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Effects of Exogenous ABA on Contents of Lycopene and Endogenous Hormone in Tomato Pericarp

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Authors' contributions

This work was carried out in collaboration between all authors. Authors YY and BZ designed the study. Author YY performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author QW managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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Short Research Article

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ABSTRACT

Aims: This research studied the regulatory effect of ABA (Abscisic acid) on the contents of lycopene and endogenous hperipheral pericarp of tomato fruit during ripening, and provided an effective measure for improving the quality of tomato fruits.
Study Design: When the second cluster of toormone in mato fruits reached green mature stage, fruits were labeled and sprayed ABA (100 mg·L^{-1}) over fruit surface, with spaying water as control, avoiding polluting the leaves. After treatment for 0, 4, 8, 12, 16, 20d, 10 fruits were sampled and dissected, peripheral pericarp for measuring the contents of lycopene, GA_3 (Gibberellic acid), ABA, ZT (Zeatin) and ETH (Ethylene).
Place and Duration of Study: Horticultural College, between February 2014 and March 2015.
Methodology: The contents of lycopene, GA_3, ABA and ZT were determined using HPLC (High Performance Liquid Chromatography). The content of ETH was determined using GC (Gas Chromatography).
Results: The effect of exogenous ABA on the lycopene content in peripheral pericarp of tomato

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fruits was firstly inhibited then promoted during fruit mature period. Exogenous ABA decreased the content of endogenous GA_3, but the endogenous ABA content was inhibited firstly, and then promoted, inhibited finally, and promoted the content decrease of endogenous ZT. The peak value was appeared early, but a little effect on the amount of ETH release.

Conclusion: This work proved the feasibility of elevating of lycopene levels in tomato fruit by the application of exogenous ABA. ABA promoted the accumulation of lycopene by the decreasing of endogenous GA_3, ZT and ABA contents, and by releasing peak appear of endogenous ETH.

Keywords: Tomato; peripheral pericarp; lycopene; endogenous hormone; ABA.

1. INTRODUCTION

Fruit coloration is one of the important factors to affect the price of the fruit and market competitiveness. It is also one of the important indicators of appearance quality. The color of tomato fruit from green to red during ripening is mainly due to the large number of accumulation of carotenoids, and lycopene is the main pigment. Lycopene, GA_3 and ABA are all the transformation products of GGPP (geranylgeranyl pyrophosphate) which is the first direct precursor substances in plant isoprenoid pathway [1]. The biological synthesis of carotenoids are regulated and controlled by endogenous hormones [2,3].

Since the tomato fruit is virtually the sole dietary source of lycopene, its formation in the tomato has been the subject of considerable attention, as has attempts to increase the levels by genetic manipulation or conventional plant breeding [4,5]. However, fewer advances have been made on cultural practice aspect. ABA as a plant hormone, commonly used in production, can stimulate production of ETH and promote ripening of tomoto [6,7]. Exogenous hormones is bound to break the balance of endogenous hormones, which affect the synthesis of lycopen. The objective of this work was to study the regulatory effect of ABA on the contents of lycopene and endogenous hormone in peripheral pericarp of tomato fruit during ripening, and provided an effective measure for improving the quality of tomato fruits.

2. MATERIALS AND METHODS

2.1 Plant Materials

Jinguan tomato (*Solanum lycopersicum*) was used as materials. The seeds were sown and transplanted to a solar greenhouse of Shenyang Agricultural University with array pitch of 50 cm and row spacing 35 cm. Other management was the same as the field management [8].

There were 3 clusters (each cluster has 4 fruits) per plant. When the second cluster of tomato fruits reached green mature stage, fruits were labeled and sprayed ABA (100 $mg \cdot L^{-1}$) over fruit surface, with spaying water as control, avoiding polluting the leaves. After treatment for 0, 4, 8, 12, 16, 20d, 10 fruits were sampled, dissected, peripheral pericarp mixed and then stored at -80℃ in isolated condition.

2.2 Methods

Lycopene extracted and analysed using HPLC which previously described in Ma et al. [9]. A 0.2 g amount freeze-dried tomato powder and 10 μg of inter standard were mixed with 20 ml of acetone/petroleum ether 2:1(v/v), and treated for 30 min in the 100 W ultrasonic bath at 30℃. The extract was washed with water, centrifuged to remove impurity, then the petroleum ether phase was freezed, vacuum-dried, and resolved in 1 ml ethyl acetate, filtered by 0.45 μm millipore filter. The contents were assayed as described in Wang et al. [10]. Inter standard method were used in quantitative determination. Extraction and analyses of GA_3、ABA and ZT were made by HPLC that previously described in Dobrev and Kaminek [11]. ETH extracted and analysed using GC which described in Xu et al. [12]. Standards of lycopene, inter standard β-apo-8'-carotenal, GA_3, ABA, ZT and ETH were obtained from Sigma.

3. RESULTS

3.1 Effect of ABA on Lycopene Content in Peripheral Pericarp of Tomato Fruit

The results in Fig. 1 indicated that the lycopene content in the peripheral pericarp increased with ripening processes, and reached to the maximum at mature period. The ABA treatment resulted in lycopene level increase. 12d after treatment, the lycopene level in the peripheral pericarp was higher than that of control treatment. Till 20d after treatment, the lycopene content was 1.28-fold as much as that of control.

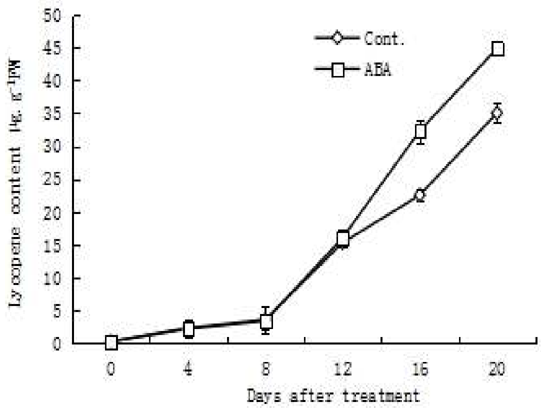

Fig. 1. Effect of ABA on lycopene content in peripheral pericarp of tomato fruit during ripening

3.2 Effect of ABA on Endogenous Hormone Contents in Peripheral Pericarp of Tomato Fruit

As shown in the Fig. 2, the content of GA_3 began to decrease rapidly at the green mature stage, then decreased slightly and reached to the minimum. The ABA treatment resulted in GA_3 level decrease in the peripheral pericarp, but no significant difference between control and treatment.

The content of endogenous ABA showed "V" curve in peripheral pericarp of tomato fruit during ripening. The content of ABA was lower than that of control after 4d treatment, but higher after 8d treatment. After 12d treatment, the ABA level was decreased gradully, the content was lower than that under control group.

The content of endogenous ZT increased firstly and then decreased during ripening. ABA treatment decreased the content of ZT in peripheral pericarp of tomato fruit, but not changed the trend of change.

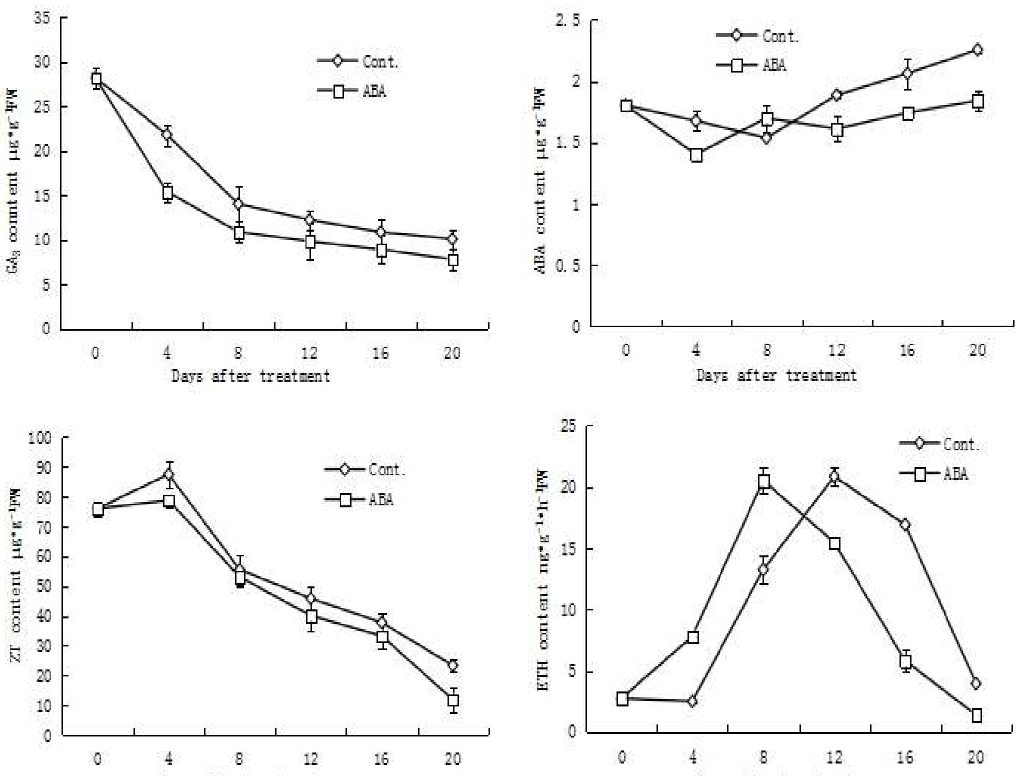

Fig. 2. Effect of ABA on endogenous hormone contents in peripheral pericarp of tomato fruit during ripening

The content of endogenous ETH showed a single peak curve in peripheral pericarp of tomato fruit during ripening, and ABA treatment made the peak value appeared early, but a little effect on the amount of ETH release.

4. DISCUSSION

With the accumulation of lycopene, endogenous GA_3, ABA and ZT in peripheral pericarp decreased gradually and endogenous ETH release peak appeared in the process of tomato fruit ripening. Endogenous hormone of plants was closely related to the metabolism of carotenoids [13]. GA_3 hindered chloroplast transformation to colored body, increased the biological metabolism of chlorophyll, delayed the accumulation which effected the main pigment (β- cryptoxanthin) of citrus fruit color development indexes [14]. ABA metabolite accumulation was blocked, increased assimilation and accumulation of lycopene in tomato during ripening [15]. CTK (Cytokinin) had the ability to maintain metabolism of leaf chlorophyll, delaying leaf senescence [16]. Tomato fruit hardness was the largest in green mature stage, meanwhile ethylene production was very low. In this case the respiration rate was also the lowest. With tomato fruit reaching maturity, the release of ethylene was faster, which reached the peak 20d after green mature stage, and then decreased rapidly. Ethylene also affected the transcription and translation of a number of genes associated with mature [17]. In this experiment, exogenous ABA treatment inhibited the accumulation of endogenous ABA. This might be that absorption of exogenous ABA feedback inhibited the synthesis of endogenous ABA in the tomato fruit ripening process [18,19]. The reduction of ABA synthesis increased the accumulation of lycopene which is synthesis precursor of ABA [20]. Simultaneously, endogenous GA_3 and ZT contents of fruit declined, and the peak of endogenous ETH content appeared earlier, which thereby promoted lycopene synthesis and accumulation of peripheral pericarp, and promoted the development of fruit color after exogenous ABA treatment. It was known that GGPP was a direct precursor of all higher plants carotenoid biosynthesis. The ABA in higher plants mainly synthesized by plant carotenoid pathway. Exogenous ABA treatment was bound to upset the balance of endogenous hormones in the fruit, thereby affecting the number of secondary material synthesis and metabolism in the fruit. The influence of endogenous hormone on tomato fruit lycopene synthesis needed further study.

5. CONCLUSION

The effect of exogenous ABA on the lycopene content in peripheral pericarp of tomato fruits was firstly inhibited then promoted during fruit mature period. Effects of plant growth regulation on the contents of endogenous hormone in tomato fruit were investigated. Exogenous ABA promoted the content decrease of endogenous GA_3, the endogenous ABA content was inhibited firstly, and then promoted, inhibited finally, and promoted the content decrease of endogenous ZT. The peak value was appeared early, but a little effect on the amount of ETH release.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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