Review Article

QUALITY BREEDING IN LEAFY VEGETABLES

Abstract

Due to their abundance in vitamins, vital fatty acids, minerals, amino acids and dietary fibre as well as a variety of necessary bioactive chemicals vegetables are typically referred to be "protective foods" in the human diet. These include phenolic compounds and antioxidant-rich secondary plant metabolites that are beneficial to health. The best and most affordable sources of protein are green leafy vegetables. This is due to their capacity to synthesise and accumulate amino acids using the ample sunshine, water, oxygen and nitrogen that are present in the environment. Green leafy vegetables have long been regarded as excellent providers of nutritional fibre. According to WHO overall malnutrition cannot no longer be addressed without reference to micronutrient status and this issue can be addressed by breeding nutritionally rich leafy vegetables.

Keywords: Protective Foods, Anti-Oxidant, Vitamin, Green Leafy Vegetables

Introduction

Leafy vegetables are incredibly important for a balanced and healthy diet due to their rich nutritional content. They are a great source of vitamins, minerals, fibre and antioxidants, all of which contribute to overall well-being. Many leafy greens are high in antioxidants, such as vitamin C, vitamin E, and various phytochemicals like flavonoids and carotenoids. Antioxidants help combat oxidative stress and free radicals in the body, which can reduce the risk of chronic diseases like heart disease, cancer, and neurodegenerative disorders. The high fiber and antioxidant content in leafy vegetables contribute to cardiovascular health. The results suggest that the vegetables if consumed in sufficient amount would contribute greatly towards meeting the nutritional requirement for normal growth and also could provide adequate protection against diseases emerging from malnutrition. This paper reviews the literature on breeding for quality in some important green leafy vegetables.

1. Spinach

Beta vulgris var *bengalensis* is a rich source of Vit A- 9770 IU. It belongs to the family Amaranthaceae (2n=2X=18). Palak is originated in Indo-China**. S**ynonyms of palak are spinach beet, beet leaf.

Quality breeding objectives:

- The main objectives are high yield, good quality of green leaf, uniformity and resistance to major disease.
- The percentage of stalks (petioles) in the harvested spinach must be low to produce a high-quality frozen product, especially when the use is for frozen whole leaves.
- The hybrids or inbred lines should be suitable for different seasons such as summer or autumn and should have the characteristics of delayed bolting and short petiole
- They should have low nitrate content and be suitable for the deep freezing industry

Research findings of quality breeding

- Calcium oxalate is found in greater amounts in spinach and may interfere with calcium absorption. A decrease in oxalic acid content with the age of the plant was recorded contents were lower in stem and petioles than in leaves
- Savoy leaf cultivars had the highest nitrate concentration and smooth leaved the lowest.
- Pandey and Kalloo (1993) reported higher levels of dry matter content in smoothed leaved types that in crinkled types.
- Higher iron content was noted in varieties with dark green leaves than light green leaves. The variety Bloomsdale Long Standing had the highest value of iron content
- The accumulation of nitrate in spinach is subjected to diurnal rhythm, with the highest concentration in the morning and lowest in the afternoon (Steingrover, 1986; Steingrijver *et al.,* 1986).
- The concentration of nitrate in spinach was found to be higher in the autumn, when the light is decreasing and the photoperiod is shortening
- In some earlier reports the content of nitrate has been claimed to be correlated to the leaf type of spinach cultivars, with higher nitrate concentration in the savoy-leaved

types compared to smooth-leaved types (Maynard & Barker, 1976). The reasons for the lower content of nitrate in smooth-leaved type cultivars is explained by higher yield, higher protein content, and a higher nitrate reductase activity.

- The content of oxalic acid, which is synthesized from oxaloacetic acid during photosynthesis, increases with increasing day-length (Sengbusch *et al.,* 1965), but decreases with increasing age of the plant.
- High levels of nitrogen, calcium, and potassium can result in an increased content of oxalic acid, whereas high phosphorus levels tend to lower the content (Sengbusch *et al*., 1965).
- Oxalic acid is claimed to be correlated to the colour of leaves, i.e., darker leaves have higher oxalic acid content (Sengbusch *et al.,* 1965).
- A correlation of chlorophyll with the concentration of oxalic acid gave a significant positive correlation (r = 0.73).

2. LETTUCE

Quality breeding objectives:

- To develop cultivar with low nitrate content
- Red pigmented lettuce contains higher phenolic compounds than green lettuce.
- To identify new genes for resistance in wild germplasm and incorporate them into advanced breeding lines.
- Development of cultivars that do not discolor could minimize or eliminate the need for MAP.
- New cultivars with longer shelf-life could reduce waste and increase the distribution system's efficiency
- Bolting resistance: Upon bolting, leafy lettuce becomes bitter and unsaleable, especially during the hot summer or in tropical regions

Research findings of quality breeding

- The lettuce nitrate and water contents vary greatly even with the same nitrogen supply and radiation level. The positive effect of nitrogen on the plant nitrate content is

known. There was a significant positive correlation between the nitrate and water contents Dapoigny *et al*., 2000

- Oh *et al.,* 2009 conducted the research of stress on different acids of lettuce. The concentrations of two major phenolic compounds in lettuce, chicoric acid and chlorogenic acid increased significantly in response to all the stresses. In addition, key genes such as phenylalanine ammonia-lyase (PAL), l-galactose dehydrogenase (l-GalDH), and γ-tocopherol methyltransferase (γ-TMT) involved in the biosynthesis of phenolic compounds, ascorbic acid, and α-tocopherol, respectively, were rapidly activated by chilling stress while heat shock and high light did not appear to have an effect on the expression of PAL and γ-TMT. The results also show that these mild environmental stresses had no adverse effects on the overall growth of lettuce, suggesting that it is possible to use mild environmental stresses to successfully improve the phytochemical content and hence the health-promoting quality of lettuce with little or no adverse effect on its growth or yield.
- **Solan Kirti:** It is an open type (non-heading) cultivar of lettuce having long leaves, soft & dark green in color. Early in maturity (71.57 days), rich in beta-carotene contents (5.59 Âµg/100g), iron (1.63 mg/100g) and calcium (58.07 mg/100g). Average yield per hectare is 24.8 t/ha in open field conditions. Under protected conditions, it is very early in maturity and matures in 62 days after transplanting. Average yield is 8.0 kg m-2.

3. AMARANTHUS

Quality breeding objectives:

- High green yield
- High leaf:stem (more than 1)
- Lowers amount of anti-nutritional compounds
- Increasing harvest ability
  - Lodging resistance
  - Uniform maturity
- Good seedling vigour

- Resistance to phomopsis blight, stem borer, sucking pests, white rust and alternaria blight
- Cold and heat tolerance

Quality improvement in amaranthus

- Lines with high anti-oxidant capacity
  - IIHR-74 (355 mg/100 g f.w.b AEAC)
  - IIHR-70 (265 mg/100 g f.w.b AEAC)
  - IIHR-65 (255 mg/100 g f.w.b AEAC)
- Lines with lowest amount of nitrates and oxalates content
  - IIHR-7 (35.9 mg/100 g f.w.b and 593 mg/100 g f.w.b respectively)
- Genetic studied indicated that nitrate content in amaranthus is governed by additive gene action

Chart 1: Varieties of trees with scientific name and special features.

Varieties	**Spp**	**Special features**
Arka Varna	*Amaranthus tricolor*	High Antioxidant Activity Of 417mg (AEAC Units), Nitrate Content Of 37.6mg And 1.42g Of Oxalates Per 100g fresh weight of leaves.
Arka Arunima	*Amaranthus tricolor*	Pure line selection from IIHR-49Multicut variety with broad dark purple variety, first picking starts in 10-12 days interval, yield is 27 t/ha, rich in calcium and iron.
Arka Samraksha	*Amaranthus tricolor*	High Antioxidant Activity of 499mg (AEAC Units) and minimum nitrate content Of 27.3 mg and 1.34g of oxalates per 100g fresh weight of leaves. It is a pulling type Amaranth variety with Green Leaves and stem, Yields 10.9t/ha In 30-35 days duration
Arun	*Amaranthus tricolor*	Deep red coloured variety, average yield 20 t/ha

Kannara Local	*Amaranthus tricolor*	Deep red coloured variety, High yielding season bound variety comes to flowering in Nov-December
Krishnasree	*Amaranthus tricolor*	Red coloured variety, leaf yield 14.8 t/ha
Mohini	*Amaranthus tricolor*	Green leaf colour
Renusree	*Amaranthus tricolor*	Green leaf colour and purple stem having low anti nutritional factors, leaf yield 15.5 t/ha

- Kashi Suhaavani (VRAM-42): Luxuriant plant growth with lusture green canopy, soft succulent green leaf, delayed flowering and high yield potential (30-33 t/ha). Suitable for growing during summer and rainy season. Rich in protein content 15.50 % on dry weight basis, tolerant to white rust (Anon, 2018).

4. BASELLA

- **B.N**. – *Basella alba & Basella rubra*
- **Common name** – Poi, Malabar nightshade, Indian Spinach
- **Family**- Basellaceae
- Basella is very low in calories and fats (100g of raw leaves provide just 19K calories). Nonetheless, it holds an incredibly good amounts of vitamins, minerals, and antioxidants.
- Fresh leaves, particularly of *Basella rubra*, are rich sources of several vital carotenoid pigments such as Beta-carotene, lutein, zeaxanthin.
- Its thick fleshy leaves are an excellent source of non-starch polysaccharide, mucilage. In addition to natural fiber that found in stems and leaves, its mucilaginous leaves facilitate smooth digestion. It is also used as a poultice
- Vine spinach leaves and stems are rich sources of vitamin A.
- Basella has more vitamin C content than English spinach (100g of fresh leaves contains 102mg of vitamin C).

- Likewise in spinach, basella too is an excellent source of iron (1.20 mg per 100 g of fresh leaves).
- Further, basella leaves are good sources of minerals like potassium, magnesium and copper.
- The colouring matter present in the red cultivar is reported to have been used as a dye.

Good substitute for spinach

- In *Basella alba var. alba* the stem colour is green, while in *Basella alba var. rubra stem colour is red/ purple.* However, flower colour of both red and green types are with pink/purple tinge and mature fruits are enriched with dark purple fruit juice having ample amount of betalains. The major betalain pigment in mature fruit of *Basella is Gomphrenin I and has* great potential for utilization as natural food colourant, dye making and cosmetics. The photometric results obtained for total betalains (betanins and vulgaxanthin) exhibits maximum pigment content in ripened fruits of VRB-30 (200.93 mg/100 g FW), followed by VRB 3 (150.87 mg/100 g FW. However, the genotype with colourless fruit juice or with low expression of betalain can never be ignored as it is the basic material for understanding the genetics of betalain. These identified genomic regions can be delineated to further identify the candidate gene(s) associated with the betalain production (Anon, 2018).
- Charcoal rot: Symptom consisted of brownish to black discoloration at the collar region of the stem and branches that progressed into wilting and drying of entire plant. Infected plant stems appeared shredded and contained black microsclerotia. On the basis of morphological characteristics and pathogenicity test, the isolated charcoal rot causing pathogen was identified as *Macrophomina phaseolina.*
- EC769321-1(VRB-48-1): A unique *Basella* genotype with snow-white flower (Anon, 2018). The variant possesses intermediate growth habit with green, caudate, soft and succulent leaves. Immature fruits are green in colour without any pinkish or purple tinge. Even mature fruits are green coloured and the juice is colourless devoid of any red/purple pigment. This is also a rare trait. This unique feature may help in study of flower colour inheritance and can be utilized as a morphological marker linked to other desirable traits in conventional breeding programme. Since this germplasm is devoid of betalain even in the mature fruits, such

pigmentation markers could be used for studying the metabolic pathways of betalain biosynthesis in basella. The segregation for pigmentation showed that the genetics of pigmentation is governed by single dominant gene and followed the simple Mendelian genetic ratio of 3:1 for pigmented and non-pigmented type plant

- Kashi Poi-3 Fast growing plant having twinning growth habit, red stem and mid ribs, high betalain content, suitable for year round cultivation. Variety is excellent source of Carotenoids 635.9mg/100g FW with lower oxalate content (522.3 mg/100g FW). First picking starts 40 days after transplanting and continues up to 240-250 days at 20-25 days interval. High yield of 61.3t/ha.

REFERENCES

Anonymous, (2018). IIVR Annual Report, 152pp.

Dapoigny, L., De Tourdonnet, S., Roger-Estrade, J., Jeuffroy, M.H. and Fleury, A., (2000). Effect of nitrogen nutrition on growth and nitrate accumulation in lettuce (Lactuca sativa L.), under various conditions of radiation and temperature. *Agronomie*, *20*(8), pp.843-855.

Maynard, D.N., Barker, A.V., Minotti, P.L. and Peck, N.H., (1976). Nitrate accumulation in vegetables. *Advances in agronomy*, *28*, pp.71-118.

Oh, M.M., Carey, E.E. and Rajashekar, C.B., (2009). Environmental stresses induce health-promoting phytochemicals in lettuce. Plant Physiology and Biochemistry, *47*(7): 578-583.

Pandey, S.C. and Kalloo, G., (1993). Spinach: Spinacia oleracea L. In *Genetic improvement of vegetable crops* (pp. 325-336). Pergamon.

Sengbusch, R.V., Sücker, I. and Handke, S., (1965). Untersuchungen über den Gehalt an Oxalsäure in Spinat (Spinacia oleracea) als Grundlage für die züchterische Bearbeitung dieses Merkmals. *Der Züchter (Zeitschrift für theoretische und angewandte Genetik)*, *35*(3): .90-98.

Steingrover, E. (1986). Nitrate accumulation in spinach: Uptake and reduction of nitrate during a dark or a 'low light' night period. Plant and Soil *91* :429-432.

Steingrover, E., Ratering, P., & Siesling, J. (1986). Daily changes in uptake and storage of nitrate in spinach grown at low light intensity. Physiologia Plantarum *66*:550-556.