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Yellow flesh Watermelons: natural mutation or GMO?

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ABSTRACT
Yellow flesh watermelon a newly introduced cash crop gaining a high level of economic importance in the generation of income as the exterior doesn't look any different than red variety of watermelon. But these are the hybrids of different varieties of melon but not genetically modified products. The flesh colors in watermelon are due to the intrinsic regulatory mechanisms of carotenoid metabolic pathway leading to accumulation of specific major carotenoids. *Lcyb, Chyb* genes are responsible for breakdown of lycopene to β carotene and zeaxanthin. Therefore, the colour in yellow fleshed watermelon may be mainly attributed to β carotenoids and xanthophylls.
Keywords: Carotenoids, genetically modified products, hybrids, xanthophylls, Yellow flesh watermelon

Thirst Quenching Fruit: Origin of Yellow Watermelon

Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai], belonging to cucurbitaceous family, is globally famous and liked because of its high nutrition, flavor and aroma accompanied with divergent shapes and colors of flesh and skin. Watermelon has been cultivated since ancient times for water and food over 4000 years ago (Paris, 2015). The centre of origin and diversity of the genus Citrullus is Africa (Levi *et al.* 2017). The wild watermelons have a typical watery, hard textured, pale coloured fruit flesh tasting bland or bitter. The well-known sweet dessert watermelons, *C. lanatus*, are non-bitter, tender, well coloured flesh and most of its cultivar share a narrow genetic base. This suggests that they originated from a series of selection events in a single ancestral population. Investigation suggests that North-eastern Africa is the Centre of origin of these dessert watermelons (Paris, 2015). Even though melon fruit and plant improvement by traditional hybridization has led to a generation of improved new varieties, this method of new plant development is relatively slow and limited to a restricted gene pool. Scientists are trying to impart different color of melon such as red, yellow, pink, and orange depending on the concentration of carotenoids and anthocyanin. But these are the hybrids of different varieties of melon but not genetically modified products.

Features of Yellow Watermelon

Yellow watermelon makes the area as a popular commercialize fruits in global as well as Indian market for its vibrant color, flavor. Although in terms of nutritional value, yellow watermelon amounts to about 46 kilocalories in a cup, high in mineral elements such as potassium, magnesium, iron, calcium, phosphorous as well as vitamins A, B and C, which can support the immune system and skin health. Unlike red watermelon, yellow watermelon contains more beta-carotene, which is an antioxidant that may protect against cancer and eye diseases. Yellow watermelon is around 16-18% sweeter than regular red fleshed varieties. With its many health benefits and low calorie count, yellow watermelon is a great choice for anyone who's looking for a sweet, refreshing snack. This yellow fruit can also be used for desserts, such as fruit tarts or smoothies, or it can also be included as a topping on a creative salad. It can also be juiced for a refreshing drink that retains the yellow watermelon's original flavor. Not only can yellow watermelon aid with detoxing and prevent bloating, but the high percentage of water can also keep you hydrated for the whole day.

Varieties in Market

The yellow fleshed watermelons varieties include-Yellow Flesh Black Diamond, Yellow Crimson, Desert King Yellow, Buttercup, Tastigold, Yellow Doll, Yellow Baby, yellow petite etc. The food qualities of a few common varieties have been discussed below.

1. **Yellow Crimson:** Identical to Crimson Sweet (traditional pink watermelon) on the outside, this variety has bright yellow flesh and tastes even sweeter.
2. **Yellow Doll:** This early-maturing melon only weighs about 5 to 7 pounds but tastes very sweet.

3. **Buttercup Yellow Melon:** This seedless, hybrid variety has dense yellow flesh and very high sugar content.
4. **Desert King:** This variety is orange like cantaloupe but has the crisp texture of watermelon.
5. **Yellow Petite:** At times considered as a personal watermelon, Yellow Petites are small weighing 4 to 7 pounds each and have a high sugar content.

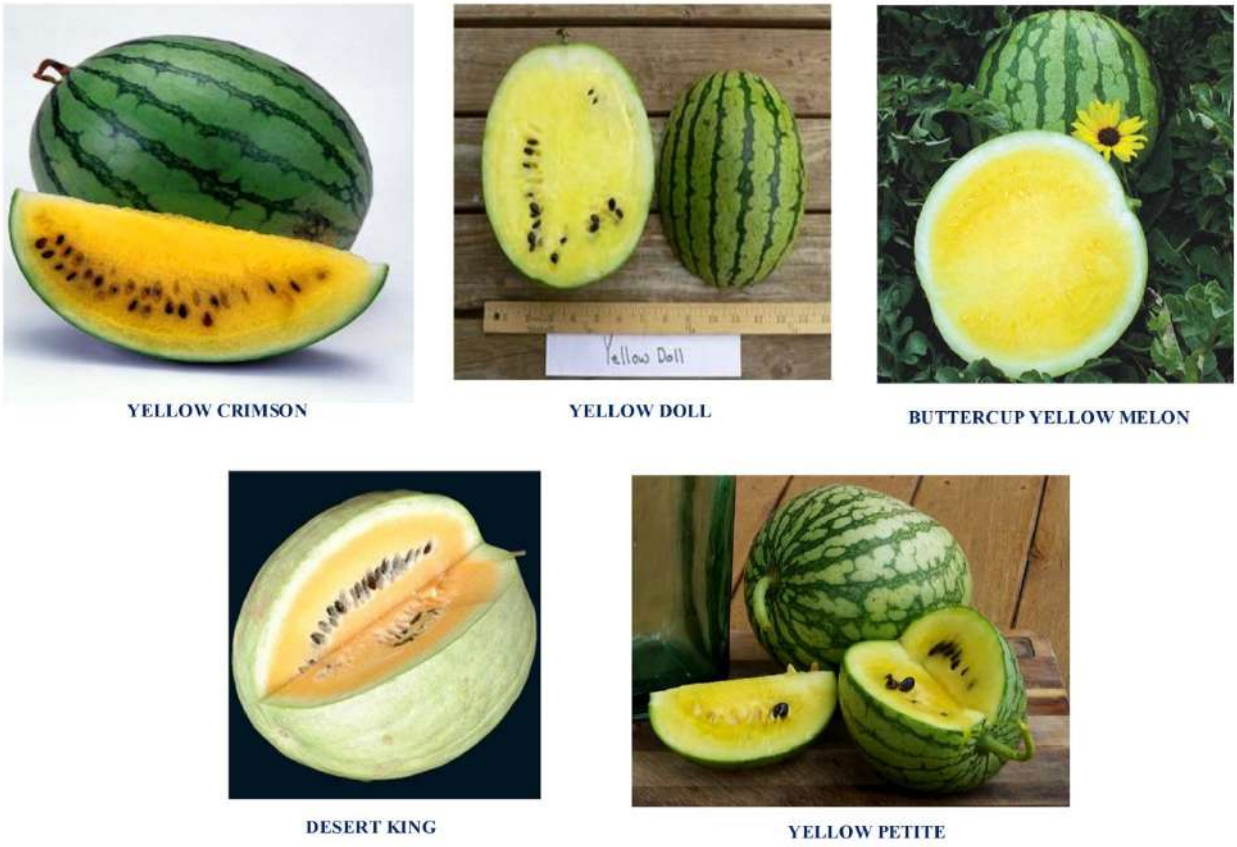

Fig 1. Different common varieties of the yellow fleshed watermelons

What makes the inside colors different?

The varied flesh color in watermelon varieties can be attributed to the varied composition and concentration of different carotenoids (Fraser and Bramley, 2004). The accumulation of carotenoids in fruits occurs during the stages of ripening and results in changes in pigmentation. In the traditional red- fleshed watermelon varieties, the major carotenoid is lycopene. In contrast, in yellow fleshed varieties there is much less lycopene.

Carotenoid and Genetic Regulation

The multiple flesh colors in watermelon fruit are due to the intrinsic regulatory mechanisms of carotenoid metabolic pathway leading to accumulation of specific major carotenoids. However, few studies have been carried out with regard to carotenoid metabolism in watermelon at molecular level, although great advances have been made in analysis of carotenoids in watermelon. At genome level, genes namely *Psy*, *Pds*, *Zds*, *CrtIso*, *Lcyb*, *Chyb* are reported to contribute mainly for carotenoid biosynthesis and genes *Nced1*, *Nced2* expressed themselves during their catabolism in watermelon fruits (Kang et al. 2010). The pathway as observed in higher plants has been depicted though the flow diagrams (Figure 2). The regulation of these genes when studied at transcription level showed that in the red and pink fleshed varieties of watermelon, the color was due to substantial reduction in the expression of *Lcyb*, *Chyb* during maturation leading to accumulation of lycopene imparting the colour. While in Yellow fleshed variety, high transcript levels were detected for almost all the genes during maturity including the above two. Through a thorough analysis of carotenoid contents in different colored varieties, total carotenoids and lycopene content were much less in yellow variety when compared with red or pink variety though neoxanthin was present in traceable amount in yellow variety of watermelon only. Therefore, the yellow colour in yellow fleshed variety of

watermelon may be mainly attributed to β carotenoids and xanthophylls. Now the question arises that if expression of nearly all the genes involved in carotenoid biosynthesis were high in yellow variety then why was there no accumulation of total carotenoids and lycopene in this variety? The explanation to this can be divided in two parts. Firstly, as seen above, there is a reduction in the expression level of *Lcyb, Chyb* during maturation in the case of red or pink fleshed varieties whereas these genes are expressed at high level during maturity of yellow fleshed variety of watermelon. These genes are responsible for the breakdown of lycopene to β carotene and zeaxanthin. This suggests that these genes play a key role in the accumulation of lycopene in red fleshed watermelon fruits.

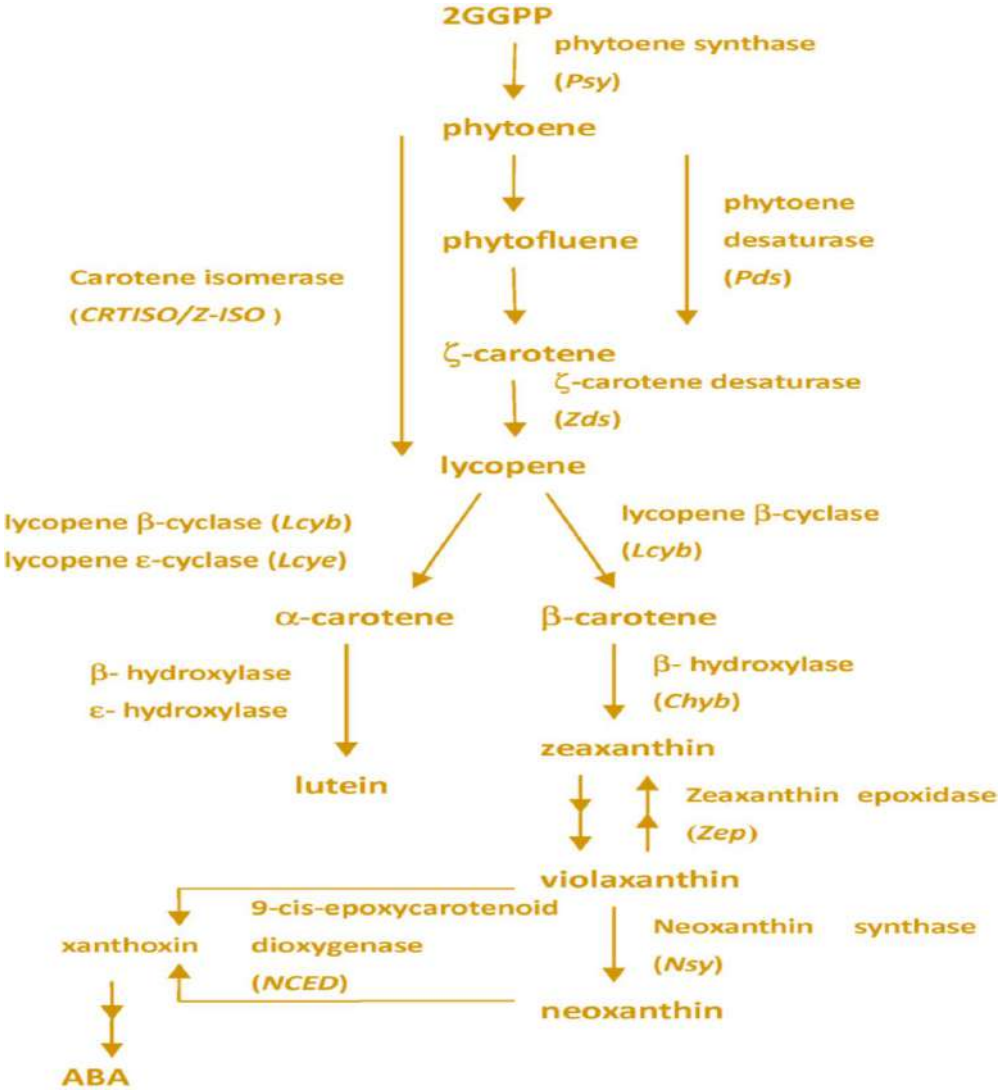

Fig 2. The carotenoid biosynthesis pathway in higher plants (Source: Kang *et al.*, 2010)

A Boon for Farmers

Due to its novel and attractive colour, sweetness and honey like taste, the demand of yellow fleshed watermelon is souring high in Indian market. As per the reports from the farmers' fields in Hyderabad the price of yellow pulped watermelon is around double as compared to its pink/ red variants. A village cluster from Malappuram in Kerala, fetched revenue as high as four times from Anmol variety of yellow fleshed watermelon, than the regular red fleshed watermelons (TOI news). High returns from this variety could be attributed to its taste and comparatively thin rind. Timely sowing (February) and mulching (both organic and plastic) did result in better yield. Furthermore, Investigation of carotenoid composition and content, and its metabolic pathway in watermelon should become **a** crucial field of watermelon breeding for quality estimation and nutrition breeding.

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