Control of Chlorophyll and Solanine Formation in Potato Tubers by Oil and Diluted Oil Treatments

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Abstract. A treatment of potato tubers (Solanum tuberosum L.) at 22°C with corn oil, peanut oil, olive oil, vegetable oil, or mineral oil significantly and effectively inhibited chlorophyll and solanine formation. A concn of 1/8 corn oil and 7/8 acetone was the minimum effective diluted oil treatment.

Studies on the inhibition of chlorophyll and solanine developments in potatoes have been carried out in our laboratory by treatments with chemicals, ionizing radiation, cultivar character and tuber maturity, control atmospheres, and the intensity, quality, and duration of light (3, 4).

Our previous investigations have shown that waxing of potato tubers with paraffin at 140° or 160°C completely inhibited solanine and chlorophyll formation as well as sprouting and, after 50 days of storage, these potato tubers were in as good condition as at the beginning of the experiment (4). Recently, we found that dipping the potatoes in corn oil at 22°C inhibited chlorophyll and solanine formation (5).

Our present study is to determine the effect of various types of oils on solanine and chlorophyll formation in 'Russet Burbank' potato tubers and the minimum amount of oil needed to inhibit these formations effectively.

In expt. 1, 2 types of oil, lipid and hydrocarbon, were evaluated. These included lipid oils; corn (Mazola® CPC International, Inc., Inglewood Cliffs, N. J.); peanut (Planters® Oil Standard Brands, Inc., New York, N. Y.); olive (Pompeian® Inc., Baltimore, Md.); vegetable (Wesson® Hunt-Wesson Foods, Inc., Fullerton, Calif.); and mineral oil purchased from a local market. Treatments included the control and oils at 22°C arranged in a completely randomized block design, each with 3 replications. Each replication consisted of 6 tubers of uniform size. The treatments were accomplished by a 1/2 sec dip of the tubers in the oil bath. Excess oil on the tubers was wiped away with tissue paper so only a thin layer remained.

In expt. 2, the tubers were treated with corn oil diluted with acetone to determine the min amount of oil needed to inhibit chlorophyll and solanine formation. Treatments included control (untreated), oil only, 1/2 oil and 1/2 acetone, 1/4 oil and 3/4 acetone, 1/8 oil and 7/8 acetone, 1/16 oil and 15/16 acetone, 1/32 oil and 31/32 acetone, 1/64 oil and 63/64 acetone, and 1/128 oil and 127/128 acetone (v/v), and acetone. There were 3 replications of each treatment, each consisting of 6 tubers of uniform size. The treatment was accomplished by a 1/2 sec dip of the tubers in the liquid at 22°C. Excess liquid was removed from the surface with tissue paper.

The tubers for both the experiments were then exposed to fluorescent light of 18.5 lux (200 ft-c) for 10 days at 16°C and 60% relative humidity. Peels (1 mm thick) were removed for the determination of solanine and chlorophyll. Chlorophyll was determined by the AOAC method (1) and solanine extraction and determination by that of Gull and Isenberg (2).

Fig. 1 shows that oil treatments of potato tubers at room temp significantly inhibited solanine and chlorophyll formation. There is a significant difference (at 1% level) between the control and the treated but none among the oil treatments. Corn, peanut, olive, and vegetable oil (composed of soybean and cottonseed oils) are glycrides of fatty acids, however, they differ in composition. Mineral oil is composed of hydrocarbons with relatively high boiling points. As we indicated previously (6), subsequent to oil treatments, some of the oil might have been absorbed into the tissues of the tubers and might have consequently inhibited certain biochemical processes such as chlorophyll and solanine biosynthesis in the peels. Although the oils we used in these experiments were different in molecular species, they behaved similarly as far as inhibitions of chlorophyll and solanine formation were concerned. This indicated that there may be no molecular specificity for the inhibition.

Although the oil treatment of potato tubers effectively controlled solanine and chlorophyll formation, this method consumed too much oil and the treated potatoes had an oily appearance. To decrease the oil utilization and at the same time effectively control chlorophyll and formation, corn oil was diluted with acetone. The more the oil was diluted, the less the potatoes absorbed. Subsequently, the acetone evaporated and only a small amount of oil remained on the tubers. On the average, 100 g of potato tubers absorbed 100 mg of oil after the treatment with oil only. Fig. 2 shows the effects of different dilutions of corn oil on the solanine and chlorophyll formation. Treatment with 1/2, 1/4, and 1/8 oil significantly (at 1% level) and effectively inhibited the solanine and chlorophyll formation. Treatment with 1/16, 1/32, and 1/64 oil inhibited the chlorophyll formation by 95%, 72%, and 22% and solanine formation by 82%, 49%, and 28%, respectively. The treatment with 1/128 oil or acetone alone did not significantly inhibit chlorophyll and solanine formation. This indicated that the treatment with 1/8 oil was sufficient to control solanine and chlorophyll synthesis effectively.

According to our estimation, using this method approx 1 g of oil dissolved in 50 g of acetone is enough to treat 8000 g of potato tubers. There was no apparent harmful effect from acetone treatment of tubers. For practical application, acetone can be recovered by passing the treated tubers through a warm air chamber and condensing the acetone in the warm air by a cooling coil. By so doing, the treated tubers have a clean appearance. According to our observation, the treatment with diluted oil also inhibited sprouting of the tubers. This procedure provides an effective, inexpensive, and safe method to control greening and solanine formation in potato tubers.

Fig. 1. Effects of different oil treatments on chlorophyll and solanine development in peels of 'Russet Burbank' potatoes. After treatments, tubers were exposed to 18.5 lux (200 ft-c) for 10 days at 16°C. A) original (zero-time sample), B) control (non-treated potatoes), C) corn oil, D) peanut oil, E) olive oil, F) vegetable oil, G) mineral oil.

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Fig. 2. Effects of different dilutions of corn oil with acetone on chlorophyll and solanine development in peels of 'Russet Burbank' potatoes. After treatments, tubers were exposed to 18.5 lux (200 ft-c) for 10 days at 16°C: (A) original (zero-time sample), (B) control (untreated potatoes), (C) 100% oil, (D) 1/2 oil and 1/2 acetone, (E) 1/4 oil and 3/4 acetone, (F) 1/8 oil and 7/8 acetone, (G) 1/16 oil and 15/16 acetone, (H) 1/32 oil and 31/32 acetone, (I) 1/64 oil and 63/64 acetone, (J) 1/128 oil and 127/128 acetone, (K) acetone.

An Excised Leaflet Test for Evaluating Potato Frost Tolerance

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Abstract. A simple reproducible procedure is described for assessing frost injury of potato foliage, involving controlled freezing of excised leaflets and measurement of leached electrolytes. Test results are shown for 5 tuber-bearing Solanum species representing a wide range of frost tolerance. The test can be used in selection and breeding for frost tolerance in potato.

Frost injury is a major cause of yield reduction in potato in many regions of the world. In breeding for frost tolerance it is convenient to use a stress test which would require only a few leaves and which can be reliably and reproducibly performed in the laboratory (4).

In the following test, excised leaflets were subjected to controlled freezing and injury was estimated immediately afterwards by using a modification of the electrolyte leaching technique described by Dexter (2). For purpose of comparison, whole potted plants were also test-frozen and injury was estimated visually several days later. The 7 different genotypes tested included 2 cultivars and 4 species chosen for a range in apparent frost resistance from susceptible ('Red Pontiac') to the most resistant species known (Solanum acaule Bitt.).

Cuttings of each genotype were made from a single plant. Rooted cuttings were transplanted to a sterilized 1:1 mixture of sand, loam, and peat in a 15 cm styrofoam pots and grown for 3 weeks at a 12 hr photoperiod in a walk-in growth chamber with a day/night temp regime of 22/12°C. Prior to testing, plants were preconditioned for at least 2 weeks at 12/2°C and a 12 hr photoperiod.

Terminal leaflets from young, intermediate age, and fully matured leaves were used in each freezing run. Sufficient leaves were sampled in each test so that 2 leaflets of each stage of maturity could be removed from the cooling bath at each test temp. Two freezing runs were conducted for each genotype using leaflets obtained from several uniform plants.

The leaflets were washed in deionized water, blotted dry, and each was placed at the bottom of a 15 cm test tube. The tubes were stoppered with 1-holed rubber stoppers through which short glass tubes had been inserted, and immersed in an ethylene glycol cooling bath (Wilkens-Anderson Lo-Temp Bath). Copper-constantan thermocouples and a multipoint potentiometric strip chart recorder (Barber-Coleman) monitored bath and tissue temp. The bath temp could be regulated with an accuracy of ± 0.2°C.

At the beginning of each test, the bath temp was rapidly lowered to -20°C which was maintained for 30 min. Sample freezing was initiated by rubbing a frost covered pipe cleaner up and down in the access tube of each test tube. The pipe cleaner had been previously dipped in liquid N and held in the room air for a few sec. This technique always initiated freezing, as shown by rise in tissue temp, if the leaves were at or below -20°C. The bath temp was maintained at -20°C for 1 hr more and then lowered 1°C/hr. Leaflets were removed at different test temp and slowly warmed in a 0°C refrigerator.

After 1 hr at 0°C, leaflets were removed from the tubes and immediately leached. All leaflets of 1 genotype removed at a specific test temp were placed together in a flask with 50 ml of deionized water and the flasks were shaken at 29°C for 1 hr in a water bath. The conductance of the decanted leachate was measured at 60 cycles with a conductivity bridge (Industrial Instruments). The flask containing the leaflets was then dipped in liquid N for 5 min to kill the samples. The original leachate was poured back into the flask and samples shaken again for 1 hr. The conductance of final leachate was measured. Conductance of leachate after test freeze x 100 / final conductance after killing, was expressed as % leaching.

Figure 1 shows mean % leaching for 2 runs plotted against test temp. In general there is a steep rise in leaching when a critical temperature is reached. The correlation between runs was good for all genotypes (r = 0.87 to 0.99). We attribute this to the uniformity of material and growing conditions plus the large size of samples.

One whole potted plant of each genotype was test frozen in a modified top-loading domestic freezer to the temp that resulted in 50% leaching in the excised leaflet test of that genotype. Another plant was frozen to 1°C above this temp. After slow thawing, plants were removed to a greenhouse and injury was visually estimated after 2 weeks. The foliage of all plants was killed at the 50% leaching temp of that genotype. Plants frozen to 1°C above this temp either had no visible injury or, as