Moderate glycemic index (have a GI between 56 and 69)			
Fruits	Banana, Grapes, Mango, Pineapple, Lichi, Kiwi, Fig, Raisin	Eat in moderation	<ul style="list-style-type: none"> ■ Shall be preferred as healthy snacks to achieve normoglycemia.
Vegetables	Beets, Corn		
High glycemic index (have a GI 70 or higher)			
Fruits	Dried dates, Watermelon, over-ripe Banana	Eat moderately and use ways to make it glycemic-friendly	<ul style="list-style-type: none"> ■ Shall be consumed with low glycemic food items. ■ Shall be consumed with high fibre food items. ■ Additionally, shall be restricted with glycemic peaks.
Vegetables	Potato, canned or frozen Corn, Sweet potato		

causes more alkaline urine pH level which helps protect healthy cells and balance essential mineral levels. It may lead to increase in intracellular magnesium, which is required for the function of many enzyme systems, may reduce acid load leading to preservation of muscle mass in older men and women and may further activate vitamin D to provide its beneficial effects in the vitamin D apocrine/exocrine systems. Additionally, it may provide added benefit for some chemotherapeutic agents requiring a higher pH^{21,22}.

(3) Other Protective Components :

As per ICMR, fruits and vegetables are hub of protective components such as flavonoids, dithiolthiones, glucosinolates, indoles, isothiocyanates, coumarins, protease inhibitors, plant sterols, isoflavones/ lignans, saponins, inositol hexaphosphate, allium compounds, limonene^{1,4}. They also provide nitrogen-containing compounds, organosulfur compounds and carotenoids⁸. Its protective mechanisms include alkaline properties and electrolyte properties also besides functional properties, such as low glycemic load and energy density⁹.

Common Fruit Exemplars :

Grapefruit (*Citrus paradisi*) is used in traditional medicine as an antimicrobial, antifungal, anti-inflammatory, antioxidant, and antiviral, as an astringent solution and as a preservative agent. As an excellent source of many phytochemicals and nutrients like vitamin C, folic acid, phenolic acid, potassium, calcium, iron, limonoides, terpenes, monoterpenes, and D-glucaric acid, it also contain varieties also contain beta-carotene and lycopene, antioxidants that the body can convert into vitamin A. The flavonoid present has the greatest concentration of naringin, which humans metabolize into naringenin. Evidence support its beneficial role in cellular regeneration, cholesterol reduction, the detoxifying process, in the maintenance of heart health, in rheumatoid arthritis, for the control of body weight, and in cancer prevention²³.

Blueberries/cranberries (*Vaccinium* spp) has shown to be beneficial in cardiovascular diseases, neurodegenerative diseases and other diseases associated with aging, in obesity, and in some human cancers (mainly esophageal and gastrointestinal with the possible agents responsible being diverse phenolic-type phytochemicals such as flavonoids (anthocyanines, flavonols, and flavanols); tannins [condensed tannins (proanthocyanidins) and hydrolyzable tannins (ellagitannins and gallotannins)]; stilbenoids and phenolic acids. Oxidative stress (OS) and dysfunction of cellular immunity are important

indicators in the pathogenesis of hepatic diseases caused by diverse xenobiotics. The anthocyanins present show antioxidant, anticarcinogenic, and anti-inflammatory biological activity²³.

Grape (*Vitisvinifera* L) - The leaves, as well as the fruit, are a stupendous source of vitamins and minerals and other active ingredients responsible for exhibiting laxative, astringent, diuretic, cicatrisant, immunological stimulant, anti-inflammatory, hypocholesterolemic activities, as well as preventive activity against cardiovascular disease and some cancers (mainly prostate and colon)²³.

Mango (*Mangifera Indica*): It is a fruit with good nutritive value, low glycemic load as well as with acceptable glycemic index. It provides all the significant Vitamins A, B, C, and K along with calcium, iron, copper, and potassium, respectively. Mangiferin, a bioactive substance found in mango seeds (0.42 mg/kg), peel (1690.4 mg/kg), and pulp (4.4 mg/kg), is thought to have hypoglycemic properties. Mangiferin is a xanthone with high antioxidative activity. It inhibits sucrase, isomaltase, maltase and thus decreases in glucose intestinal absorption. Mango also contains dietary fiber, which can reduce digestion of carbohydrate and lower glucose absorption. It may improve postprandial glucose, hemoglobin A1C, markers of atherosclerosis and decrease systolic blood pressure^{23,24}.

Some other potential disease-preventive mechanisms of action of different fruits and vegetables evidenced in human dietary studies have been summarized in Table 2²⁵⁻³⁰.

Clinical Highlights :

An RCT published by Christensen *et al*, 2013 has shown that recommendation to reduce fruit intake as part of standard medical nutrition therapy in overweight patients with newly diagnosed type 2 diabetes is ineffective on HbA1c, weight loss and waist circumference¹².

A systematic review and meta-analysis conducted by Carter *et al*, 2010 had shown that greater intake of green leafy vegetables was associated with a 14% (hazard ratio 0.86, 95% confidence interval 0.77 to 0.97) reduction in risk of type 2 diabetes (P=0.01)¹⁸. The intake of whole fruits and vegetables instead of fruit juices may reduce long-term risk of obesity and weight gain among middle-aged women^{19,20}.

Another systematic review conducted by Amiot *et al*, 2016 has shown that dietary polyphenols have beneficial effects on features of metabolic syndrome (MetS) (obesity, dyslipidemia, blood pressure and glycemia), and associated complications (oxidative

stress and inflammation) hence popularising Mediterranean diets among such patients. Such diets include functional foods such as fruits, vegetables, oily fish, olive oil, and nuts etc providing wholesome natural contents of nutraceuticals, including polyphenols, terpenoids, flavonoids, alkaloids, sterols, pigments and unsaturated fatty acids^{10,11}.

A review published by McMacken *et al*, 2017 has highlighted various mechanisms with respect to the benefits of a plant-based diet in ameliorating insulin resistance, including promotion of a healthy body weight, increases in fibre and phytonutrients, food-microbiome interactions, and decreases in saturated fat, advanced glycation end products, nitrosamines and heme iron²⁵.

Since vegetables and fruit include roots, leaves, stems, fruit and seeds from >40 botanical families, they have the potential to contribute significant variety and complexity to the human diet. They slow or prevent the onset of cardiovascular disease, several common cancers and other chronic diseases. The phytochemicals in cell-culture systems and animal models provide a wealth of information on the mechanisms by which a diet high in fruit and vegetables may lower the risk of chronic disease in humans¹³⁻¹⁵.

Conclusion :

Vegetables and fruits, owing to the potent effectors of biological systems among both people with or without diabetes, are shown to modify antioxidant pathways, detoxification enzyme profiles and the immune system, as well as alter cholesterol and steroid hormone concentrations and metabolism. Hence, fruits and vegetables can be essentially regarded as glycemic-friendly hub of beneficial healthful nutrients.

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Table 2 — Potential disease-preventive mechanisms of fruits and vegetables evidenced in human dietary studies^{5,13,16,25-30}

Function	Action/Mechanism
Antioxidant activity	<ul style="list-style-type: none"> ■ Fruits and vegetables are significant sources of the antioxidant enzymes (metalloenzymes) ■ Prevent radical formation, remove radicals, repair oxidative damage, eliminate damaged molecules and prevent mutations. ■ Antioxidant vitamins C, E, β-carotene and flavonoids decrease plasma lipid peroxide concentration. ■ Inhibit N-nitroso compound formation by destroying nitrosating agents
Modulation of detoxification enzymes	<ul style="list-style-type: none"> ■ Flavonoids, isothiocyanates, and allyl sulphides may modulate cytochrome P450 (CYP) monooxygenases (which catalyze oxidation, hydroxylation, and reduction reactions—convert hydrophobic compounds to reactive electrophiles in preparation for their reaction with water-soluble moieties to improve excretion)
Stimulation of the immune system	<ul style="list-style-type: none"> ■ Affect Natural killer (NK) cells activity without influencing cell number which is a component of the antitumor host defenses during tumour growth and metastasis ■ Supplementation with vitamins C and E results in a transient increase in cytokine production
Alteration in cholesterol metabolism	<ul style="list-style-type: none"> ■ Isolated dietary fibers from vegetable and fruit sources (like pectin) show hypocholesterolemic action in humans ■ Addition of pectin- and fiber-containing foods to experimental diets also lowers plasma cholesterol to varying degrees ■ Increase excretion of fecal bile acids and neutral steroids, alter ratios of primary to secondary bile acids, increase fecal cholesterol and fatty acid excretion
Modulation of steroid hormone concentrations and metabolism	<ul style="list-style-type: none"> ■ Alters circulating concentrations of sex steroid hormones, increase fecal excretion of estrogens and change hormonal profiles ■ May influence metabolism of endogenous steroid hormones ■ Alter the potency of testosterone, estrogen, and their derivatives via oxidation and hydroxylation reactions
Blood pressure reduction	<ul style="list-style-type: none"> ■ Higher intakes of dietary fiber and minerals from fruits and vegetables help to reduce blood pressure
Antibacterial and antiviral activity	<ul style="list-style-type: none"> ■ Cranberry juice is believed to treat urinary tract infections in women

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