Enzymic Browning and Free Tyrosine in Potatoes as Affected by Pentachloronitrobenzene

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Two potato varieties, Pungo and Irish Cobbler, grown in soil treated with pentachloronitrobenzene (PCNB) at 50 pounds per acre were lower in free tyrosine content than were control potatoes. PCNB lowered total phenolic content of Irish Cobblers, but not that of Pungos. The PCNB treatment did not significantly affect tyrosinase activity. The amount of free tyrosine was related to enzymic browning. The results indicate that PCNB, when used as a soil fungicide, tended to decrease tyrosine content of two potato varieties and may also decrease enzymic browning. Storage for 1 month at 70° F. generally increased tyrosine content.

The fungicide, pentachloronitrobenzene (PCNB), has been reported to be effective against potato scab (*Streptomyces scabies*) and black scurf (*Rhizoctonia solani*) (Erickson, 1960).

Fry (1959) and Brogdon *et al.* (1965) have reported flavor changes in potatoes grown in soil treated with PCNB. Mondy (1966) found also that PCNB-treated potatoes, after storage for 4 or 16 weeks at 40° F., were lower in total phenols than were control potatoes.

In work reported here, a study was made of the effect of PCNB on the quality of potatoes. Phenols, particularly free tyrosine, have been reported to be involved in enzymic browning (Bourquelot and Bertrand, 1895; Bertrand, 1896; Mapson *et al.*, 1963). For this reason, the possible effect of PCNB treatment on phenols, including free tyrosine, and on enzymic browning of potatoes was investigated.

MATERIALS AND METHODS

In 1966, potatoes of the Pungo variety were grown in untreated soil, and in soil treated with 50 pounds per acre of PCNB at Painter, Va. Potatoes of the Irish Cobbler variety, treated in the same manner, were obtained from Rosemount, Minn. The Pungo potatoes were delivered to the laboratory on the day of harvest and the Irish Cobbler about a week after harvest.

Work was begun on the potatoes immediately after receipt. Work was also carried out on potatoes stored for 1 month at 70° F. and for periods of 2 and 5 months at 55° F. Compositional factors determined, that might be related to color, were free tyrosine, tyrosinase, and phenols. Color was evaluated by a Gardner color difference meter.

Since the authors believed that some of these quality factors might not be uniformly distributed in the potato, the bud and stem ends were investigated separately. Samples were taken to include representative areas of the potato. All determinations were replicated for 4 successive days for each storage period.

Free Tyrosine. Very thin slices were taken from 10 unpeeled potatoes to make a total of 100 grams. The potatoes were diced and boiled for 20 minutes in 95% alcohol. The extract was blended, then filtered through sintered glass, and diluted to 500 ml. with alcohol. A 50-ml. aliquot was evaporated under reduced pressure to remove alcohol. The sample was taken up in water and passed through Dowex 1 (Sweeney and Simandle, 1966). The eluate was clarified with Hyflo Super Cel (a diatomaceous earth) and the free tyrosine determined by the method of Ceriotti and Spandrio (1957).

Phenols. Phenols were determined on an aliquot of the above extract by the method of Rosenblatt and Peluso (1941). Corrections were made for ascorbic acid.

Tyrosinase. Tyrosinase was determined on a 50-gram sample taken from 10 unpeeled potatoes as described above. The method used was the ascorbic acid oxidation procedure described by Ponting and Joslyn (1948).

Color Difference Meter. Samples were cut from pared potato sections taking care to include representative areas of the potato. The samples were cut into 1-inch cubes. A 100-gram aliquot was placed, with a flat side of each cube down, in a glass dish, 9-cm. diameter and 5 cm. high, and tested for color with the Gardner color difference meter (Gardner Laboratory, Bethesda, Md.). The color standard used was L 79.2, a_L 1.7, b_L 22.6. Five readings were taken, turning the sample dish about 72° between readings. One hour later the readings were taken again. The decreases in L and b_L readings were expressed as ΔL and Δb_L. These were taken as a measure of browning of the sample.

RESULTS AND DISCUSSION

Free Tyrosine. The stem portion of the potatoes tended to be higher in tyrosine content than was the bud portion (Table I). Mapson *et al.* (1963) have reported that in immature potatoes most of the tyrosine was found within the area bounded by the vascular ring. In mature potatoes, they reported tyrosine to be distributed more or less uniformly over the cut surface of the potato, when the potato was cut longitudinally. The present results show bud and stem differences on mature potatoes not entirely in agreement with those of Mapson *et al.* (1963).

Storage of the intact potato for 1 month at 70° F. generally tended to produce an increase in tyrosine content (Table II). When stored at 55° F., the Pungo potatoes generally had higher tyrosine content after 5 months

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Table I. Tyrosine and Phenolic Content, and Enzymic Browning of Two Potato Varieties as Affected by PCNB[a]

Treatment	Pungo				Irish Cobbler			
	Tyrosine, μg./g.	Phenols, mg./g.	ΔL^b	Δb_L^c	Tyrosine, μg./g.	Phenols, mg./g.	ΔL^b	Δb_L^c
				STEM				
Control	200a	0.45a	6.14a	1.98a	444a	0.72a	13.42a	5.79a
PCNB	151b	0.43a	2.98b	1.03b	384a	0.68a	13.43a	5.37a
				BUD				
Control	136a	0.44a	3.08a	1.05a	335a	0.68a	11.41a	5.00a
PCNB	116a	0.44a	1.78b	0.52b	259b	0.59b	9.36a	4.32a

[a] Values having different letters differ significantly at 1% level.
[b] ΔL values indicate increase in darkness of sample.
[c] Δb_L values indicate decrease in yellowness of samples.

Table II. Tyrosine Content and Browning of Two Potato Varieties as Affected by PCNB Treatment, Storage Time, and Temperature[a]

Storage Time and Temperature	Pungo				Irish Cobbler			
	Untreated		Treated		Untreated		Treated	
	Stem	Bud	Stem	Bud	Stem	Bud	Stem	Bud
			TYROSINE, G./G.					
No storage	164a	134a	117a	119a	370a	290a	366a	270a
1 month, 70° F.	220ab	156a	182ab	146a	490ab	382a	414a	248a
2 months, 55° F.	177a	111a	120a	83a	495ab	382a	424a	285a
5 months, 55° F.	238b	144a	185ab	118a	395a	278a	315a	227a
			ΔL VALUES					
No storage	...	...	...	...	13.35a	12.10a	11.08a	11.58a
1 month, 70° F.	5.28a	3.32a	2.92a	2.52ab	13.92a	11.72a	11.58a	9.30a
2 months, 55° F.	5.45a	2.80a	2.05a	0.72a	13.92a	12.40a	14.52a	9.92a
5 months, 55° F.	7.70b	3.10a	3.98a	2.10ab	11.40a	8.80a	14.43a	8.70a

[a] a differs from b at 1% level. a differs from ab at 5% level. Letters apply only to values within a column.

than after 2 months. With Irish Cobblers, the reverse was true; tyrosine content was highest after 2 months.

Enzymic Browning, Tyrosine, and Phenolic Content. Highly significant correlations were obtained between enzymic browning of the potatoes, as measured by ΔL and Δb_L color difference meter values, and tyrosine content (Table III). The correlations between browning and tyrosinase were nonsignificant. Correlations between browning and phenol content were significant only for the Irish Cobbler variety. These results confirm those of Mapson *et al.* (1963) that the limiting factor in enzymic browning is the concentration of tyrosine.

Enzymic Browning and PCNB. Potatoes grown in soil treated with PCNB tended to be lower in tyrosine content than were control potatoes receiving no PCNB (Table I). For the Pungo variety, differences were significant for the stem portion. For bud portions of the Irish Cobblers, differences were significant for both phenols and tyrosine. Mondy (1966) has reported that potatoes treated with PCNB and stored for periods of 4 to 16 weeks at 40° F. were lower in total phenols than were control potatoes.

For the Pungo potatoes, differences in tyrosine content between PCNB treated and control potatoes remained fairly constant for each of the storage periods (Table II). For the Irish Cobblers, tyrosine differences between treated and control potatoes, as received, were not large. After storage for 1 month at 70° F. or 2 or 5 months at 55° F., tyrosine differences between treated and control potatoes were considerably increased.

Table III. Correlation of Various Compositional Factors with Enzymic Browning of Two Potato Varieties

Factor One	Factor Two	Correlation Coefficient		
		Pungo	Irish Cobbler	Pungo and Irish Cobbler
Tyrosine	ΔL^a	0.91[b]	0.71[b]	0.93[b]
Tyrosine	Δb_L^c	0.84[b]	0.64[b]	0.91[b]
Phenols	ΔL	0.39	0.59[d]	
Tyrosinase	ΔL	0.55	0.01	

[a] ΔL denotes increase in darkness of sample as measured by light reflectance.
[b] Significant at 1% level.
[c] Δb_L denotes decrease in yellowness of sample.
[d] Significant at 5% level.

Tyrosinase content of the PCNB-treated potatoes did not differ significantly from that of the control potatoes.

Enzymic browning of the potatoes appeared to be related to PCNB treatment (Table I). For the Pungo variety, both the stem and bud portions of the untreated potato showed significantly more browning when cut and allowed to stand for 1 hour than did the treated potatoes. This is demonstrated by the lower ΔL and Δb_L values for the treated potatoes.

The Irish Cobblers were higher in tyrosine and phenolic content and showed much greater enzymic browning than did the Pungo potatoes (Table I). Although the Irish Cobblers treated with PCNB tended to be lower in enzymic browning than were the untreated Cobblers, the differences were not significant. It is possible that the amount of browning of this variety after 1 hour was so great that the method of measurement used was not sufficiently sensitive to detect differences in browning between control and PCNB treated samples. In future work, readings will be taken at 10-minute intervals over a period of 1 hour.

The results of the work indicated that PCNB when used as a soil fungicide tended to decrease tyrosine content of two potato varieties and may also decrease enzymic browning.

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