Flavor Evaluation of Potatoes Grown in Soils Treated with Pentachloronitrobenzene

PEGGY CROOKE FRY
Department of Home Economics, Nebraska Agricultural Experiment Station, University of Nebraska, Lincoln, Neb.

Flavor evaluation tests on pentachloronitrobenzene-treated potatoes showed statistically significant flavor changes for only six of 19 treatment amounts. Potatoes grown in fine sandy loam had a slight tendency toward greater flavor changes than those grown in silt loam and land having a high content of organic matter. Variance analyses showed that pentachloronitrobenzene did not alter the flavor of potatoes grown in treated soil to the extent that consumer acceptance could be affected adversely. Taste panels of untrained individuals were apt to show wide ranges of acuity in detecting flavor changes.

Field tests have shown that three serious obstacles to potato production—potato scab (*Streptomyces scabies*), black scurf (*Rhizoctonia solani*), and tuber flea beetle damage—may be overcome by use of the organic compound pentachloronitrobenzene (PCNB) (*5*). Since the 1930's, the potato scab problem in Nebraska has been so acute that several areas have discontinued production as a consequence. Now that soil treatment with pentachloronitrobenzene will control these diseases, it is necessary to know whether any flavor changes occur in the tubers grown in treated soil. Some reports (*2–4*) indicate that the flavor of produce grown in soils treated with relatively large amounts of certain other pesticides is appreciably altered. The degree of acceptability on the open market of table stock potatoes grown in pentachloronitrobenzene-treated soils is indicated in this study.

Less than 0.05 p.p.m. of pentachloronitrobenzene can be recovered from potatoes grown in soil which has been treated with 100 pounds of active chemical per acre, and pentachloronitrobenzene fed in amounts 1000 times that found as residues in crops grown in soil treated with this chemical was not toxic to animals. This pesticide is registered with the United States Department of Agriculture and has been classified in the no-residue category because it is seemingly innocuous to animals (*7*).

This report presents some findings of organoleptic tests on potatoes grown in Indiana, Maine, Nebraska, Ohio, and Oregon in 1957 on pentachloronitrobenzene-treated and untreated plots.

Soil Treatment Procedures

The treatment amounts, soil types, and methods of applying pentachloronitrobenzene were varied from one planting location to another. Potatoes tested in this study were grown on the following classes of soil: light mineral or very fine sandy loam, heavy mineral or silt loam, and muck soil or land having a high content of organic matter. Untreated plots were planted at each location and in each type of soil throughout the study. In each location, pentachloronitrobenzene was applied to the surface and then mixed in the soil by mechanical means. Poundage of the compound refers to active pentachloronitrobenzene in every instance. Table I summarizes details of the procedures.

Flavor Evaluation Procedures

Two pounds of tubers that were firm and free of greening were selected for each cooking sample. Injuries from potato scab, black scurf, and tuber flea beetle were present on some of the untreated samples. Samples were stored at approximately 35° F. The week before testing, they were kept at room temperature in paper or cloth bags.

To prepare the potatoes, raw tubers were washed, peeled, and cut in approximately 1-inch cubes. Two pounds of raw potatoes, 600 ml. of water, and 2 grams of salt were measured into each metal pan and the potatoes were covered and cooked until tender—approximately 20 minutes. When done, they were drained in sieves, beaten 30 seconds with an electric mixer, then set over hot water to keep warm while serving. No additional seasonings were used. Individual portions of each sample were served while warm in small paper cups on metal serving trays to each of the tasters.

Each member of the judging panel received four (or five) sample cups at each testing period. One cup was labeled R and contained an untreated check sample for reference. The other three (or four) cups, labeled with five-digit code numbers from a random number table, contained the two (or three) different treatments and another untreated sample.

Flavor was judged at tables in a room separate from that in which the samples were prepared. The judges were requested to score the coded samples in direct relation to the reference sample on a printed ballot using a four-point difference scale. The potato samples were judged as having the same flavor as the reference or being slightly different, moderately different, or extremely different in flavor. These judgments were later scored with zero being assigned to the first category of no difference from the reference sample and one, two, and three being assigned to the other categories, respectively. Hence, the lower the score, the less the flavor change.

The tests were all run twice using 24 judges who had not been screened as to tasting acuity. There were three alternates who were used when necessary to keep the number of judgments per day constant throughout the study. The taste panel was composed of nine males and 15 females, with alternates of two females and one male. The plan provided two scores per sample per taster, producing a total of 1344 flavor judgments. These evaluations of palatability were subjected to variance analyses (*6*) in order to determine whether real differences existed in the flavor of the potatoes tested. The data were not coded before statistical treatment.

Results

Mean flavor scores in the study (Table I) suggest that potatoes grown on light soils evidence more flavor change than those grown on heavy and muck soils. On the basis of the over-all analyses of variance, however, differences in flavor scores assume additional meaning.

Variance analyses in Table II show that in only four of the nine soil locations did the treatments produce significantly different flavors in potatoes. These were in Ohio light soil, Maine muck soil, Indiana muck soil, and Oregon heavy soil. In the four instances where the treatment mean square was statistically significant, least significant differences (L.S.D.s) were calculated at the 5% and 1% levels (*6*). These values were then used to determine whether or not the differences between the means of

Table I. Mean Flavor Scores for Cooked Potatoes Grown in Untreated Plots and Plots Treated with Pentachloronitrobenzene[a]

Location of Test and Soil Type	Potato Variety	Method of Application	Dosage, Lb./Acre	Panel Flavor Scores[b] (Sample Means)	
		NEBRASKA			
Light soil	No. 315				
Untreated		...	...	0.938	
Treatment 1		Band (16 in.)[c]	30 (65)[d]	1.208	1.10
Treatment 2		Band (16 in.)[c]	60 (130)	1.146	
Heavy soil	Progress				
Untreated		...	...	0.833	
Treatment 1		Band (16 in.)[c]	50 (112)	0.938	0.875
Treatment 2		Band (16 in.)[c]	100 (225)	0.833	
		OHIO			
Light soil					
Untreated		...	...	0.729[f]	
Treatment 1		Spray (5 ft.)[e]	60	1.146	1.08
Treatment 2		Spray (5 ft.)	100	1.375[g]	
L.S.D. 0.05				0.334	
L.S.D. 0.01				0.446	
Muck soil					
Untreated		...	...	0.604	
Treatment 1		Spray (5 ft.)	100	0.750	0.71
Treatment 2		Spray (5 ft.)	150	0.771	
		MAINE			
Light soil	Katahdin				
Untreated		...	...	0.854	
Treatment 1		Band[c]	100 (225)	1.188	1.01
Treatment 2		Band[c]	200 (450)	0.979	
Muck soil	Cobbler				
Untreated		...	...	0.750	
Treatment 1		Broadcast[c]	50	0.729	
Treatment 2		Broadcast[c]	100	1.312[g]	0.99
Treatment 3		Broadcast[c]	200	1.167[g]	
L.S.D. 0.05				0.302	
L.S.D. 0.01				0.402	
		INDIANA			
Muck soil					
Untreated		...	...	1.083	
Treatment 1		Broadcast	100	1.167	0.97
Treatment 2		Broadcast	200	0.667[f]	
L.S.D. 0.05				0.389	
		OREGON			
Heavy soil	Netted Gem				
Untreated		...	...	0.438	
Treatment 1		Broadcast[h]	50	0.438	0.56
Treatment 2		Broadcast[h]	150	0.812[g]	
L.S.D. 0.05				0.231	
L.S.D. 0.01				0.308	
Light soil	Netted Gem				
Untreated		...	...	0.646	
Treatment 1		Broadcast[h]	50	0.938	0.81
Treatment 2		Broadcast[h]	150	0.854	

[a] Means of 24 judges' scores, 2 replications. [b] The lower the flavor score, the less change in flavor judged to be present. [c] Chemical applied as 20% dust. [d] Numbers in parentheses are equivalent amounts in broadcast. [e] Spraying in 5 feet widths is similar to broadcasting. [f] Significant at the 5% level. [g] Significant at the 1% level. [h] As powder.

Table II. Summarized Variance Analyses of Flavor Scores on Potatoes Grown in Pentachloronitrobenzene-Treated Soils

		Ohio Light Soil		Maine Muck Soil		Indiana Muck Soil		Oregon Light Soil		Maine Light Soil		Nebraska Light Soil		Ohio Muck Soil		Oregon Heavy Soil		Nebraska Heavy Soil	
Source of Variation	d.f.[a]	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.	M.S.	F.
Trays (replications)	1	0.2500	0.3786	0.0052	0.0094	0.4445	0.4974	8.5069	18.78[b]	4.3403	6.59[c]	0.0000	0.000	1.7778	4.11[c]	0.8403	2.67	5.4444	12.71[b]
Tasters	23	2.0580	3.1168[b]	2.6683	4.8313[b]	2.3430	2.6217[b]	1.2364	2.73[b]	1.7606	2.67[b]	1.4481	2.12[c]	1.7428	4.03[b]	1.1712	3.72[b]	2.5978	6.06[b]
Treatments	2	5.1458	7.7931[b]	4.0052	7.2519[b]	3.4444	3.8541[c]	1.0834	2.39	1.3612	2.07	0.9653	1.41	0.3958	0.92	2.2500	7.14[b]	0.1458	0.34
Treatments × trays	2	0.2708	0.4101	3.0330	5.4916[b]	1.1944	1.3365	0.8611	1.90	0.8611	1.31	2.4375	3.57[c]	0.4652	1.08	0.5278	1.67	1.5486	3.61[c]
Treatments × tasters (error)	46	0.6603		0.5523		0.8937		0.4529		0.6582		0.6827		0.4321		0.3152		0.4284	
Treatments × trays × tasters / Treatment × trays	69	0.5248		0.5913		0.4517		0.5257		0.8614		0.7120		0.4390		0.4001		0.5139	
C.V.			75.2%		75.1%		97.5%		83.1%		80.3%		75.1%		92.6%		100.3%		74.8%

[a] Degrees of freedom are the same in every instance with the one exception of Maine muck soil, where they are, from top to bottom: 1, 23, 3, 3, 69, 92, respectively.
[b] Significant at the 1% level.
[c] Significant at the 5% level.

each treatment and the control plots were significant. The results of these comparisons are presented in Table I.

Undoubtedly the most statistically significant and consistent finding in Table II is that the 24 tasters are not all equally discerning potato tasters and that they do not rate potatoes similarly. In four cases, significant differences were found in the same potatoes tasted on two different days (or trays)—i.e., in the case of potatoes grown in Oregon light, Maine light, Ohio muck, and Nebraska heavy soils. The reasons for this occurrence are unknown, although it is probably not due to experimental error. Possibly, it was a consequence of using scoring, rather than ranking ballots.

There was a significant amount of interaction between treatments and trays (or replications) in three instances: when potatoes were tasted from Maine muck, Nebraska light, and Nebraska heavy soils. This may mean that the tasters did not give the same treatments the same relative ratings on the two different days of sampling.

The coefficients of variation in Table II are high, ranging from 74.8% to 100.3%. This is another indication of the tasters' failure to rate the treatments the same relative to one another.

The nine locations planted (Table I) can be subdivided in this fashion: four light soil, two heavy soil, and three muck soil. The treatments which produced statistically significant flavor changes in the potatoes were used on one light soil, one heavy soil, and two muck soils. However, a chi square test (*6*) showed no significant relationship when the soil types and the number of locations that produced significant mean scores were compared ($p = 0.900$).

A chi square test was also made to determine whether there was any association between the use of over 100 pounds per acre of pentachloronitrobenzene and the presence of a significant flavor change, as evidenced by a high mean flavor score. The test proved not to be significant ($p = 0.990$), and hence the use of over 100 pounds per acre of pentachloronitrobenzene is not associated with a flavor change in this study.

Again using chi square, the possibility was investigated that there might be some relationship between the methods of applying pentachloronitrobenzene and the following variables: types of soil, the treatments yielding significant flavor differences, and the amounts of pesticide used per acre. In none of these tests was p found to be significant at the 5% level—i.e., there was no statistically significant relationship between methods of application of pentachloronitrobenzene (spray, band, or broadcasting) and the three other factors enumerated above.

The term flavor change rather than off-flavor has been used in this report, purposely, because it was not clear at the conclusion of the study that the change in flavor of some of the potato samples was to the detriment of the product. Some of the tasters reported that they felt the change was an improvement in the flavor—i.e., that on some days the potatoes marked with five-digit numbers tasted less watery and were of better texture than the samples marked R. This was not, however, uniformly true at all times. On some occasions, some tasters described the change in the samples as a definite off-flavor.

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FEEDSTUFFS ANTIOXIDANTS

Toxicity Studies on the Antioxidant 6-Ethoxy-1,2-dihydro-2,2,4-trimethylquinoline

ROBERT H. WILSON and FLOYD DeEDS

Western Regional Research Laboratory, Agricultural Research Service, U. S. Department of Agriculture, Albany, Calif.

The effects on rats of the antioxidant 6-ethoxy-1,2-dihydro-2,2,4-trimethylquinoline have been investigated. The following aspects are emphasized: acute toxicity, chronic toxicity, skin toxicity, weight of vital organs, and reproductive ability.

STABILIZATION OF CAROTENE, provitamin *A*, in dehydrated alfalfa and other forage products has been a problem for many years. Many antioxidants have been tried, but 6-ethoxy-1,2-dihydro-2,2,4-trimethyl-quinoline (EMQ) has proved to be the most active and usable compound found to date (*1*). When added to alfalfa meal at a level of 0.015% (150 p.p.m.) it affords considerable protection to carotene. Use in feeds should be permitted only if no chronic toxicity were apparent at the proposed levels. Acute toxicity tests and tests on skin reactions are important, because the results might be used to prevent undesirable reactions in individuals applying the materials to alfalfa, or handling the treated material as such, or incorporating it into finished feeds.

Acute Toxicity

Acute oral toxicity was determined in rats. Twenty and 50% solutions of EMQ in cottonseed oil were given by stomach tube at dosage levels of 125 to 1000 mg. per kg. Five of seven rats receiving 1000 mg. per kg. died, as did two out of five receiving 800 mg. per kg., and one of five receiving 640 mg. per kg. Symptoms noted before death or recovery were loose stools attributable to the oil, and a depression developing on the second day and lasting 4 or 5 days.

Acute intraperitoneal and intravenous toxicity was determined on mice. The EMQ was mixed with half its volume of Tween 80 and suspended in physiological saline to produce 2 or 5% emulsions. Control animals receiving corresponding amounts of the emulsifying agent in saline showed no symptoms. The depression noted in rats given EMQ orally was much more apparent in mice receiving the material intraperitoneally or by vein. At a dosage level of 1000 mg. per kg. intraperitoneally, there was excitement and uncertain gait, followed by prostration within 5 minutes. Within a few minutes, the animals were comatose. Five of seven mice died. With a dose of 800 mg. per kg. or less, all animals survived, being free of symptoms the following day. A mild depression lasting a few hours was seen with a dose as low as 400 mg. per kg. Following intravenous injection of lethal dosages, there was immediate convulsive jumping followed within seconds by prostration and coma. Death occurred in 2 minutes to a few hours. With nonlethal injections, there was a depression lasting less than a day. The LD_{50} was 178 mg. per kg. [19/20 confidence limits were 152 to 208 mg. per kg. as calculated previously (*5*)].

Chronic Toxicity

The chronic toxicity tests were made on 270 weanling albino rats from the colony, described previously in detail (*8*), by incorporation of EMQ into the diet and feeding *ad libitum* for considerable periods. Thorough mixing was ob-