Using HPP (Hydrogen Peroxide Plus) to Inhibit Potato Sprouting

During Storage

U. Afek,* Janeta Orenstein and E. Nuriel

Department of Postharvest Science of Fresh Produce, Gilat Experiment Station, ARO, The Volcani Center, Mobile Post Negev 2, 85-280, Israel.

ABSTRACT

Potatoes (*Solanum tuberosum* L.) samples ,cv. 'Desiree', were treated for sprout control and stored at 10 ± 1 C for 6 months. Those treated four times with HPP (hydrogen peroxide plus), applied with the "Shira Aeroponics System", had a 0% rate of sprouting. Those treated with CIPC also had no sprouting, while the nontreated control had 84%. A single treatment with HPP or CIPC resulted, after 6 months of storage at 10 ± 1, in sprouting rates of 61 and 58%, respectively, vs. 87% in the untreated control.

ADDITIONAL KEYWORDS: Potato, *Solanum tuberosum* L., sprouting, storage.

EXPLANATION OF ABBREVIATIONS

CIPC, Chloropropham

HPP, Hydrogen peroxide plus

MH, Maleic hydrazide

TCNB, 2,3,5,6-tetrachloronitrobenzene

INTRODUCTION

Sprouting is a major cause of losses in stored potatoes. Not only does it reduce the number of marketable potatoes, but intense evaporation of water from sprout surfaces also reduces the weight of the remaining tubers (Afek and Warshavsky, 1998). There are two main methods of keeping potatoes sprout free during storage: storing at low temperatures (2 to 4° C) and using sprout suppressants (Khanbari and Thompson 1996; Prange, *et al*., 1997; Rastovski, 1987).

Low temperatures, however, cause the degradation of starch to sugar and increases the tubers sweetness (Es and Hartmans, 1987a; Morell and Rees, 1986; Rees *et al*., 1981; Ross and Davies, 1992). This reduces their quality, particularly when they are intended for industrial use (Rastovski, 1987). Control atmosphere (low concentration of O_2 and high concentration of CO_2) was also found to suppress sprouting (Prange, *et al*., 1997). However, a high concentration of CO_2 can result in a physiological defect: black heart

(Afek and Warshasky, 1998).

Many chemical compounds (e.g. ethylene, camptothecin, volatile monoterpenes, jasmonates, ethanol, nonanol, abscisic acid, indole-acetic acid, dichlorbenil dimethylnaphthalene and diisopropylnaphthalene) are known to inhibit sprouting. However, most of these substances have never been used commercially, or have been used only for a short time, (Beveridge *et al*., 1981; Coleman and Coleman, 1986; Es and Hartmans, 1987b; Hartmans and Es, 1979; Prange, *et al*., 1997; Wang *et al*., 1980; Wiltshire and Cobb, 1996; Lewis *et al.*, 1997). Ozone is also has been tested as a sprout inhibitor of stored potatoes (Prange, *et al*., 1997).

The sprout inhibitors chloropropham (CIPC) and maleic hydrazide (MH) have also proved to be of value (Buitelaar, 1987; Es and Hartmans, 1987b; Hajslova and Davidek, 1986; Prange, *et al*., 1997; Yada *et al*., 1991). However, their application can be problematic. Due to environmental concerns, in several countries use of CIPC and other chemicals, are either restricted or may become restricted (Afek and Warshavsky, 1998; Es and Hartmans, 1987b). MH is applied as a foliar application in the field 4 to 6 weeks before harvest, but its timing is delicate: if the treatment is carried out too early, the yield will be reduced, but late treatment will have an insufficient effect on sprouting (Es and Hartmans, 1987b; Yada *et al*., 1991). TCNB is not effective if dormancy is broken, if the store is excessively ventilated, or if the storage temperature is kept above 10° C (Es and Hartmans, 1987b).

In recent years, several studies have found carvone to be efficacious (Oosterhaven *et al.*, 1996; Sorce *et al*., 1997; Wiltshire and Cobb, 1996). It has been registered as a sprout inhibitor and is used commercially in several countries. But because it is expensive, many countries, such as Israel, do not use it.

The present study examined HPP (G.A.T.S. Biology, P.O. Box 652 Nes Ziona 74106, Israel), a new sprout inhibitor that is based on hydrogen peroxide stabilized with a mixture of substances; it was applied with a fogger (the Shira Aeroponics System).

MATERIALS AND METHODS

Plant material and storage procedure

Potato tubers (cv. 'Desiree') were harvested from fields in Israel's northern Negev, cured for 12 days at 13 ± 1° C and 95% relative humidity (RH), and stored in three rooms. Each room (15 x 15 x 7 m^3) contained 5 perforated ducts (70 cm in diameter) which were positioned on the floor from the plenum to the opposite wall. These ducts were covered with 750 tons of potatoes, piled 5 meters high (Brook *et al.*, 1995). For each treatment, 5 sacks, each comprising 25 kg potatoes, were buried at random in each pile. The sacks, which had been attached to ropes to help extricate them, were removed from the piles once every five weeks, and sprout percentages were determined. This was repeated for 6 months per year over a three-year period.

Application of HPP and CIPC

On the first day after curing, the potatoes in room A received treatment with HPP (sole a.i.) for 10 h. Preliminary experiments showed that the concentration of HPP most effectively inhibited sprouting. The HPP was applied with the Shira Aeroponics System. Three fans (one m diameter) forced the combination of humidified air and HPP into the bottom of the plenum; this mist reached the perforated ducts, and was then pulled up through the potato pile to the vacuum space produced above the pile (Afek and Warshavsky, 1998).

In room B, CIPC was applied to the cured potatoes in accordance with standard commercial practices (60 g CIPC/ton of potatoes) (Afek and Warshavsky, 1998). Room C was the control: the Shira Aeroponics System produced humidified air as described in room A, but no HPP was added to the water.

After the treatments, the temperature in the storage rooms was reduced to 10 ± 1 C, and the RH adjusted to 95%; these settings were maintained for 6 months. The treatments were repeated every 5 weeks for a total of four treatments.

In addition, following the first treatment, 500 tubers were sampled from each pile, and stored under the same conditions as in the source treatments; this helped evaluate the effects of a single treatment with HPP or CIPC on sprout inhibition.

Statistical analysis

The experiment was conducted during 3 years in a randomized block design and a year was considered as one replicate. Each block comprised 15 sacks that was considered as 5 sub samples of 3 sacks for each treatment each month for a total of 90 sacks.

Data were analyzed by ANOVA procedures by means of the Statistical Analysis System (SAS) package (Cary, NC, USA).

RESULTS AND DISCUSSION

After 6 months of storage at 10 ± 1 C, during which the potatoes recieved 4 treatments with HPP or CIPC, a 0% sprouting rate was found in room A (treated with HPP) and in room B (treated with CIPC); an 84% rate was found in room C (control) (Table 1). (Sprouting was considered as less than 2 mm.) In the samples that were taken after the first treatment, the percentages of sprouting after 6 months at 10 ± 1 C were 61, 58 and 87% from rooms A, B and C, respectively (Table 2).

The trend today is to minimize the use chemicals in stored fresh produce (Crossley and Mascall, 1997), and to find alternatives to currently used potato sprout suppressants (Prange *et al*., 1997). Results of the present study show that HPP applied with the Shira Aeroponics System is efficacious as a sprout inhibitor (Tables 1, 2). The technology of this fogger is based on ultrasonic nebulizers; it produces very small droplets that have almost no mass, carrying the HPP as a weightless gas that covers the potatoes in the storage rooms. Microscopic examination indicated that the action of HPP in inhibition of potato sis by damaging the sprout tips.

Application of HPP by fogging with the Shira Aeroponics System technique is a method that is friendly to the environment, easy to implement and inexpensive.

ACKNOWLEDGMENTS

Contribution from the Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel. Series No. 442 -1998.

LITERATURE CITED

Afek, U. and S. Warshavsky, 1998. Problems in storage of potatoes in Israel. *In*: Levy, D. (ed.). Potato in Hot Climate. Israel Agresearch, Journal of the Agricultural Research Organization (in Hebrew, English abstract) Agricultural Research Organization (ARO), The Volcani Center, Israel. Vol. 9: 97-114.

Beveridge, J.L., J. Dalziel and H.J. Duncan, 1981. The assessment of some volatile organic compounds as sprout suppressants for ware and seed potatoes. Potato Res 24: 61-76.

Buitelaar, N., 1987. Sprout inhibition in ware potato storage. *In*: Rastovski, A. and A. van Es (eds), Storage of Potatoes: Post-harvest Behavior, Store Design, Storage Practice, Handling. Pudoc, Wageningen, The Netherlands, pp. 331-341.

Burton, W.G., 1978. The physics and physiology of storage. *In*: Harris, P.M. (ed), The Potato Crop: The Scientific Basis for Improvement. Chapman and Hall, London, pp. 545-606.

Coleman, W.K. and S.E. Coleman,1986.The effects of bromoethane and ethanol on potato (*Solanum tuberosum*) tuber sprouting and subsequent yield responses. Am Potato J 63: 373-377.

Crossley, S.J. and R.P. Mascall., 1997. Pesticide rediues - UK EC legislation, Conference Proceedings, Postharvest News and Information 8:23-26.

Edgar, A..D., 1968. Storage of potatoes. *In*: Smith, O. (ed), Potatoes; Production, Storing, Processing. The Avi Publishing Company, Westport, Connecticut, pp. 344-358.

Es, A.van and K.J. Hartmans., 1987a. Starch and sugar during tuberization, storage and sprouting. *In*: Rastovski, A. and A. van Es (Eds), Storage of Potatoes: Post-harvest Behavior, Store Design, Storage Practice, Handling. Pudoc, Wageningen, The Netherlands, pp. 79-113.

Es, A.van and K.J. Hartmans. 1987b. Dormancy, sprouting and sprout inhibition. *In*: Rastovski, A. and A. van Es (Eds), Storage of Potatoes: Post-harvest Behavior, Store Design, Storage Practice, Handling. Pudoc, Wageningen, The Netherlands, pp. 114-132.

Hajslova, J. and J. Davidek, 1986. Sprout inhibitors IPC and CIPC in treated

potatoes. Nahrung Food 30: 75-79.

Hartmans, K.J. and A.van Es, 1979. The influence of growth regulators GA3, ABA, kinetin and IAA on sprout and root growth and plant development using excised potato buds. Potato Res 22: 319-332.

Khanbari, O.S. and A.K. Thompson, 1996. Effect of controlled atmosphere, temperature and cultivar on sprouting and processing quality of stored potatoes. Potato Res 39: 523-531.

Lewis, M.D., G.E. Kleinkopf and K.K. Shetty, 1997. Dimethylnaphthalene and diisopropylnaphthalene for potato sprout control in storage. Application methodology and efficacy. Am Potato J 74: 183-197.

Morell, S. and T. Rees, 1986. Sugar metabolism in developing tubers of *Solanum tuberosum*. Phytochemistry 25: 1579-1585.

Oosterhaven, K., A.C. Leitao, L.G.M. Gorris and E.J. Smid, 1996. Comparative study on the action of S-(+)-carvone, in situ, on the potato storage fungi *Fusarium* solani var. *corruleum* and *F. sulphureum*. J Appl Bacteriology 80: 535-539

Prange, R., W. Kalt, B. Daniels-Lake, C. Liew, J. Walsh, P. Dean, R. Coffin and R. Page. 1997. Alternatives to currently used potato sprout suppressants. Conference Proceedings, Postharvest News and Information 8:37-41.

Rastovski, A., 1987. Storage losses. *In*: Rastovski, A. and A. van Es (Eds), Storage of Potatoes: Post-harvest Behavior, Store Design, Storage Practice, Handling. Pudoc, Wageningen, The Netherlands, pp. 177-180.

Rees, T., W.L. Dixon, C.J. Pollock and F. Franks, 1981. Low temperature sweetening of higher plants. *In*: Friend, J. and M.J.C. Rhodes (Eds), Recent Advances in the Biochemistry of Fruits and Vegetables. Academic Press, London, pp. 41-61.

Ross, H.A. and H.V. Davies, 1992. Sucrose metabolism in tubers of potato (*Solanum tuberosum* L.): Effect of sink removal and sucrose flux on sucrose-degrading enzymes. Plant Physiol 98: 287-293.

Sorce, C., R. Lorenzi and P. Ranalli, 1997. The effects of (s)-(+)-carvone treatments on seed potato tuber dormancy and sprouting. Potato Res 40:155-161.

Wang, C.Y., J.G. Buta, H.E. Moline and H.W. Hruschka, 1980. Potato sprout inhibition by camptothecin, a naturally occurring plant growth regulator. J Am Soc Hort Sci 105: 120-124.

Wiltshire, J.J.J. and A.H. Cobb, 1996. A review of the physiology of potato tuber dormancy. Ann Appl Biology 129: 553-569.

Yada, R.Y., R.H. Coffin, M.K. Keenan, M. Fitts, C. Dufault and G.C. Tai, 1991.

The effect of maleic hydrazide (potassium salt) on potato yield, sugar content and chip color of Kennebec and Norchip cultivars. Am Potato J 68: 705-709.

TABLES

Table 1. Sprouting of potato tubers (%) during 6 months of storage at 10 ± 1 C and 95% RH, following four treatments with HPP, CIPC or control.

Sprouting (%) during the storage period

Treatment	1 month	2 months	3 months	4 months	5 months	6 months
HPP	0 a[1]	0 a	0 a	0 a	0 a	0 a
CIPC	0 a	0 a	0 a	0 a	0 a	0 a
Control	8 b	26 b	48 b	63 b	74 b	84 b

[1]Different letters within a column indicate significant differences according to Fisher's protected least significant difference test

(*P*=0.05).

Table 2. Sprouting of potato tubers (%) during 6 months of storage at 10 ± 1 and 95% RH, following one treatment with HPP, CIPC or control.

Sprouting (%) during the storage period

Treatment	1 month	2 months	3 months	4 months	5 months	6months
HPP	0 a[1]	9 a	22 a	37 a	50 a	61 a
CIPC	0 a	8 a	20 a	35 a	47 a	58 a
Control	14 b	37 b	52 b	65 b	73 b	87 b

[1]Different letters within a column indicate significant differences according to Fisher's protected least significant difference test (*P*=0.05).

Note: Published with author's permission

Back to Potato report | Back to Shira home page