Abstract

The possibility that sugar accumulation of potatoes stored at low temperatures may be linked to activation of cyanide-resistant respiration (CRR) was investigated. After a lag period of several days, continuous HCN treatment stimulated CO₂ production of tubers stored in 20% O₂. At 1°C in 20% O₂, HCN treatment increased respiration over that effected by low temperature treatment. After several weeks of treatment, cyanide-stimulated CO₂ production was greater at 1°C than at 10°C. Sucrose and malate levels of HCN treated tubers were sometimes higher than those of the 10°C control tubers, but they were always lower than those of the 1°C control tubers. This indicated that CRR alone could not account for the sugar increases at 1°C. Storage in 2% O₂ blocked the increase in CO₂ production and changes in constituents associated with HCN treatments in 20% O₂. HCN treatment had no significant effect on chip color. The level of CRR was measured in freshly cut slices from Monona, Norchip, and Kennebec tubers previously stored at 10°C, 5°C, or 1°C for several months. Slices from tubers previously stored at 1°C had increased CRR, but there was no difference in CRR between the 5°C and 10°C treatments. Sugars accumulated at 5°C, again indicating that sugar accumulation in potatoes stored at low temperatures was at least partially independent of the activation of CRR.

Introduction

Fifty years ago, Hanes and Barker (11) found that continuous HCN treatment of intact King Edward tubers at 15°C stimulated respiration, increased sucrose content after seven days’ exposure, and increased reducing sugars after 14 days’ exposure. More recently it was reported (23) that continuous ethylene or HCN treatment of “Russet” (presumably Russet Burbank) tubers at 20°C stimulated respiration and increased sucrose after 160 hrs and 70 hrs exposure for C₂H₄ and HCN, respectively. Rychter et al. (20)
and Janes et al. (15) prepared freshly cut slices with cyanide-resistant respiration (CRR) from Norchip tubers previously treated with HCN, ethylene, or acetaldehyde vapors to stimulate intact tuber respiration at room temperature. CRR describes cellular respiration insensitive to inhibition by terminal inhibitors and by inhibitors which act between b- and c-type cytochromes (13). Janes et al. (15) concluded that CRR is not normally functional in potato tubers but that the application of cyanide and other compounds leads to its development. Solomos and Laties (23) proposed that activation of CRR in potatoes deregulates aerobic respiration with sucrose synthesis functioning as a sink for the excess energy (ATP) formed.

Storage of potatoes below 5°C stimulated respiration and increased sugars (1, 2, 14). Solomos (22) suggested that the alternate oxidase of CRR has a lower affinity for oxygen than does cytochrome oxidase. Low oxygen level was effective in suppressing the sugar (12) and malate (Sherman and Ewing, unpublished) accumulation of potatoes stored at 1°C, and Goodwine et al. (9) reported that CRR development in freshly cut slices from tubers previously stored at 1°C was blocked when tubers were stored in low oxygen. The similar results for tubers stored at low temperatures and tubers treated with HCN or ethylene suggested that the sugar accumulation of potatoes stored at low temperatures may be linked to the development of CRR. The objective of these studies was to investigate the relationship between low temperatures and CRR.

**Materials and Methods**

*Experiment 1 - Solanum tuberosum* L. cv Kennebec, Monona, and Norchip used in this experiment and in Experiment 3 were grown at the Homer C. Thompson Vegetable Research Farm in Freeville, New York. Tubers were harvested in late September, washed, graded, cured, and placed in a 10°C storage room. No sprout inhibitors were applied but sprouts were removed prior to tuber use. A 2x2x2 factorial experiment consisting of temperatures (10°C and 1°C), atmospheres (20% O₂ and 2% O₂), and HCN (with and without 240 μl/l) was conducted during March 1979. Replications were one replication each of the Monona, Kennebec, and Norchip cultivars. There were 20 tubers per sample. HCN treatments were initiated when the CO₂ evolution of tubers stored at 1°C reached a minimum. Flow rates were 8 and 4 liters hr⁻¹ for the 20% O₂ treatments at 10°C and 1°C, respectively. Flow rates for the 20% O₂ treatments were half the rates of the 20% O₂ treatments. CO₂ levels around the samples were never above 0.3%.

*Experiment 2 -* During June, 1979, freshly harvested Sebago tubers from Florida were used in a 2x2x2 factorial experiment with 3 replications. We estimate that the potatoes were received within 5 days of harvest. Tubers were stored at 15.5°C for five days and moved to 10°C for the experiment. Treatments consisted of an early HCN treatment at 10°C (with