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Colourful Healthy Cole Vegetables Sneaking in Indian Kitchens

Colourful cole vegetables, including cabbage, cauliflower, broccoli, Brussels sprouts, *kohlrabi*, and kale, are gaining popularity in India for their aesthetic appeal and significant health benefits. Traditionally, Indian consumers have preferred white cauliflower and green broccoli, but recent trends show growing interest in biofortified coloured variants such as red cabbage, orange and purple cauliflower, and various coloured broccoli types. These vibrant vegetables are rich in health-promoting compounds like glucosinolates, anthocyanins, β-carotene, and chlorophyll, which contribute to disease prevention and overall wellness. Natural mutations, such as the *Or* and *Pr* genes, have enabled the development of these colourful varieties without involving GMOs, making them consumer-friendly. Their visual appeal enhances garden aesthetics and encourages healthy eating, especially among children. Furthermore, these vegetables are ideal for microgreens, providing dense nutritional content and culinary versatility. This rising consumer acceptance highlights the potential of colourful cole vegetables in promoting nutrition-sensitive agriculture in India.

A colourful diet is beneficial to health because it contains pigments with functional properties that contribute to nutrition and protect against various ailments. These pigments are primarily found in fruits and vegetables. The major food-derived pigments include chlorophyll (green), anthocyanin (purple), lycopene (red), and β-carotene (orange). Cole vegetables include cabbage, cauliflower, broccoli, Brussels sprouts, kohlrabi (knol khol), and kale. Nowadays, all of these are cultivated in India, with cabbage and cauliflower holding the largest share; they rank 5th and 6th, respectively, in the country's total vegetable production. Broccoli is emerging as a promising crop due to its unique taste, health benefits, growing consumer base, and higher market value.

Traditionally, white cauliflower, cabbage, and green broccoli were preferred by consumers. However, there is now a global trend towards colourful variants, developed by breeders, as people become more aware of their nutritional value. This trend is increasingly visible in the Indian market. Biofortified varieties–such as red cabbage, orange and purple cauliflower, and broccoli in green, purple, and yellowish-green hues–are now available in supermarkets and retail outlets. Frequent media coverage of these colourful vegetables is rapidly drawing consumer interest, especially among health-conscious, educated individuals.

White cauliflower (Pusa Cauliflower Hybrid 3): Rich in nutrients and glucosinolates

Health and nutritional benefits

The health benefits are plenty in coloured Cole vegetables, because red cabbage, purple cauliflower and purple broccoli, purple knol khol, purple kale derive their colour from the presence of very powerful antioxidant anthocyanin. Antioxidants scavenge/neutralize free radicals from the human body and prevent from oxidative damages caused by these free radicals. Anthocyanins are beneficial for managing diabetes and pancreatic disorders, protect from damage to the fragile fats that make up cell membranes, thus, anthocyanin-rich Cole vegetables prevent/protect from various diseases. The common varieties and their key nutritional constituent are reviewed below:

Colour	Varieties	White	Orange	Purple	Green
Glucosinolates: White, orange, purple, green	All varieties/ hybrids	19.5 – 42.6 mg/100 g fw	25.0 – 30.0 mg/100 g fw	30.0 mg/100 g fw	17.6 – 46.9 mg/100 g fw
β-carotene: Orange and yellow	Pusa ProVitA Hybrid-1	0.10 µg/g fw	602.0 µg/100 g fw	Negligible (0.19 µg/g fw)	-
Anthocyanin: Purple	Pusa Purple Cauliflower-1, Pusa Purple Broccoli, Pusa Red Cabbage Hybrid-1	-	-	(375 mg/100g fw)	-
Chlorophyll: Green	*Palam Kanchan*, All green broccoli	-	-	-	19.27 mg/ 100g dw

**Source:* Kalia et al., 2023: *Genome Designing for Nutritional Quality in Vegetable Brassicas, In Kole (ed.),* Compendium of Crop Genome Designing for Nutraceuticals, Springer

Purple cauliflower (advanced breeding line PC2304-67 at ICAR-IARI): Rich in minerals, glucosinolates and anthocyanin

Sub-tropical flowering purple cauliflower 'PC-1': Rich in nutrients, glucosinolates, anthocyanin

Colour genes from natural mutants

Fortunately, these crops have natural mutants which serve as a source of gene(s) for these natural colour mutants. In cauliflower, orange curd (edible portion) is due to *Or* gene identified by Mr Crisp and his group from United Kingdom. This gene is not from the carotenoid pathway but responsible for the conversion of plastid or proplastids into chromoplast. The chromoplasts serve as a sink for the β-carotene accumulation in curd portion. Anthocyanin colour of curd is due to the *Pr* gene. This gene was reported by Mr Liu and his group in purple

Orange cauliflower: Rich in nutrients, glucosinolates and β-carotene (selected curds from Pusa *Kesari*VitA-1)

cauliflower 'Graffiti' in the United States of America and in a Sicilian Purple (an intermediate of cauliflower and broccoli) genotype 'PC-1' by Mr Shrawan Singh and his group at ICAR-IARI, New Delhi in India. The *Pr* gene is from the anthocyanin biosynthesis pathway and is responsible for the purple colouration of curd portion. In case of red cabbage, the pigment of leaves of the head (edible portion) is a polygenic character. Different colours in anthocyanin rich Cole vegetables is due to variation in prominent anthocyanin compounds and also due to pH level of these crops. From this, since it is clear that these are native gene(s), therefore product developed using them will not be GMO, which make it easy to promote and popularize these among consumers.

Yellow-green heading Broccoli: *Palam Kanchan*

Rising acceptance for colourful Cole vegetables

Nowadays, people are well aware of the importance of diet in managing good health. The intake of a

Cabbage Pusa Hybrid-1: Rich in nutrients, carotenoids and glucosinolates

Red Cabbage (Pusa Cabbage Hybrid-1): Rich in nutrients, carotenoids and glucosinolates

balanced diet rich in fruits and vegetables is particularly being emphasized after the emergence of new infectious diseases and increasing literature on the role of these foods in the management of various non-communicable cardiovascular, respiratory and metabolic diseases. Consumer acceptance is already there for the traditional colour of these crops and developing coloured varieties without affecting taste or flavour probably does not distract health-conscious consumers and growers. That is the reason that the colourful varieties of Cole vegetables, especially cauliflower, cabbage and broccoli are now being grown, marketed, and accepted by the consumers in India.

Culinary preparation for the retention of pigments

Notably, anthocyanins are water-soluble and boiling is not at all advised since leaching out of anthocyanins from red cabbage, purple cauliflower and purple broccoli may distract consumers. Rather, frying or blanching is the best way for these purple vegetables, and time for this will depend upon the preference for levels of tenderness to eat, however for broccoli steaming is enough. In the case of carotenoid rich vegetables such as orange cauliflower, there is no cooking specificity and it can be boiled, fried, or blanched depending upon the choice of culinary items. It is ideal to avoid deep cooking practices to retain the nutrient to the maximum possible extent. Further, the hard texture of these coloured Cole vegetables as orange cauliflower may also suit for pickle making, red cabbage for dried shreds and purple broccoli may be suitable for fortifying fast foods and development of fusion foods.

Nutritive values of colour Cole vegetables

A full-size marketable curd of Orange cauliflower contains β-carotene in the range of 8-12 ppm, while in the case of white it is almost absent. Similarly, white cauliflower is devoid of anthocyanin pigment whereas purple cauliflower contains it in the range of 40-45 mg/100g as reported by ICAR-IARI Regional Station, Katrain in its newly released variety Pusa Snowball Purple Cauliflower-1. The level of anthocyanin in Purple Broccoli line Delhi Purple Broccoli is around 30 mg/100g and 38-40 mg/100 in a sub-tropical purple cauliflower line 'PC-1' developed by ICAR-IARI, New Delhi. In red cabbage, the content of anthocyanin is reported to be in a wide range depending upon varieties as per the findings of Yuan and his group. The highest anthocyanin content they reported was 280 mg/100 g fresh weight of red cabbage.

Green broccoli (An advance tropical broccoli line): Rich in nutrients, carotenoids and glucosinolates

Pusa Purple Broccoli-1: Rich in nutrients, β-carotene, glucosinolates and anthocyanin

Aesthetic look to customized gardens

Diverse colours always attract the eyes of visitors in the garden. These diverse colours in cabbage, broccoli

and cauliflower also impart rainbow of colours such as green, white, purple/violet, red and orange to kitchen garden/terrace garden/home gardens/ school gardens besides providing nutritious foods. These colours will attract kids to learn more about the advantages of coloured nutritious foods getting, thereby, sensitized to consume such foods which in turn will add value to their nutrient intake balance sheet.

Coloured Cole vegetables are a potential candidate for microgreens

These biofortified vegetables are most promising for microgreens which are miniature plants (1-3 inches) grown in specialized containers and growing conditions and harvested after the emergence of cotyledons to baby greens. These are not sprouts, since sprouts do not have visible leaves. The microgreens are packs of nutrients and health beneficial phytochemicals. These microgreens are used for garnishing food dishes, have visual attractiveness, act as a nutrition supplement besides adding flavour and texture to food. Since Cole vegetables are rich in anticancer glucosinolates, vitamin C and polyphenols, with pigments such as anthocyanin (purple/red coloured), carotenoids (orange and green), chlorophyll (green) there will be added advantage of multiple health benefits to consumers because of nutrition and pleasing look that they provide to dishes.

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