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Changes in Ascorbic Acid Content of Blackspot-resistant and -susceptible Potatoes Following Bruising

Michael K. Thornton[1] and Milton Workman
Department of Horticulture, Colorado State University, Fort Collins, CO 80523

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Abstract. **Experiments were conducted to determine if changes in tuber ascorbic acid content following bruising were related to blackspot susceptibility in potato (*Solanum tuberosum* L.). Tubers of four potato clones were bruised at three locations. Ascorbic acid content of bruised and nonbruised tissue on the same tubers was determined 0, 3, 6, 12, and 24 hr after bruising. Differences in initial ascorbic acid content between clones were highly significant, but not related to blackspot susceptibility. Differences in ascorbic acid content between bruised and nonbruised tissue of a tuber were significant in two of the four clones. Changes in ascorbic acid content of tubers with time occurred to a similar extent in bruised and nonbruised tissue. This experiment indicates that factors other than ascorbic acid content may determine differences in clonal susceptibility to blackspot.**

Blackspot is a physiological disorder of potatoes that develops after mechanical damage to the tuber. Reduction of blackspot can be achieved by careful operation of machinery and avoidance of low temperatures during harvesting and handling (9). However, even when treated carefully, the tubers of some cultivars still exhibit high levels of blackspot.

Blackspot appears as a general discoloration that develops immediately below the periderm, but usually does not penetrate beyond a depth of 1 cm. The discoloration results from enzymatic oxidation of phenolic substrates (tyrosine and chlorogenic acid) by polyphenol oxidase (7). However, phenolic content (3, 10) and polyphenol oxidase activity (2, 11) have not been consistently associated with blackspot susceptibility.

Plant tissue darkening often is closely related to ascorbic acid oxidation (1, 8). Darkening of damaged tissues does not occur until all reducing substances have been oxidized (1, 7). Development of pigments associated with blackspot is a relatively slow process, requiring up to 48 hr at 10°C (4). Presumably, the ascorbic acid in bruised tissue would be slowly oxidized during this time. In tissue expressing blackspot, ascorbic acid would be completely oxidized when the pigments begin to develop. In bruised tissue that does not express blackspot, the ascorbic acid may not be completely oxidized, preventing the development of pigments.

Previous workers have not found a consistent relationship between tuber ascorbic acid content and blackspot susceptibility (2, 3, 12). However, only the initial level of ascorbic acid was determined and not the changes that occur following bruising.

The objective of this experiment was to determine if there was a relationship between blackspot susceptibility and changes in ascorbic acid content of tubers following bruising. This information will be helpful in understanding differences in blackspot susceptibility between cultivars.

Tubers of three cultivars ('Centennial Russet', 'Lemhi Russet', and 'Russet Burbank') and one seedling clone (BC9289-1) grown at the San Luis Valley Research Center, Center, Colo., were selected for this study. Distinct differences in blackspot susceptibility of the four clones had been observed in 2 years of evaluations. 'Lemhi Russet' and 'Russet Burbank' are susceptible to blackspot, while 'Centennial Russet' and BC9289-1 are resistant.

Tubers were harvested in Sept. 1981 and stored at 3° to 5°C until the analyses were begun in Feb. 1982. Five uniformly sized tubers (170 to 226 g) from each clone were bruised on one side by dropping a 150-g hemispherical weight 45 cm onto the bud end, middle, and stem end when tuber temperature was 5°. These three locations were chosen because potato tuber susceptibility to blackspot varies with location of the tissue, with the stem end usually being most susceptible (11). The tubers were incubated at 28° following bruising. At time intervals of 0, 3, 6, 12, and 24 hr after bruising, the tubers were analyzed for ascorbic acid content. A 1.5-cm-diameter cork borer was centered over each bruised location and run transversely through the tuber. One centimeter of tissue was taken from each end of the resulting core to provide bruised and nonbruised tissue. The three-core sections of bruised or nonbruised tissue from each tuber were combined and adjusted to a total weight of 9 g. The samples were placed immediately in 90 ml of 0.25% oxalic acid in a blender. Samples were blended 4 min, then filtered through grade 515 fluted filter paper. The first 10 ml of filtrate was discarded, while the remainder was collected in a 125-ml Erlenmeyer flask. Reduced ascorbic acid content of a 2-ml aliquot was determined by the 2,6-dichlorophenolindophenol method (5).

Table 1. Changes in ascorbic acid content (mg/100 g fresh weight) with time in bruised and nonbruised tissue of potato clones differing in blackspot susceptibility.

		Time after treatment (hr)[z]					
Clone	Treatment	0	3	6	12	24	Mean
Resistant							
BC9289-1	Bruised	10.8	9.8	10.0	10.8	8.9	10.1
	Nonbruised	10.6	11.1	11.1	10.6	10.0	10.7
Centennial Russet	Bruised	14.9	17.4	16.8	16.2	16.6	16.4
	Nonbruised	14.5	16.6	15.6	15.0	14.7	15.2
Susceptible							
Lemhi Russet	Bruised	15.7	16.7	16.2	13.8	12.1	14.9
	Nonbruised	17.5	18.8	16.4	15.2	15.6	16.7
Russet Burbank	Bruised	7.7	8.8	8.8	8.4	6.7	8.1
	Nonbruised	8.7	8.6	8.7	8.0	7.6	8.3
Mean	Bruised	12.3	12.8	13.0	12.3	11.1	
	Nonbruised	12.8	13.7	12.9	12.2	12.0	
Significance							
BC9289-1			Bruised vs. nonbruised			NS	
Centennial Russet			Bruised vs. nonbruised			**	
Lemhi Russet			Bruised vs. nonbruised			**	
Russet Burbank			Bruised vs. nonbruised			NS	

[z]Values are means of five measurements.
**,NSSignificant or nonsignificant at the 1% level, single degree of freedom contrasts.

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[1]Present address: Dept. of Plant, Soil and Ent. Sci., Univ. of Idaho, Moscow, ID 83843.

The content of ascorbic acid in nonbruised tissue was not related to blackspot susceptibility. 'Lemhi Russet', a susceptible clone, had the highest ascorbic acid content of all clones in nonbruised tissue (Table 1). 'Russet Burbank', also susceptible, contained about 50% less ascorbic acid than 'Lemhi Russet'. These results confirm previous reports (3, 12) that there is no relationship between initial ascorbic acid content and blackspot susceptibility.

Although cellular damage was apparent in bruised core sections of all clones, blackspot developed within 24 hr after bruising in only two of 15 cores in BC9289-1, and three of 15 cores in 'Centennial Russet'. Blackspot developed in 10 of 15 cores in 'Lemhi Russet' and 13 of 15 cores in 'Russet Burbank' during this same time period. Differences in ascorbic acid content of bruised and nonbruised tissue were significant in two of the four clones (Table 1). 'Centennial Russet' tubers contained about 8% higher ascorbic acid in bruised tissue than nonbruised tissue. However, bruised tissue of 'Lemhi Russet' contained about 11% less ascorbic acid than nonbruised tissue, resulting in a significant interaction between clones and bruise. There was no relationship between bruising and ascorbic acid content in 'Russet Burbank' or BC9289-1.

Ascorbic acid oxidation has been closely related to darkening of damaged plant tissue (1, 8). Even after blackspot developed in 'Lemhi Russet' (between 6 and 12 hr after bruising), the differences in ascorbic acid content between bruised and nonbruised tissue were not great. The mean ascorbic acid content of bruised 'Lemhi Russet' tissue was 23% less than nonbruised tissue after 24 hr (Table 1), the largest difference observed in any of the clones. This difference is much less than would be expected if complete oxidation of reducing substances was required for pigment formation (1, 7).

Ascorbic acid has been reported to increase in sound cells next to a damaged area in potato tubers (6). Only 5% to 15% of the cells in a blackspot area may be damaged and discolor (10). Therefore, it may be difficult to differentiate between changes in ascorbic acid content of undamaged cells next to a bruise and the oxidation of ascorbic acid in damaged cells.

The relationship between ascorbic acid content of tubers and time of incubation at 28°C varied between clones (Table 1). There was no significant relationship between ascorbic acid content and time for BC9289-1. The relationship was linear for 'Russet Burbank', with ascorbic acid content decreasing significantly with time. The relationship between ascorbic acid content and time of incubation at 28° in 'Lemhi Russet' was both linear and cubic. Ascorbic acid content increased between 0 and 3 hr, then decreased (Table 1). The relationship between ascorbic acid content and time was cubic for 'Centennial Russet', with ascorbic acid levels higher after 24 hr of incubation at 28° than at 0 hr, resulting in a significant interaction between clones and time. Changes in ascorbic acid content during incubation at 28° occurred to a similar extent in both bruised and nonbruised tissue of all clones (Table 1). The mean ascorbic acid content of the clones increased 7% between 0 and 3 hr, but decreased by 14% between 3 and 24 hr after treatment. Therefore, these changes may have been a response to handling conditions rather than to bruising.

The hypothesis tested in this experiment was that blackspot-resistant clones would exhibit a different pattern of change in ascorbic acid content following bruising than susceptible clones. However, the results indicate that the content of ascorbic acid in bruised and nonbruised tissue, and changes in ascorbic acid content with time after bruising, were not related to blackspot susceptibility.

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Postharvest Handling of Bud-cut Freesia Flowers

William R. Woodson
Department of Horticulture, Purdue University, West Lafayette, IN 47907

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Abstract. **The opening of *Freesia hybrida* Bailey flowers cut in the tight bud stage was promoted by treatment with sucrose and 200 mg·liter^{-1} 8-hydroxyquinoline citrate. A pulse treatment for 24 to 48 hr with 20% sucrose resulted in complete inflorescence development and prolonged vase life. Reduced sucrose concentrations or increased pulse durations were not as effective. Pulse-treating flowers with 20% sucrose for 24 hr prior to 3 days of simulated shipping improved subsequent flower opening and vase life.**

Freesia is an important cut flower crop in Europe, and its production in the United States has increased in recent years. Freesia offers an excellent alternative crop for northern greenhouses, since its production is dependent on low temperatures. The demand for cut freesia flowers is increasing due to increased availability, their attractive scent, and their relatively long vase life.

Little information is available on the postharvest handling of cut freesia flowers. It has been reported that inflorescences harvested prior to the opening of the first floret fail to open 100% of their flowers before senescing (8). In addition, flowers opening on tight-bud harvested inflorescences are not as large and colorful as those opening on stems harvested at the normal commercial stage (8).

Bud opening is a technique whereby flowers harvested at the tight bud stage are opened

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