

In Search of High Lycopene Watermelon

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The red pigment in red-fleshed watermelon (*Citrullus lanatus* (Thunb.) Matsum. & Nakai) is from the carotenoid lycopene and comprises 70-90% of the total carotenoids in watermelon (Gross, 1987). Watermelon exceeds tomato in average lycopene content (49 µg/g vs 31 µg/g fresh weight) (Holden et al., 1998; USDA National Nutrient Database 2003).

Increasing lycopene in watermelon interested breeders as the plethora of health studies with lycopene ingestion continued to show positive trends for prostate health, cardiovascular improvement, and lowered incidence of certain cancers (Giovannucci, 1999; Rissanen et al. 2003; Sesso et al., 2004). Currently, there is no set standard for lycopene intake. Although Agarwal and Rao (2000) estimated an average daily intake of lycopene to be 25 mg in Canada, intake is more likely 2.5 mg daily in the U.S., especially if the diet has few tomato products. Vitamins provide 0.03 to 2 mg lycopene and intake from tomatoes, watermelon, red grapefruit juice and tomato products typically provide 2 to 20 mg/serving (USDA National Nutrient Database, 2003).

Synthetic lycopene was approved for use in vitamins in 2003 (IFT, 2003). While lycopene is not produced by animals, it can be isolated from fungi such as the *Phycomyces*, or obtained from genetically modified bacteria or yeast (Sandmann, 2001). Natural sources of lycopene continue to be of great interest to consumers who wish to eat fruits and vegetables for better health. Although the genetics of lycopene accumulation have not been fully studied, a likely approach to improving lycopene content is to cross high lycopene varieties with other high lycopene varieties.

Initial studies underway in our lab demonstrate that 'Dixielee' is the highest lycopene-containing, open pollinated variety. 'Dixielee' was released from the University of Florida breeding program (Crall and Elmstrom, 1979; 1980). In preliminary data, crosses with 'Dixielee' to a low lycopene open pollinated variety ('Black Diamond') resulted in F₁ melons with lycopene levels similar to 'Dixielee', suggesting that lycopene/redness is inherited in a dominant fashion (Table 1). However, the large range of lycopene values of ripe melons indicates that more fruit will need to be assayed before inheritance can be statistically verified.

Watermelons from growers and cultivar trials in Oklahoma and Texas have been analyzed for total lycopene content using spectrophotometric and colorimetric assays (Perkins-Veazie et al., 2001; Davis et al., 2003). Most watermelon fruit of commercial importance, both seeded and seedless, ranged in lycopene content from 50 to 70 µg/g fresh weight (Table 2). Some varieties were found to be extraordinarily high in lycopene, ranging from 80 to 105 µg/g fw lycopene (Table 2). Such variation is well known in tomato, where high pigment lines and processing tomatoes at the red ripe canning stage contain 100 to 150 µg/g (Dumas et al. 2003). Genetically modified tomatoes were reported to contain as much as 300 µg/g (Mehta et al. 2002). Additionally, *gac* (*Momordica cochinchinensis* (Lour.) Spreng), a cucurbitacea member, is reported to contain 1000-2000 µg/g lycopene in its arils (Ishida et al., 2004). This suggests that watermelon has the potential to contain extraordinarily high amounts of lycopene. The key questions remaining in developing high lycopene watermelons are: how will fruit

quality and flavor be affected (taste, sugars, firmness), how much lycopene can be produced by watermelon (e.g.100, 300, 500 µg/g fw), and will high lycopene fruit be a positive or a negative marketing factor for consumers (eg will high lycopene fruit cause health issues in consumers).

Literature cited

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Table 1. Initial inheritance study of lycopene accumulation using two open pollinated diploid watermelon with low ('Black Diamond') and high ('Dixielee') lycopene content (bc₁=backcross of F₁).

Cross	Number of melons	Mean Lycopene content (µg/g)	Standard deviation	Range of lycopene (min/max)
Black Diamond	46	33.06c	6.20	19.90-43.50
Dixielee	31	64.77a	12.84	38.94-93.12
F ₁	37	59.25ab	16.41	32.23-107.73
F ₂	25	55.05ab	11.32	32.19-81.47
bc ₁ x Black Diamond	7	50.12b	18.29	29.53-81.23

Means within column separated by Bonferroni t test, P<0.01. All melons in F₁ and F₂ crosses were red fleshed and all were used for lycopene analysis.

Table 2. Lycopene content among red-fleshed watermelon varieties and seed company selections sampled from 1999 through 2003.

Variety	Type	Number of melons sampled	Mean Lycopene content (µg/g)	Std dev	Range of lycopene content (min/max)
Sangria	Diploid, Hybrid	475	52.54	8.23	38.90-80.40
Jamboree	Diploid, Hybrid	20	61.06	5.08	52.75-71.39
Imagination	Diploid, Hybrid	17	69.09	10.06	53.86-95.26
Summer Flavor 800	Diploid, Hybrid	123	72.78	8.78	61.96-91.88
Summer Flavor 710	Diploid, Hybrid	11	83.03	7.1	73.57-97.08
Tri-X-313	Triploid	36	60.59	7.44	36.77-76.87
Hazera 6007	Triploid	27	100.00	15.64	67.76-129.28
Hazera 6009	Triploid	20	88.64	12.56	70.70-111.12
Sugar Baby 4N	Tetraploid	14	76.39	15.16	55.13-99.81
Millenium	Triploid	29	74.93	14.73	43.80-96.04
AllSweet	Diploid, Open-pollinated	22	48.39	5.95	38.52-60.67
Calhoun Gray	Diploid, open pollinated	8	37.21	5.7	30.80-45.30