

Relationship patterns of the genetic regulation of carotenoid and flavonoid accumulation in tomato fruits (*S. lycopersicum*)

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Carotenoid and flavonoid compounds of plants are secondary metabolites of terpenoid and phenolic nature respectively that perform important signaling and protective functions developed in the course of evolution, providing a wide degree of adaptability to the effects of abiotic and biotic stresses (resistance to excessive solar radiation, low temperatures, damage caused by insects, etc.). From the point of view of food production for humans, the composition of carotenoids and flavonoids determines the nutritional, taste and commercial qualities of products, as well as their purpose during consumption and processing. One of the most important properties of products determined by the level of accumulation of carotenoids and flavonoids is antioxidant activity, which determines a degree of the body's protection against oxidative stress, resistance to infections, and as a result, an increased life expectancy. In order to develop food products with maximum antioxidant activity, it is important to understand the relationship between substance accumulation mechanisms of the above classes.

In order to study the relationship between the genetic regulation of carotenoid and flavonoid accumulation in tomato fruits, the following experiments were carried out: assessment of changes in the expression pattern of the structural *tangerine* (*t*) genes of carotenoid isomerase (CRTISO) and *Beta* (*B*) lycopene- β -cyclase (*Cyc-B*), as well as determine carotenoid and anthocyanin concentration in tomato fruits depending on the allelic composition of carotenoid biosynthesis genes, the genes of MYB transcription factors (TF) *Yellow* (*Y/y*) SlMYB12 TF, *Anthocyanin 1* (*Ant1/ant1*) R2R3MYB TF, *Golden 2-like* (*U/u*) MYB TF regulating an expression level of the structural genes of flavonoid biosynthesis.

The study material was a collection of tomato accessions from the Institute of Genetics and Cytology of the National Academy of Sciences of Belarus with a different allelic combination determining flavonoid and carotenoid accumulation, as well as the coloration of fruits (r, at, t, og, ogc, B, gf-3, gf-5, hp-1, hp-2dg, u, gs, SlMyb12, and Ant1); a collection of tomato accessions with different fruit coloration from the All-Russian Institute of Plant Genetic Resources.

The study results related to the expression of alleles that determine the accumulation of carotenoids *tangerine* (*t*), and *Beta* (*B*) and anthocyanins *Anthocyanin1* (*Ant*) in tomato forms with their various combinations demonstrated the following:

- a different expression level at different stages of development depending on the combination of alleles: the maximum expression level of the *Ant* gene when combined

with the allele *t* at the stage of technical ripeness and in combination with the allele *B* at the stage of the complete ripeness of fruits (Fig. 1);

- a decreased expression level of the allele *t* of carotenoid isomerase at the stage of fruit ripening in forms with the alleles in their genotype that determine the high content of chalcone (*Y*) and anthocyanin (*Ant*) flavonoids.

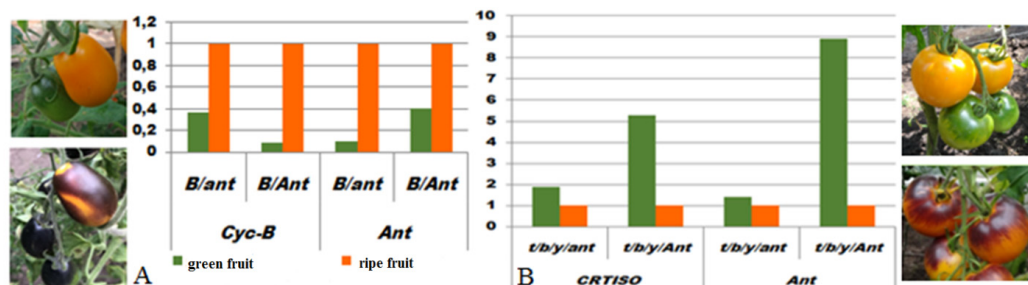


Fig. 1. Relative expression level of alleles that determine the accumulation of carotenoids and anthocyanins in fruits at the stages of technical (green fruit) and biological (ripe fruit) ripeness in tomato forms with their various combinations: A – *Beta* (*B*) alleles of lycopene- β -cyclase (*Cyc-B*) and *Anthocyanin 1* (*Ant*) R2R3MYB transcription factor (TF); B – *tangerine* (*t*) alleles of carotenoid isomerase (CRTISO) and *Anthocyanin1* (*Ant*) R2R3MYB TF

Evaluation of carotenoid and anthocyanin accumulation in tomato fruits depending on the allelic composition demonstrated an increased concentration of pigments (chlorophyll, carotenoids, and anthocyanins) in the fruits with the *U* alleles of the *Golden 2-like*, *hp-2^{dg}* of the DET1 nuclear protein gene, *gf-3* alleles, and *gf-5* of the Stay-Green gene in the genotype. The patterns of accumulation of carotene forms in tomato fruits depending on the alleles of the lycopene- β -cyclase gene were confirmed: the maximum lycopene accumulation in forms with the *og^c* allele, carotene – with the *B* allele, and the predominant accumulation of lycopene – in forms with the *b* allele. Nature of the relationship between the genetic regulation of flavonoid and carotenoid accumulation was shown – the maximum accumulation of anthocyanins in tomato fruits with *Ant1*, *Y*, and *U* alleles in the genotype is associated with the decreased concentration of lycopene in fruits; the allele *y* of the chalcone synthase gene increases the accumulation of lycopene in tomato fruits.

Based on the study results, tomato accessions with various combinations of the gene alleles of carotenoid and flavonoid accumulation were selected as models for the further study of the genetic regulation of pigment accumulation in fruits and use in the breeding process aimed to develop forms with a high level of antioxidant activity.

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