

“A Review on the Nutritional value of some leafy vegetables used in India”

Abstract

This review explores the nutritional profiles of leafy vegetables commonly used in Indian cuisine, emphasizing their significance in promoting human health and well-being. Leafy greens play a pivotal role in traditional Indian diets, contributing essential vitamins, minerals, and antioxidants. The low calorific value of leafy vegetables makes them ideal for human weight balance. The good nutrition profile of leafy vegetables are beneficial in reducing the risk of major diseases such as cardiovascular and cancer. Anti nutritional factors are chemical compounds in plant tissues, which deter the absorption of nutrients in humans. From all the findings it was suggested that consumption of leafy vegetables fulfills the nutrition requirements and avoid from malnutrition.

Keywords – Leafy vegetables, Anti-nutritional, Minerals, Antioxidants.

Introduction

“Leafy green vegetables are a rich source of nutrients, dietary fiber, and rich in folate, ascorbic acid, vitamin K and Mg. They also contain some phytochemicals like β -carotene, flavonoids” (Randhawa *et al.*, 2015). The first three objective of Sustainable Development Goals (SDGs) is to achieve zero poverty, zero hunger, and optimal health and well-being for all (UNDP, 2015). It is recommended by World Health Organization (WHO) that on daily basis at least 400g of fruit and non-starchy vegetables should be consumed for proper nutrition (WHO, 2021). “Green leafy vegetables offer a cheap but rich source of a number of micronutrients and other phytochemicals having antioxidant properties. The potential of about 30 raw and cooked leafy vegetables form as natural antioxidant supplements for vegetarian diets was evaluated” (Tarwadi & Agte, 2003). Leafy vegetables ensures a requisite intake of nutrition which can contribute to balanced diet and also solve the problem of nutrient deficiency. (Kumar *et al.*, 2020). Many bioactive substances known as phytochemicals, which are found in large quantities in plants, are thought to be essential for optimal health (Dias *et al.*, 2017). By many scientists it was observed that phytochemical composition is very variable and unique to individual plants (Dias, 2012). There is a significant consumption of leaves from a variety of sources, including aquatic, annual, and perennial trees.

Some communities worldwide consume traditional leafy vegetables, which are either harvested from their local environment or grown on small scale (Mahyao *et al.*, 2008). Because it helps to increase the availability and consumption of foods rich in micronutrients, the diet and food-based approach are crucial in the fight against micronutrient malnutrition.(FAO, 1997). “Generally consumed leafy vegetables are spinach (*Spinacia oleracea*), amaranth (*Amaranthus gangeticus*), fenugreek (*Trigonella foenumgraecum*), drumstick (*Moringa oleifera*), cabbage (*Brassica oleracea var. capitata*), bathua (*Chenopodium album*), and many more” (Ashok *et al.*, 2020).

“Majorly phytochemicals can be broadly categorized as nutritional which includes essential fatty acids, proteins, vitamins, minerals and phenolic compounds and second anti-nutritional which includes oxalates, tannins, nitrate type of chemical compounds” (Uusiku *et al.*,2010). Concluding, the health promoting phytochemicals will be stated to as nutritional factors and the health-inhibiting or toxic phytochemicals will be stated to as anti-nutritional factors.

Table no.1- Nutritional compositions of some green leafy vegetables (per100g edible portion).

Name of leafy vegetables	Macronutrients (per100g)					Vitamins (per100g)				Minerals (per100g)		
	Energy	Moisture	Protein	Fat	Carbohydrate	Thiamine	Riboflavin	Niacin	Ascorbic	Calcium	Phosphorus	Iron
Spinach	26.0	92.1	2.0	0.7	2.90	30	260	500	28	73	21	1140
Coriander	44.0	86.3	3.3	0.6	6.3	50	60	800	135	184	71	1420
Mint leaves	48.0	84.9	4.8	0.6	5.8	50	260	1000	27	200	62	1560
Fenugreek	49.0	86.1	4.4	0.9	6.0	40	310	800	82	395	51	1930
Bathua	30.0	89.6	3.7	0.4	2.9	10	140	600	35	150	80	4200
Cabbage	27.0	91.9	1.8	0.1	4.6	60	90	400	124	39	44	800
Amaranth	45.0	85.7	4.0	0.5	6.1	30	30	1200	99.0	397	83	3490
Drumstick	38.0	75.9	6.7	1.7	4.1	60	50	800	52	440	70	850

Source : Gopalan *et al.*, (2004).

Nutritional components in green leafy vegetables:-

Dietary fiber

“Vegetables that are high in fiber are spinach and cabbage” (Ogles, 2014). “Consumption of higher levels of vegetable fiber resulted keeps the digestive system healthy, helps healthy body weight and reduced risk of cardiovascular diseases and possibly, colon cancer”. (Jenkins *et al.*,2001; Ogles, 2014). The amount of total dietary fiber in green leafy vegetables can vary with different plant variety of the same species, agro-climatic conditions, stages of maturity and type and rate of fertilizer applications.

Proteins

“Green leafy vegetables are the richest and cheapest sources of proteins. This is because of their ability to synthesize and accumulative amino acids with the help of abundant source of sunlight, water, oxygen and nitrogen which is readily available in the atmosphere” (Aletor,2002). “The amount of protein content in leafy vegetables can vary with farming practices and prevailing environmental conditions” (Odhav, 2007). “Bioavailability of protein in leafy vegetables is typically influenced by thermal processing, which inactivates heat-labile anti-nutritional factors such as protease inhibitors, lectins, thiaminases and goitrogens but enhances digestibility of proteins and starch” (Gibson *et al.*, 2006).

Vitamins

“In leaves, vitamin A is present in the form of provitamin A carotenoids such as β -carotene, α -carotene, γ -carotene, β -cryptoxanthin and non-provitamin” (Britton, 1996). “Increasing the consumption of green leafy vegetables that are widely available in developing countries help in combating prevailing vitamin A deficiency in regions where pharmaceutical supplements and vitamin A fortified foods are limited” (Baudoin and Louise, 2002). “Each half-cup of boiled spinach provides 573mcg of vitamin A” (Kumar *et al.*,2020). “Plants are the major source of foliates for humans especially, green leafy vegetables” (Castorena *et al.*, 2014)

Minerals

“Spinach, lettuce, curly lettuce, chard, chicory etc adds sufficient minerals in our diet. The zinc content of *C. album* compares favourably to most values for green leafy vegetables reported in research” (Hamazaki et al., 2001). “WHO,1996 stated that the overall malnutrition must no longer be considered without reference to micronutrient status, as the two are inextricably linked. Attempting to improve protein-energy status without addressing micronutrient deficiencies will not result in optimal growth and function” (Baudoin *et al.*,2002). “Minerals have greater stability during food processing as compared to vitamins and proteins” (Kala, 2004).

Anti-nutritional factors in green leafy vegetables-

Anti nutritional factors are chemical compounds in plant tissues, which deter the absorption of nutrients in humans . Some of the anti nutrients commonly found in leafy vegetables are nitrates, oxalates, tannins, and phytates.

Nitrate: “Nitrate is one of the important and natural compounds found in vegetables, and is responsible for characterizing vegetable quality. Nitrate concentration in the parts of leaf is found higher than other groups of vegetables such as root and fruits vegetables” (Tamme *et al.*,2010). “Amount of nitrate content present per serving of any vegetable is non-toxic but its metabolites and bi products such as nitrite, nitric oxide and N-nitrous compounds are the main compounds of health concern” (Parks *et al.*,2008). “The World Health Organization has set the acceptable daily intake of nitrate at 3.7 mg/kg body weight and nitrite at 0.06 mg/kg body weight” (Alexander *et al.*,2008)

Oxalates: “Oxalic acid in combination with its salts or minerals form oxalates. Oxalic acid is present in the cell sap of many of the green leafy vegetable” (Champ,2002). “The adverse effect of calcium absorption is higher when the ratio of oxalate: calcium is more than 9:4” (Noonan, 1999). “oxalates are also formed in the human body as the by-product of ascorbic acid and glyoxylate metabolism” (Williams, 1989). “Generally, the amount of oxalate is high in leaves followed by seeds and less in stems” (Osweiler *et al.*,1985). “Hence, consumption of leafy vegetables has more of a concern when there is a risk of high oxalic acid concentration. Reports show leaves of amaranth, spinach and beet (*Beta vulgaris*) have more oxalate levels” (Noonan, 1999).

Tannins: “Plant tannins are present in plant bark, wood, fruits, fruit pods, leaves, roots and plant galls” (Mane *et al.*,2007; Ricci *et al.*,2015). Gupta & Haslam, further explained that “vegetable tannins are normal metabolic products and are not the products of in vitro transformation by chemical or other means” .“Tannins are classified into two groups based on the structural types, that are; hydrolysable tannins and condensed tannins” (Freudenberg *et al.*,1962). “Of the two groups, condensed tannins are abundantly found in higher plants (e.g., proanthocyanidins). The hydrolysable tannins consist of glucose surrounded by phenolic acids and are readily hydrolyzed by acids, bases and certain enzymes” (Bule *et al.*,2020)

Phytates: Phytates or phytic acid are the natural occurring phosphorus storage compound found in all leafy vegetables (Nissar *et al.*, 2017). **Plant tissues contain cationic salts of potassium, magnesium, and calcium of phytic acid.** According to Reddy and Sathe , 2001 the large number of negatively charged phosphate groups in phytic acid makes important mineral nutrients in the human body , rendering them less accessible for absorption. Protein binding by phytate can be direct means it can directly bind to protein or indirect by constructing a cation bridge (Ravindran *et al.*,1999). “Processing methods such as boiling and cooking have no effect in reducing the level of phytic acid as the phytate is relatively heat stable” (Wang & Guo,2021; Ryden *et al.*,1993).

Benefits of green leafy vegetables in human diet

Leafy green vegetables includes kale, spinach, arugula, chinopodium, chard etc. are important source of nutrient in our diet, which consist of low in calories, high in fiber, vitamins, and phytonutrients, the benefits of leafy greens are incredible for human health in various ways-

Optimal brain functioning –Leafy vegetables contain high levels of folate (B9). B vitamins facilitate the production of neurotransmitters (chemicals that transfer messages from the brain to the rest of the body) in the brain. Folate is found in leafy green vegetables such as spinach, broccoli, and lettuce as well as in lemons, bananas, and melons.

Relieve stress - Dark leafy greens are an excellent source of folate, which helps human body to produce mood-regulating hormones such as dopamine and serotonin which relief from stress.

Regulate optimal gut health – Consumption of green leafy vegetables produce innate lymphoid cells. These cells protect human body against gut infections and facilitate a healthy inflammatory response.

Support immune system - Dark leafy green vegetables such as moringa, kale leaf facilitate a healthy response to oxidative stress caused by free radicals and build a strong immunity.

Bone health : Leafy greens are particularly high in vitamin K, a crucial nutrient for bone health and blood clotting. Adequate vitamin K intake is associated with a reduced risk of fractures and improved bone mineral density. Incorporating leafy greens into one's diet can be especially beneficial for individuals looking to support skeletal strength and overall bone health (Pearson, D. A. 2007).

Conclusion: - This review provides a understanding of leafy vegetables in promoting human health through their rich nutritional source and potential preventive effects against various diseases. The findings contribute to the existing body of knowledge, advocating for the incorporation of leafy greens into a dietary and public health initiatives for a healthier global population. . There is an opportunity for research to identify the potential of edible leaves of indigenous and under-exploited plants for consuming as food and medicine. Research is also needed to explore different varieties and options of adopting agronomic practices that will reduce the effect of anti-nutritional factors in green leafy vegetables and enhance their nutritive value.

References

1. Aletor O, Oshodi A, Ipinmoroti K (2002) Chemical composition of common leafy vegetables and functional properties of their leaf protein concentrates. *Food Chemistry* 78(1): 63-68.
2. Alexander J, Benford D, Cockburn A, Cravedi J, Dogliotti E, et al. (2008) Nitrate in vegetables scientific opinion of the panel on contaminants in the food chain. *EFSA J* 689: 1-79.
3. Ashok, A. D., Ravivarman, J., & Kayalvizhi, K. (2020). Underutilized leafy vegetables of India and their pharmaceutical value to provoke human immune system. *Journal of Pharmacognosy and Phytochemistry*, 9(3), 1319-1327.

4. Baudoin WO, Louise Fresco O (2002) Food and nutrition security towards human security. ICV Souvenir Paper, Italy, p. 1-19.
5. Baudoin WO, Louise Fresco O. Food and nutrition security towards human security. ICV Souvenir Paper, Italy, 2002, 1-19.
6. Britton G (1996) Carotenoids. In: Hendry GAF et al. (Eds.), Natural food colorants, Springer, USA, pp. 197-243.
7. Bule, M., Khan, F., Nisar, M. F., Niaz, K., Nabavi, S., Saeedi, M., & Sanches Silva, A. (2020). Tannins (hydrolysable tannins, condensed tannins, phlorotannins, flavono-ellagitannins). *Recent advances in natural products analysis*, 132-146.
8. Castorena Torres F, Ramos Parra PA, Hernández Méndez RV, Vargas García A, García Rivas G, et al. (2014) Natural folates from biofortified tomato and synthetic 5-methyl-tetrahydrofolate display equivalent bioavailability in a murine model. *Plant Foods Hum Nutr* 69(1): 57-64.
9. Champ MM (2002) Non-nutrient bioactive substances of pulses. *Br J Nutr* 88(S3): S307-S319.
10. Da Silva Dias João Carlos, Imai S (2017) Vegetables consumption and its benefits on diabetes. *Journal of Nutritional Therapeutics* 6(1): 1-10.
11. Dias JS (2012) Major classes of phytonutriceuticals in vegetables and health benefits: A review. *Journal of Nutritional Therapeutics* 1(1): 31-62.
12. FAO (1997). Preventing micronutrient malnutrition: a guide to food based dietary approaches. Washington: FAO.
13. Freudenberg K, Weinges K (1962) Catechins and flavonoid tannins. *The Chemistry of Flavonoid Compounds*, pp. 197-216.
14. Gibson RS, Perlas L, Hotz C (2006) Improving the bioavailability of nutrients in plant foods at the household level. *Proc Nutr Soc* 65(2): 160-168.
15. Gopalan C, Sastri R, Balasubramanian SC. Nutritive value of Indian foods. National Institute of Nutrition, ICMR, Hyderabad, 2004, 52.
16. Gupta R, Haslam E (1980) Vegetable tannins: Structure and biosynthesis. Paper presented at the Polyphenols in Cereals and Legumes: Proceedings of a Symposium, UK.
17. Hamazaki T, Okuyama H. Fatty acids and lipids—New findings. Karger Medical and Scientific Publishers, Japan, 2001, 1-53.

18. Jenkins DJ, Kendall CW, Popovich DG et al., Effect of a very-high-fiber vegetable, fruit, and nut diet on serum lipids and Colonic function. *Metabolism*. 2001; 50(4):494-503.
19. Kala A, Prakash J. Nutrient composition and sensory profile of differently cooked green leafy vegetables. *International Journal of Food Properties*. 2004; 7(3):659-669.
20. Kirtan Tarwadi & Vaishali Agte, (2003) Potential of commonly consumed green leafy vegetables for their antioxidant capacity and its linkage with the micronutrient profile, *International Journal of Food Sciences and Nutrition*, 54:6, 417-425
21. Kumar, D., Kumar, S., & Shekhar, C. (2020). Nutritional components in green leafy vegetables: A review. *Journal of Pharmacognosy and Phytochemistry*, 9(5), 2498-2502.
22. Kumar, D., Kumar, S., Bhadana, N. K., Singh, B., & Shekhar, C. (2020). Vegetables: Source of adequate health benefits. *Annals of Horticulture*, 13(2), 124-130.
23. Mahyao, A., N'zi, J. C., Fondio, L., Agbo, E., & Kouame, C. (2008, March). In *International Symposium on Underutilized Plants for Food Security, Nutrition, Income and Sustainable Development* 806 (pp. 361-366).
24. Mané C, Sommerer N, Yalcin T, Cheynier V, Cole R, et al. (2007) Assessment of the molecular weight distribution of tannin fractions through MALDI-TOFMS analysis of protein-tannin complexes. *Anal Chem* 79(6): 2239-2248.
25. Nissar, J., Ahad, T., Naik, H. R., & Hussain, S. Z. (2017). A review phytic acid: As antinutrient or nutraceutical. *Journal of Pharmacognosy and Phytochemistry*, 6(6), 1554-1560.
26. Noonan S, Savage G (1999) Oxalate content of foods and its effect on humans. *Asia Pac J Clin Nutr* 8(1): 64-74.
27. Odhav B, Beekrum S, Akula U, Baijnath H (2007) Preliminary assessment of nutritional value of traditional leafy vegetables in KwaZulu-Natal, South Africa. *Journal of Food Composition and Analysis* 20(5): 430-435.
28. Osweiler GD, Carson TL, Buck WB, Van Gelder G (1985) *Clinical and diagnostic veterinary toxicology*. Kendall/Hunt Publishing Company, USA, pp. 1-494.
29. Otles S, Ozgoz S. Health effects of dietary fiber. *Acta Scientiarum Polonorum Technologia Alimentaria*. 2014; 13(2):191-202.

30. Parks S, Huett D, Campbell L, Spohr L (2008) Nitrate and nitrite in Australian leafy vegetables. *Australian Journal of Agricultural Research* 59(7): 632-638.
31. Pearson, D. A. (2007). Bone health and osteoporosis: the role of vitamin K and potential antagonism by anticoagulants. *Nutrition in Clinical Practice*, 22(5), 517-544.
32. Randhawa, M. A., Khan, A. A., Javed, M. S., & Sajid, M. W. (2015). Green leafy vegetables: A health promoting source. In *Handbook of fertility* (pp. 205-220). Academic Press.
33. Ravindran V, Selle P, Bryden W (1999) Effects of phytase supplementation, individually and in combination, with glycanase, on the nutritive value of wheat and barley. *Poult Sci* 78(11): 1588- 1595.
34. Reddy, N. R., & Sathe, S. K. (Eds.). (2001). *Food phytates*. CRC Press.
35. Ricci A, Olejar KJ, Parpinello GP, Kilmartin PA, Versari A (2015) Application of Fourier transform infrared (FTIR) spectroscopy in the characterization of tannins. *Applied Spectroscopy Reviews* 50(5): 407-442.
36. Ryden P, Selvendran R (1993) Phytic acid: Properties and determination. *Encyclopedia of Food Science, Food Technology and Nutrition*, Academic Press, UK, pp. 3582-3587.
37. Tamme T, Reinik M, Roasto M, Meremäe K, Kiis A (2010) Nitrate in leafy vegetables, culinary herbs, and cucumber grown under cover in estonia: Content and intake. *Food Addit Contam Part B Surveill* 3(2): 108-113.
38. Uusiku NP, Oelofse A, Duodu KG, Bester MJ, Faber M (2010) Nutritional value of leafy vegetables of sub-Saharan Africa and their potential contribution to human health: A review. *Journal of Food Composition and Analysis* 23(6): 499-509.
39. Wang, R., & Guo, S. (2021). Phytic acid and its interactions: Contributions to protein functionality, food processing, and safety. *Comprehensive Reviews in Food Science and Food Safety*, 20(2), 2081-2105.
40. Williams HE, Wandzilak TR (1989) Oxalate synthesis, transport and the hyperoxaluric syndromes. *J Urol* 141(3): 742-747.
41. World Health Organization (WHO),2021. Nutrition-data and statistics.