Effects of Gibberellin（GA_3）on Antioxidant Enzyme Activity in Sweet Cherry Fruit at Different Developmental Stages

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Abstract: An experiment was conducted to study the effect of different concentrations (20, 40, 60, 80, 100mg/kg) of gibberellin (GA_3) on antioxidant enzymes of 'Hongdeng' sweet cherries. The results showed that POD, CAT and SOD activity decreased during the development of sweet cherry fruit;GA_3 concentration of the processing of three kinds of enzyme activity were lower than control at the time of the fruit mature, especially the 60, 80, 100 mg/kg of GA_3 treatment has lower antioxidant enzyme activity, accelerate the aging of the fruit. Therefore, it is suggested that the use of GA_3 should be reduced in the actual production process, especially high-concentration GA_3 spraying is unfavorable to fruit.

1. Introduction

Sweet Cherry (*Prunus avium* L.), called cherry, European sweet cherry, fruit nutrient-rich, fruit grain, flavor unique [1]. Gibberellin is an important plant hormone, which plays an active role in promoting plant stem and leaf elongation, seed germination, fruit maturation and senescence [2-3]. The maturation and senescence of fruit is a controlled oxidation process, and the Free radicals damage theory considers that the dynamic equilibrium of oxygen free radicals produced and cleared in vivo is destroyed, thus aggravating the membrane lipid peroxidation [4]. It is reported that the GA_3 spraying can improve the antioxidant activity of grape [5], Mango [6], Persimmon [7] and apricot [8]. In this study, the effects of different concentrations on the activity of POD, CAT and SOD were studied in the GA_3 of sweet cherry during the growth and development of the fruit, aiming to standardize the rational use of GA_3 in production, and to provide theoretical basis and guide practice for improving its economic benefit comprehensively.

2. Materials and Methods

Materials. The varieties of sweet cherry trees were 'Hongdeng', about 10 years, and the rootstock was Mountain cherry. The experimental site was farmer orchard in Pinghe Village, Xixi Township, Hanyuan County, Sichuan Province. The experiment was carried out by selecting sweet cherry plants with the same tree potential and normal growth and development. Test reagent for GA_3 (75% gibberellic acid crystalline powder, Shanghai Tongrui Biotechnology Co., Ltd.).

Experimental Design. In late March 2017, the experiment was carried out to select sweet cherry plants with normal growth, sweet cherry at the beginning of flowering period, choose the same flowering time of the branches listed, and marked flowering time. The GA_3 was applied to the whole tree in the early flowering period of sweet cherry and around 9:00 a week after anthesis. Set 6 concentrations: 20, 40, 60, 80, 100mg/kg, with spraying water treatment as control (CK), other management measures the same, high level of management. In the 15th day after full flowering period, fruit with uniform flowering period was adopted. According to the fruits of the east, south, west, and north, the fruit size was the same, there were no pests and no mechanical damage, 30 samples were taken for 5 days. After sampling, immediately put into the ice cassette back to the laboratory, stored in the -80℃ refrigerator, and the activities of peroxidase (POD) [9], catalase (CAT) [10] superoxide dismutase (SOD) [11] were measured.

Statistical Analyses. Statistical analyses were conducted using SPSS 13.0 statistical software (IBM, Chicago, IL, USA).Data were analyzed by one-way analysis of variance with Duncan's multiple range test($p = 0.05$ confidence level)

3. Results and Discussion

Effect of Gibberellin Treatment on POD Activity. As shown in Table 1, during the growth and development of sweet cherry fruits, the POD activity of the control and each treatment generally showed a decline-rise-decline trend. From 25 d to 40 d after flowering, POD activity of the control and each treatment rapidly decreased; After the flower 45d, GA_3 treatment at 20, 40, 60, 80, and 100 mg/kg was significantly different from the control ($P < 0.05$), and the treatments were significantly reduced by 21.8%, 28.4%, 33.8%, 44.0%, and 77.12% compared to the control. As the concentration of GA_3 increases, the POD activity is lower.

Table 1 Effect of Gibberellin Treatment on POD Activity

Treatment	POD activity($U \cdot g^{-1} \cdot min^{-1}$)						
	15d	20d	25d	30d	35d	40d	45d
Contral	54.99±1.43c	25.44±1.67c	31.77±0.92e	26.71±0.59a	19.05±0.64a	17.43±0.69a	10.58±0.26a
20mg/kg	64.60±1.73b	27.06±1.25bc	40.11±1.67d	24.01±0.72a	15.34±0.64ab	13.56±0.06b	8.27±0.11b
40mg/kg	73.78±1.47a	37.90±0.58a	41.69±1.22cd	20.52±1.15b	11.16±0.06bc	9.59±0.17c	7.58±0.13c
60mg/kg	41.35±0.66d	38.88±0.68a	44.83±1.31c	18.26±1.46bc	10.63±3.31c	8.28±0.29d	7.00±0.20c
80mg/kg	60.72±2.02b	40.27±1.92a	59.21±1.16b	17.08±0.54c	9.15±0.18c	7.41±0.06d	5.92±0.11d
100mg/kg	42.61±1.56d	31.49±2.09b	72.42±1.48a	13.60±0.30d	7.01±0.29c	5.54±0.30e	2.42±0.24e

Different lowercase letters indicate significant differences based on one-way analysis of variance in SPSS 13.0 followed by the least significant difference test ($P < 0.05$). Same as below.

Effect of Gibberellin Treatment on CAT Activity. As shown in Table 2, during the growth and development of sweet cherry fruits, the CAT activity of the control and GA_3 treated with 20 mg/kg reached a maximum at 25 days after anthesis, and then decreased continuously; the CAT activity of 80 mg/kg and 100 mg/kg GA_3 decreased from 0.58 $mg \cdot g^{-1} \cdot min^{-1}$ and 0.63 $mg \cdot g^{-1} \cdot min^{-1}$ to 0.19 $mg \cdot g^{-1} \cdot min^{-1}$ and 0.16 $mg \cdot g^{-1} \cdot min^{-1}$, respectively, during the development of sweet cherry fruit; After anthesis 45d, there were significant differences in CAT activity ($P < 0.05$) compared with the GA_3 treated with 60, 80 and 100mg/kg, and significantly decreased by 40%, 36.7% and 46.7% compared with the control.

Table 2 Effect of Gibberellin Treatment on CAT Activity

Treatment	CAT activity($mg \cdot g^{-1} \cdot min^{-1}$)						
	15d	20d	25d	30d	35d	40d	45d
Contral	0.31±0.02c	0.39±1.24b	0.43±1.12b	0.40±1.08abc	0.34±1.62a	0.32±0.81a	0.30±0.26a
20mg/kg	0.24±0.84d	0.41±0.19b	0.42±0.81b	0.41±0.52ab	0.33±1.52a	0.31±0.74ab	0.23±0.77ab
40mg/kg	0.44±0.15b	0.47±0.56a	0.43±1.21b	0.42±0.85ab	0.38±0.84a	0.34±0.38a	0.21±0.31abc
60mg/kg	0.30±0.94cd	0.48±0.65a	0.41±0.49b	0.34±0.42c	0.31±1.12a	0.30±1.59ab	0.18±0.63bc
80mg/kg	0.58±0.16a	0.46±0.68a	0.49±1.62a	0.46±0.38a	0.32±0.59a	0.31±0.77ab	0.19±0.41bc
100mg/kg	0.63±1.21a	0.28±0.87c	0.52±1.59a	0.36±0.77bc	0.35±0.88a	0.29±0.65b	0.16±1.13c

Effect of Gibberellin Treatment on SOD Activity. As shown in Table 3, during the growth and development of sweet cherry fruit, the SOD activity of the control and each treatment showed a trend of decreasing-increasing-decreasing, reaching a maximum at 15 days after anthesis; 25 days to 45 days after anthesis, the treated SOD activity has been decreasing, especially the GA_3 treatment at 80mg/kg and 100mg/kg decreased from 5.24 $U \cdot g^{-1}$, 4.89 $U \cdot g^{-1}$ to 1.75 $U \cdot g^{-1}$, 1.18 $U \cdot g^{-1}$; At 45 days after flowering, the CAT activity of GA_3 in each treatment was significantly different from that of the control ($P < 0.05$), and significantly decreased by 17%, 30%, 21.2%, 27% and 50.8% compared to the control.

Table 3 Effect of Gibberellin Treatment on SOD Activity

Treatment	SOD activity($U \cdot g^{-1}$)						
	15d	20d	25d	30d	35d	40d	45d
Contral	4.91±0.49c	4.20±0.19b	4.71±0.25c	4.52±0.53a	3.97±0.23a	3.35±0.55a	2.40±0.18a
20mg/kg	4.62±0.21cd	4.25±0.28b	5.00±0.33b	4.32±0.14b	3.14±0.56b	2.31±0.53c	1.99±0.29b
40mg/kg	5.03±0.43d	3.36±0.24d	4.53±0.30b	3.74±0.48c	3.18±0.25b	2.74±0.13b	1.68±0.36c
60mg/kg	5.55±0.89a	5.13±0.15a	5.49±0.17a	3.19±0.91d	2.82±0.41c	2.42v0.16c	1.89±0.68b
80mg/kg	5.24±0.58b	3.62±0.14c	4.69±0.43c	3.26±0.54b	2.53±0.42d	2.49±0.22c	1.75±0.32c
100mg/kg	4.89±0.85c	4.09±0.13b	4.41±0.97d	2.68±0.21e	2.45±0.31d	1.91±0.62d	1.18±0.44d

4. Conclusions

The results of this study show that the effect of different concentrations of GA_3 on POD, CAT and SOD activity were different during the fruit development of sweet cherry. POD and SOD activity decreased-increased-decreased with increasing number of days of fruit development, and CAT activity showed a trend of rising-descending; with the increase of GA_3 concentration, POD, CAT and SOD activity decreased, high concentration of GA_3 spraying accelerated the senescence of the fruit, and suggested that the use of GA_3 should be reduced in production.

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References

[1] Y. Yu, H. Dai, B. Li and A. Chen: Journal of Fruit Science Vol. 20 (2003), p. 135.

[2] C. Rodrigues, J.D. Oliveira, C.R. Soccol: Critical Reviews in Biotechnology Vol. 32 (2012), p. 263.

[3] I. Lara: Stewart Postharvest Review Vol. 9 (2013), p. 1.

[4] R.L. Zheng: *Free radical medicine and agronomy* (Higher Education Press, Beijing 2009).

[5] S.F. Tian, Y. Wang, G. Du and Y.X. Li: Acta Physiologiae Plantarum Vol. 33 (2011), p. 2467.

[6] S. Banerjee, S. Sengupta and B. Das: Progressive Horticulture Vol. 47 (2015), p. 89.

[7] E. Biton, I. Kobiler, O. Feygenberg, M. Yaari, H. Friedman and D. Prusky: Postharvest Biology and Technology Vol. 94 (2014), p. 82.

[8] F.A. Canli, M. Sahin, N. Temurtas and M. Pektas: HortTechnology Vol. 24 (2014), p. 424.

[9] Y. Nakano and K. Asada: Plant and Cell Physiol Vol. 22 (1981), p. 867.

[10] R.S. Dhindsa, P. Plumb-Dhindsa and T.A. Thorpe: Journal of Experimental Botany Vol. 32 (1981), p. 93.

[11] B.W. Jr, I. Fridovich: Analytical Biochemisty Vol. 161(1987), p. 559.