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Quality Breeding in Leafy Vegetables

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Vegetables are commonly known as "protective foods" in the human diet owing to their quantity of vitamins, essential fatty acids, minerals, amino acids, and dietary fiber, as well as a range of critical bioactive compounds. These include health-promoting phenolic chemicals and secondary plant metabolites that are high in antioxidants. Greens are the best and most economical sources of protein. This is because of their ability to use the abundant amounts of nitrogen, sunlight, water, and oxygen in the environment to synthesize and accumulate amino acids. It has long been recognized that green leafy vegetables are a great source of dietary fiber. The WHO states that in order to effectively combat general malnutrition, it is now necessary to consider the micronutrient status of the diet. Breeding green vegetables with high nutritional content can help solve this problem.

Keywords: Protective foods; anti-oxidant; vitamin; green leafy vegetables.

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1. INTRODUCTION

Due to their high nutritional value, leafy vegetables are essential for a diet that is both balanced and healthful. Green leafy vegetables have generated interest worldwide as they exhibit multiple benefits for health of human beings. Green leafy vegetables are major components of a healthy diet, and their sufficient daily consumption could help prevent major diseases [1-4]. 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. They are made up of cellulose, hemicellulose and pectin substances that give them their texture and firmness [5]. By assisting the body in battling oxidative stress and free radicals, antioxidants can lower the risk of developing chronic illnesses including cancer, heart disease, and neurological disorders. The high fiber and antioxidant content in leafy vegetables contribute to cardiovascular health. The findings imply that vegetables, if consumed in appropriate quantities, might both adequately prevent diseases resulting from malnutrition and significantly contribute to fulfilling the nutritional needs for proper growth. The literature on breeding essential green leafy vegetables for quality is reviewed in this work.

2. 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.

2.1 Quality Breeding Objectives

The primary goals are resistance to major diseases, uniformity, high yield, and high-quality green leaf. When frozen whole leaves are intended for use, a low percentage of stalks (petioles) in the harvested spinach is required to create a high-quality frozen product. The hybrids or inbred lines should have short petioles and delayed bolting, thus rendering them suitable for various seasons like summer or autumn. They needs to be appropriate for the deep freezing sector and have a low nitrate content. Research findings of quality breeding.

Higher concentrations of calcium oxalate are present in spinach, which may hinder the absorption of calcium. Oxalic acid content was found to decrease with plant age, with lower levels found in the stem and petioles compared to the leaves. Smooth-leafed cultivars had the lowest nitrate concentration, while savoy leaf cultivars had the highest. Smoothed leaf types have higher levels of dry matter content than crinkled leaf types, according to Pandey and Kalloo [6]. Varieties with dark green leaves were found to contain more iron than those with light green leaves. The variety with the highest iron content value was Bloomsdale Long Standing.

There is a diurnal rhythm to the nitrate accumulation in spinach; the concentration is highest in the morning and the least in the afternoon [7,8]. In the fall, when the light is fading and the photoperiod is shortening, spinach was found to have a higher nitrate content. Previous research investigations have suggested a correlation between the nitrate content and the type of leaves on spinach cultivars, with savoy-leaved varieties exhibiting a higher nitrate concentration than smooth-leaved varieties [9]. Higher yields, higher protein contents, and higher nitrate reductase activity all contribute to the smooth-leaved type cultivars' lower nitrate content.

As plants age, their content of oxalic acid, a compound which is produced during photosynthesis from oxaloacetic acid, decreases, but it increases with longer days [10]. Oxalic acid content can be increased by elevated levels of nitrogen, calcium, and potassium, while it may be lowered by high levels of phosphorus [10]. According to Sengbusch et al. [10], there is a correlation between oxalic acid content and leaf color, with darker leaves having a higher concentration of oxalic acid. A significant positive correlation (r = 0.73) was found between the concentration of oxalic acid and chlorophyll.

3. LETTUCE

3.1 Quality Breeding Objectives

To develop a cultivar that contains less nitrate. Compared to green lettuce, red-pigmented lettuce has more phenolic compounds. to find novel resistance genes in wild germplasm and add them to high-tech breeding lines. The development of discolor-resistant cultivars may reduce or even completely remove the need for MAP. Bolting up against resistance: Leafy lettuce bolts, turning bitter and unmarketable, particularly in hot summer months or tropical climates.

3.2 Research Findings of Quality Breeding

Even at the same radiation level and nitrogen supply, there are significant differences in the nitrate and water contents of lettuce. It is well known that nitrogen has a positive effect on the nitrate content of plants. The nitrate and water contents showed a strong positive correlation. Dapoigny et al. [11]; Oh et al. [12] studied the effects of stress on various lettuce acids. Under every scenario, lettuce's concentrations of the two primary phenolic compounds—chlorogenic acid and chicoric acid—rose significantly.

- Even with the same radiation level and nitrogen supply, the nitrate and water contents of lettuce vary considerably. Nitrogen has a known beneficial impact on the nitrate content of plants. A notable positive correlation was observed between the concentrations of nitrate and water [11]. The study of stress on various lettuce acids was carried out by Oh et al. in [12]. Chicoric acid and chlorogenic acid, the two main phenolic compounds found in lettuce, greatly increased in concentration in response to each stress.
- **Solan Kirti**: This cultivar of lettuce is open-type (non-heading), with long, soft, dark green leaves. Rich in calcium (58.07 mg/100g), iron (1.63 mg/100g), and beta-carotene (5.59 Âµg/100g) at an early maturity (71.57 days). In open fields, the average yield per hectare is 24.8 t/ha. It reaches maturity very early under protected conditions, taking 62 days after transplanting to reach maturity. Yields average 8.0 kg m-2.

4. AMARANTHUS

4.1 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.

4.2 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.
- **Kanshi Suhaavani (VRAM-42):** luxurious plant growth with a potential for high yield (30–33 t/ha), a glossy green canopy, and soft, succulent green leaves that bloom later. Ideal for growing in the summer and during the wet season. Rich in protein, with a dry weight percentage of 15.50%; resistant to white rust [13].

5. BASELLA

- B.N. – *Basella alba* & *Basella rubra*
- Common name – Poi, Malabar nightshade, Indian Spinach
- Family- Basellaceae

The calorie and fat content of basella is extremely low—100g of raw leaves only provide 19K calories. Still, it contains exceptionally high levels of antioxidants, minerals, and vitamins. Fresh leaves are an excellent source of several essential carotenoid pigments, including lutein, zeaxanthin, and beta-carotene, especially from *Basella rubra*. Its thick, meaty leaves are a great source of mucilage, a non-starch polysaccharide. Apart from the inherent fiber present in the stems and leaves, the mucilaginous leaves aid in easy digestion. It's applied topically as well. Vitamin A is abundant in the leaves and stems of vine spinach.

English spinach contains 102 mg of vitamin C per 100g of fresh leaves; basella has a higher vitamin C content. Basella is also a great source of iron, with 1.20 mg per 100 g of fresh leaves, just like spinach. Furthermore, minerals like potassium, magnesium, and copper are abundant in basella leaves. It is said that the red cultivar's coloring material was once employed as a dye. An excellent replacement for spinach.

The stem color of *Basella alba* var. *rubra* is reddish-purple, whereas the stem color of *Basella alba* var. *alba* is green. On the other hand, mature fruits are enhanced with dark purple fruit juice that contains a sufficient amount of betalains, and both red and green varieties of flowers have a pinkish-purple tint. Gomphrenin I, the main betalain pigment found in mature Basella fruit, has a lot of potential applications in

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

Varieties	Spp	Special features
Arka Varna	*Amaranthus tricolor*	High Level of Antioxidant Activity: 417 mg (AEAC Units), 37.6 mg of Nitrate, and 1.42 mg of Oxalates per one hundred grams of fresh leaf weight.
Arka Arunima	*Amaranthus tricolor*	Selection from IIHR-49, rich in calcium and iron, this multicut variety has a broad dark purple variety. First picking occurs at intervals of 10 to 12 days, yielding 27 t/ha.
Arka Samraksha	*Amaranthus tricolor*	With a minimum nitrate content of 27.3 mg and 1.34g of oxalates per 100g fresh weight of leaves, the leaves have a high antioxidant activity of 499 mg (AEAC Units). This amaranth variety is pulling type, with green leaves and stems. It takes 30 to 35 days to yield 10.9 tons per hectare.
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

natural food coloring, dye production, and cosmetics. The photometric results for total betalains (vulgaxanthin and betanins) show that VRB-30 (200.93 mg/100 g FW) ripened fruits have the highest pigment content, followed by VRB 3 (150.87 mg/100 g FW). However, the genotype associated with colorless fruit juice or low betalain expression is essential to understanding the genetics of betalain and should never be disregarded. It is possible to further identify the candidate gene or genes linked to the production of betalain by that define these identified genomic regions [8].

The symptoms of charcoal rot included brownish to black discoloration at the collar area of the stem and branches, which later led to the plant wilting and drying out completely. Black microsclerotia and shredded appearance were indicative of infected plant stems. *Macrophomina phaseolina* was determined to be the pathogen responsible for causing charcoal rot based on its morphological features and results of a pathogenicity test.

A distinct Basella genotype with snow-white flowers is EC769321-1(VRB-48-1) [13]. The variation has green, caudate, soft, succulent leaves with an intermediate growth habit. Fruits that are still immature are green in color without any hints of pink or purple. Even fully ripe fruits have a green hue, and the juice lacks any red or purple pigment and is colorless. This quality is also uncommon. This distinctive characteristic can be used as a morphological marker connected to other desirable traits in a traditional breeding program, and it may aid in the study of flower color inheritance. Such pigmentation markers could be used to study the metabolic pathways of basella betalain biosynthesis, since this germplasm lacks betalain even in mature fruits. According to Anonymous [13], pigmentation segregation revealed that a single dominant gene controls pigmentation genetics, with pigmented and non-pigmented type plants following a straightforward Mendelian genetic ratio of 3:1.

Kashi Poi-3: Robust, year-round cultivable plant with a twinning growth habit, red stem and midribs, and a high betalain content. With a lower oxalate content (522.3 mg/100g FW), variety is a great source of carotenoids (635.9 mg/100g FW). After transplanting, the first picking begins 40 days later and lasts for 240–250 days, with intervals of 20–25 days. yield of 61.3 t/ha is high.

6. CONCLUSION

This review well discussed about the breeding of leafy vegetables for quality. Greens are the best and most economical sources of protein. Many leafy greens vegetables are high in antioxidants, such as vitamin C, vitamin E, and various phytochemicals like flavonoids and carotenoids.

Varieties with dark green leaves were found to contain more iron than those with light green leaves.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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