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REVIEW ARTICLE

Vegetables for Food and Nutritional Security: A Review

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ABSTRACT

Vegetables have nutritional, and health benefits and are considered important for human nutrition. They are rich sources of proteins, vitamins, minerals, non-nutritive phytochemicals and fibers. Phytochemicals such as phenolic compounds, flavonoids, bioactive peptides etc. have shown health-promoting effects. But a part of the ever-increasing population especially resource-poor in India is still food and nutrition insecure. There is an inverse relationship between high consumption of vegetables and diseases a good reason for the inclusion of vegetables in the diet to reduce the risk of some diseases. Some vegetables like spinach, onion and broccoli are rich sources of health-promoting substances. Vegetables have shown anti-oxidative, anti-carcinogenic, cardiovascular lowering effect and antibiotic but the mechanism by which these compounds reduce the risk of diseases is still unknown. By taking advantage of different agro-climatic conditions, India is growing a wide range of vegetables round the year. These vegetables not only provide food and nutritional security but improve quality of life by providing eco-system services. Year-round production of vegetables provides income and employment also. Generally, 400-500 g carbohydrate is required for human energy. Protein 60-70 g is required for proper growth and development. While vitamins, minerals, fiber and phytonutriceuticals are required for a healthy life and vegetables are the chief sources of all types of food and nutrition. In spite of the single inclusion of vegetables, more than one is better for protection against chronic disease is recommended. For this purpose, 100 g each of leafy, fruit root and tuber crops may provide food and nutrition for a healthy life. Many states in India still produce food that is below the minimum requirement necessitating the need to increase vegetable production. c

***Key words**: Hunger; Malnutrition; phytochemicals; Food and Nutritional Security.*

The sustainable development GOAL-2 commits the end of hunger and malnutrition by 2030, but the increasing number of hunger and malnourished people are putting question on it (*Fanzo et al., 2020*). The 50 and 25 per cent of the total food insecure and under nourished people belongs to Asia and African continents, respectively (*FAO, 2021*). In the Indian villages, food and nutrition security is determined by the household production for self consumption and purchase of food from outside using farm income. Because, in rural India agriculture is the primary source of food and nutritional security of 55 per cent population. Also we call food as Aanna Devata and before eating we thank almighty for the wonderful food. In our ancient literature food has its unique place and linked with God and Goddesses as Maharishi Bhrugu stated that *"Food is Brahma. Never speak ill about food. Never reject the food. Take an oath to produce plenty of food* (*Pathak et al., 2022*).

Green revolution in India witnessed the tremendous improvement in cereal production which ensured food security and nutritional security to some extent during 1970's indicated diversification in production system by involving horticultural crops including vegetable with livestock components i.e., farming system approach (*Saxena et al., 2003*; *Panwar et al., 2021a*). The food and nutritional security in India was achieved by producing cereals, pulses, oilseeds, vegetables etc. For boosting of agricultural growth farmers need to be encourage to diversify cereal based production with high value crops (*Walia et al., 2022*) preferable with vegetables. India is self

sufficient in food grain production but at household level, food security remained a question (*Panwar et al., 2019*) necessitating the need to improve production and productivity of small and marginal farms. In rural areas, at household level food security is dependent on agricultural productivity which is uncertain due to vulnerability of flood, drought, soil erosion and market opportunities (*Thangjam et al., 2019*). Out of 113 major countries, India's ranks 68 in terms of food security index with overall score of 58.9 (*GFSI, 2022*). A large section of India's population suffers from food and nutritional insecurity, the worst affected are the people having no land or little to depend upon. The number is more in economically backward, tribal and remote area. It does not only indicate food insecurity among communities, household or at individual level but other factors such as child and gender discrimination to make them more food insecure also (*Chinnakali et al., 2014*).

The causes of malnutrition is the prevalence of nutritionally poor diet due to inadequate access to fruit and vegetables especially to resource poor (*Stadlmayr et al., 2023*) and rich people due to change it due to their lifestyle and food habits. The vitamins, minerals and other substances are needed for proper growth, development and function of the body. Under-nutrition conditions are reported to reduce the growth, performance of the people (*Emery, 2005*) and economy of the country. Death is also associated with malnutrition as *Venkatramana,* (*2020*) reported that death due to gastrointestinal cancer (14per cent), ischaemic heart disease (11per cent) and stroke (9per cent) are associated with very less or insufficient intake of fruits and vegetables. This situation needs to be addressed for reducing hunger and risk of future hunger to which the role of vegetable can be foreseen. Because vegetables are reported to provide more safety feeling than cooked food having high calorie content (*Kareem et al., 2016*).

More than 7000 plant species are consumed worldwide as food but only 30 crops are providing 95per cent of world food energy (*Noopur, 2015*). It has been reported through a survey that about 402 vegetable crops representing 69 families and 230 genera are cultivated worldwide, of which 53 per cent vegetables are young leafy shoots followed by root, tubers (17per cent) and 15 per cent are fruit vegetables (*Kays, 2011*). Generally, one part of the vegetables are consumed but there are some vegetables whose more than one parts are consumed. As regard production is concerned, India has about 86per cent small and marginal land holdings. These land holdings farmers can make significant contribution to the production of high value crops including vegetables. Their share is 44 per cent in land area but contribution is 70per cent of total production of vegetables (*Birthal et al., 20011*) and hence they contribute in food and nutritional security, besides favouring crop diversification and intensification.

Vegetables in daily diet are associated with improved health and reduced risk of a number of diseases especially heart, cancer, diabetes, anaemia, rheumatoid arthritis and other chronic disease (*Prior et al, 2000*). As stated by *Mullie and Clarys,* (*2011*) that higher amount of vegetable intake are associated with lower risk of cardiovascular disease in human. They also reported that vegetable intake in low quantity can cause 31per cent of ischemic heart disease and 11per cent stroke worldwide. However, the mechanism by which vegetable consumption reduce human disease have not yet fully understood (*Dias, 2012*). The nutritive value i.e. carbohydrate, protein, vitamins and minerals present in vegetables help in alleviating malnutrition problem and hence known as 'protective food'. If we see broccoli, it contain anti cancer compound such a di-indolymethane which is a potent modulator of immune response system, antibacterial, antiviral and anti-cancer activity (*Sarkar et al., 2014*). Broccoli also contains a compound named glucoraphanin which can be processed into sulforaphane. This sulforaphane is an anti-cancer compound (*Mukherjee and Mishra, 2012*).

Vegetable production and availability : In India, the vegetables in terms of area and production have increased markedly since 1961. The area under vegetable cultivation increased from 2.9 million hectare in 1961-63 to 11.35 million hectare in 2021-22. While vegetable production has increased 10.45 times from 19.1 million tons in 1961-63 to 200.45 million tons in 2021-22. Likewise, the productivity has also increased about 3 times during the same year of report (Table 1).The production of vegetable increased to 200.45 million metric tons during 2022 (Table 1) making country self-sufficient in vegetable production but we must be very progressive in vegetable production to make them continuously available for ever increasing population. This spectacular growth of vegetable production registered growth in per capita availability of vegetable to the tune of 21 per cent during 2010-2019 and 53 per cent during 2010-2023 (*Annonymous, 2022; up to 2022 and later self calculation of the authors*). If we investigate the consumption of vegetables, all

Table 1. Vegetable production dynamics

Year	Area (M ha)	Production (Mt)	Productivity (t/ha)
1961-63*	2.9	19.1	6.5
1970-71*	3.7	27.7	7.6
1981-83*	4.5	38.4	8.5
1991-93*	4.6	50.3	10.9
2001-03*	6.2	75.1	12.2
2011-13*	8.0	112.7	14.1
2021-22**	11.35	200.45	17.7

**Three-year average, *One year data. Source: FAOSTAT,

the vegetables produced is not necessary to reach to the market as some part of it may be retained by the producer, ensuring food security and nutrition at household level. Some part of produce is lost due to post harvest losses at harvesting, processing, packing, handling, transportation, marketing, and storage (*Sharma and Singh, 2011*). This situation necessitates the need to reduce wastages during harvesting, handling, transporting, and marketing to make it more available of what is produced.

India taking advantages of wide agro-climatic zones, is producing vegetable to the tune of 200.45 million tons while the population of India is 1408 million and hence 390 g/vegetable/person/day is available (*Noopur et al., 2023a*), this includes the vegetables produce for export, processing and seed production also, even it improves food and nutritional security at household level (*Panwar et al., 2019*). India with this vegetable production level has become second largest vegetable producing country in the world after china. However, India is number one in production of okra, chilli, pepper, onion, and bean in the world. In India vegetables are growing in open field on flat land and under high moisture content on raised beds as well as under protected cultivation i.e. polyhouse with the use of latest technologies (*Singh et al., 2017*). This technology has made it possible for round year quality production but at the same time nematode problem has emerged out in polyhouse (*Chikkeri et al., 2023a*) necessitating the need to take care while adopting protected cultivation. vegetable production Hence to ensure access to a healthy diet having adequate quantity of macro and micro nutrients is to produce different types of vegetables in kitchen garden and to provide income and employment opportunities, besides food and nutrition security (*Noopur et al., 2021a*).

Now the production has shifted from the use of traditional practices to improved technology including raised bed in maize based cropping system (*Panwar et al., 2021b*). These practices need to be made known to the farmers through efficient extension methods. It would be appropriate if farmers are taken to the farm by celebrating field day/exposure visit or participatory breeding to select best genotype/variety for their field (*Noopur et al., 2021b*) and to make them a part of vegetable breeding and to develop sense of belongingness towards developed varieties. At the same time rural youth based on socio economic preferences, can be made entrepreneur in vegetable production on commercial basis by using newly developed technology for improvement of livelihood at household level. Because becoming an entrepreneur in a society generally depends on social, economic, religious, and psychological factors of the society (*Chauhan and Saikia, 2022a*) and social aspect is very well suited to rural youth. The economic condition of farmers also not allowing farmers to adopt new technology (*Khan and Chauhan, 2005*) and vegetable-based entrepreneurship has improved their income status and hence allowing them to spent more in adoption of newly developed technology.

Though the vegetables are produced in the villages but the situation of vegetable availability is more disappointing in villages than the cities. However, keeping vegetable in daily diet is indispensible for maintenance of good health and wellbeing. *Septembre et al. (2018*) stated that consumption of vegetables means intake of fiber, vitamins, minerals, flavonoids, phytoestrogens, sulfur compounds, phenolic compound and bioactive peptides have positive effect on health. Hence the regular and fresh round year supply of vegetables is to be made possible through growing them in and around house and if possible, having kitchen garden concept (*Noopur et al., 2021a*). Home grown vegetables included at kitchen garden and on farm production. This way the produce cannot only be sold to earn income for other household expenses but used for own at household consumption. The enhanced income helps in stretching vegetable budget.

The vegetables grown in kitchen or home garden are consumed at home itself and production higher than home consumption is shared with neighbor and rest is sold out in the nearby market. This way vegetable helps in generating income and employment opportunities to small and marginal farmers especially women, besides strengthening the sociological bonding. Kitchen gardens are the best method of production of supplementary food

at household level and hence can be considered is one of the strategies of improving food security for household. In other parts of the world kitchen gardening (Home gardening) has becomes a survival strategy when food security is threatened by minimum availability of foods and its access (*Sahoo and Rocky, 2019*).

Vegetables provide sustainable solution of micronutrient and malnutrition which is affecting about 2 billion people's health especially children and woman with surviving under poverty and hunger. The home-grown vegetables improve nutritional status of the poor because home grown vegetables reduce the risk of price hick and uneven supply (*Noopur et al., 2021a*). Generally, the vegetables are grown in rural, peri-urban and to some extent in urban area for self consumption and/or commercial purpose on small, marginal and big land holdings. The heterogeneity of these land holdings in terms of agroecology and resource endowments is necessitating the need of careful targeting towards the appropriate transfer of technology *(Kaur et al., 2021*).

The balance nutrient management in vegetable cultivation not only increases the yield but the quality in terms of higher nutrient contents (*Panwar et al., 2021c*). The supply of vegetables under peri-urban areas is uneven and uncertain resulted into fluctuations in prices. These landscape offers several ecosystem services especially supply fresh vegetables to the city population, besides protection of their health along with quality life (*TEEB, 2017*) and socio-political functions (*Pole and Gray, 2013*). The peri-urban area is more important for supplying food items and reduces spoilage and hence food wastage is decreases in supply chain of vegetable marketing. Being nearer to the city, their transportation time and cost is very less while environmental foot prints are more.

The output and productivity of these land need to be increased through skill improvement and by adopting recommended technology for specific area (*Kiranmayi et al., 2016*), because education enrich people knowledge and skill improve adoption of new technology (*Singh et al., 2012*) for enhanced production. However, socio-personal variable are reported to be less significant with adoption behavior. The skill improvement especially women farmers is more relevant as the women are indispensible and a matter of concern for resource poor small and marginal land holdings. Hence women are specifically vulnerable to malnutrition although they grow food than cash crop and engaged in tedious farm work, besides cooking food, cleaning house and look after the children (*Farnworth and Hutchings, 2009*). Despite hard work done by farm women, generally they are not asked for any decision in farm and household matter managed by them (*Roy and Kadian, 2015*). The right approach for empowering women in vegetable production is to make them a part of all production and marketing related decision and for entrepreneurship development (*Chauhan and Saikia, 2022b*)

Food and security aspects of vegetables : Vegetables, an important source of nutrients, nutraceuticals, phytochemicals compounds, fiber (*Noopur et al., 2023a*) and a major portion of diet plays an important role in improving health and making human to combat various health issues. India's population being largely vegetarians is dependent on fruit and vegetables and hence vegetable have pivotal role in food and nutrition security. Carbohydrates present in vegetables are the sources of energy in food. The requirement of carbohydrate is 400-500 g/day/person. The vegetables which have the good sources of carbohydrate are potato, sweet potato, cassava, elephant foot yam, taro, garlic, pea and onion (*Singh et al., 2019*). Pumpkin is also a food during scarcity period in eastern India. Most of the villagers used to have 15-30 matured pumpkin on their roof top for winter season. These carbohydrates are of two types, i.e. simple and complex carbohydrate. Complex carbohydrate contains longer sugar molecule chain than simple carbohydrate and the body converts these sugar molecules into glucose for its use as energy. Because of longer chain carbohydrate take longer time to break down and provide more lasting energy than simple carbohydrate.

The daily requirement of protein is 60-70 g for proper growth and development. Leguminous vegetables such as cowpea, pea, beans etc. are the chief sources of protein. Likewise, a number of nutrients are required and hence inclusion of more than one type of location specific vegetables provides almost all required nutrients and better protection against chronic disease. For food and nutrition security 100 g. each of leafy, fruit, root and tuber group of vegetables are recommended. These groups have unique combination and amount of phyto-nutri-ceuticals e.g. celery, parsley and carrot are rich sources of carotenoids, vitamin C, E and flavonoids (*Nielsen, et al., 1999*). It has been reported that carotenoid levels in vegetables have

increased dramatically through classical breeding. For this purpose initially the germplasm are also being evaluated for specific traits as in case of growth, high yield and nutrient contents in tomato (*Chikkeri et al., 2023b*), high yield and YVMV resistance (*Noopur et al., 2022*) high biochemical traits and yield in okra (*Noopur, 2022*: and *Noopur et al., 2023b*), French bean (*Noopur et al., 2019*), potyvirus resistance in bottle gourd (*Choudhary et al., 2022*) and for high β carotene in pumpkin (*Kumar et al., 2022*) recommended germplasm for hybridization after proper evaluation for higher yield or bio-fortifications. The education helps the farmers to gain knowledge on modern technology.

The nutrients present in vegetables play a pivotal role in human related health issue. Potassium present in vegetable helps in maintaining blood pressure, dietary fiber reduces cholesterol levels and hence lower the risk of heart disease. Vitamin A keeps eye and skin healthy while folate reduces the risk of birth related defect. Vitamin-C takes care of whole body and helps in iron absorption. The recommendation of vegetable consumption is 300 g/person/day in India. The WHO has also recommended minimum intake of 400 g vegetables and fruits/person/day to prevent chronic disease and to supply desired quantity of micronutrients such as iron, potassium, calcium, zinc and vitamin-A (*WHO, 2015*). It means that 300 and 100 g of vegetable and fruit, respectively can be 400 g vegetable and fruit recommendations.

The number of flavonoids is varying with the variety of lettuce and small round lettuce has 11µg/g fresh weight of quercetin while in red colour lettuce "Lollo Rosso", it was 911 µg/g (*Almeida, 2006*). It was reported that the red colour in this variety was due to anthocyanins a product of phenylpropanoid pathway like quercetin and leafy and roman lettuces have more quercetin. The cucurbitaceae i.e. melon, squash, pumpkin and cucumber are rich source of carotenoids, tocopherol's and vitamin C (*Dhillon et al., 2012*) in different forms i.e. ascorbic acid and β carotene content ranged from 0.7 mg to 35.3 mg/100 g fresh fruit weight and µg/100g, respectively (*Crosby et al., 2006*). Pumpkin is also known for higher content of α and β carotene. The α carotene has about 53 per cent pro-vitamin-A activity, while β carotene has 100 per cent pro vitamin-A activity (*Kumar, et al., 2022*). In the developing countries of the world, type-2 diabetes is becoming quite common (*Dias and Ryder, 2011*) and because of anti-diabetic nature, better gourd can be a part of balance diet. Likewise for fiber and mineral, legumes are the potential sources.

CONCLUSION

Vegetable being rich in nutrients is a part of balance and varied diet. They provide a number of minerals and vitamins required for quality life. These vegetables are low in energy, fat and full of nutrients. The production of vegetables has made sufficient availability of nutrients, vitamins and phytochemicals etc. and hence 100 g each of leaf, fruit, tuber and root vegetables/person/day are recommended for quality life and prevention of a number of diseases especially heart, cancer, diabetes, anaemia, rheumatoid arthritis etc. These vegetables are good source of carbohydrate and other macro and micro nutrients if grown and make them available round the year, ensure food and nutrition security even at household level. Vegetable not only provide essential nutrients but non-nutrient chemical compounds commonly known as phytochemicals opens new vistas of research. The mechanism in the role of chemical compounds and phytochemicals in improving health related issue need to be investigated. But the first line of defense is to prevent several diseases, fresh vegetables are advocated, besides magic role of folate and anti-oxidants in fast recovery from illness.

CONFLICTS OF INTEREST

The authors have no conflicts of interest.

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