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Post Harvest Treatment with Hydrogen Peroxide Suppresses Silver Scurf (*Helminthosporium solani*), Dry Rot (*Fusarium sambucinum*), and Soft Rot (*Erwinia carotovora* subsp. *carotovora*) of Stored Potatoes

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ABSTRACT

Potato growers encounter high economic losses on a yearly basis due to potato diseases in storage. Current fungicides are becoming ineffective due to the development of resistance by potato tuber pathogens, and new and more effective chemicals are needed to replace them. Potato storage trials were conducted to determine the effect of hydrogen peroxide (H_2O_2) on the potato tuber diseases fusarium dry rot, silver scurf, and soft rot. The effect of H_2O_2 on traits that affect processing quality, such as potato glucose content, sucrose content and French fry colour, were determined before and after treatment. Potato samples (cvs. 'Shepody' and 'Norland') were inoculated with *Fusarium sambucinum*, *Helminthosporium solani*, and *Erwinia carotovora* subsp. *carotovora* before treatment. Three treatments were included in this experiment: a control (tap water); 1:100 v/v H_2O_2 to water; and 1:50 v/v H_2O_2 to water. Potato storages were set at 10°C, with 90+% relative humidity and airflow of 0.035 m^3/min/4536 kg of potatoes. Each treatment was applied as a mist using a separate humidifier at a rate of 1L/8 h. Airflow was turned on at the same time as the humidifier to allow the mist to spread through the samples. Treatments were applied daily for 2 weeks (8 h/day), and then once per week (8 h) for the duration of the experiment. H_2O_2 was effective in slowing the development of Fusarium dry rot, silver scurf and soft rot and treated potatoes were significantly less diseased compared to the untreated controls. Relative to untreated tubers, silver scurf severity was 21.0 and 15.2% less in 'Shepody', and 23.0 and 14.0% less in 'Norland' tubers treated with 1:50 and 1:100 H_2O_2, respectively. Dry rot severity was 8.1 and 5.6% less in Shepody, and 12.3 and 6.1% less in 'Norland' tubers treated with 1:50 and 1:100 H_2O_2, respectively. The severity of soft rot was 1.4 and 2.3% less in 'Shepody', and 3.4 and 3.9% less in 'Norland' tubers treated with 1:50 and 1:100 H_2O_2, respectively. Sucrose and glucose concentrations in tubers, and fry colour were unaffected by H_2O_2 treatment. Our findings indicate that hydrogen peroxide applied to potatoes after harvest is a viable option for suppressing potato diseases in storage while maintaining French fry color.

Keywords: *Erwinia carotovora* subsp. *carotovora*, fry color, *Fusarium sambucinum*, glucose, H_2O_2, *Helminthosporium solani*, *Solanum tuberosum*, StorOx, sucrose

INTRODUCTION

Integrated pest management of potato (*Solanum tuberosum* L.) diseases in Canada requires frequent application of costly pesticides to maintain high yield and quality. Despite this extensive use of pesticides, more than 20% of potato yield is lost annually to diseases and pests (Ross 1986). In order to supply the market demand for commercial potatoes, tubers must be stored from one harvest to the next. Commercial potatoes intended for consumption are generally stored between 5 and 10°C (Iritani and Sparks 1985). Accumulation of reducing sugars results in an undesirable darkening of fry color in processed potatoes (Habib and Brown 1957; Iritani and Sparks 1985). Therefore, following wound healing, potatoes intended for processing are stored at warmer temperatures (~10°C) in order to slow the accumulation of reducing sugars (Iritani and Sparks 1985).

Potato storage diseases are often difficult to control once they occur inside storages for two reasons: 1) there are very few post harvest chemicals for control of diseases registered for use on potatoes; and 2) the storage environment and conditions can favor the spread of certain diseases (Lund and Kelman 1977; Buelow *et al*. 1986; Schaupmeyer 2000). Post harvest treatments may be necessary to protect potatoes from diseases that occur or progress during storage. Such diseases include silver scurf, soft rot, dry rot, pink rot, early blight, late blight, leak, powdery scab and others (Al-Mughrabi 2005a, 2005b, 2006).

Helminthosporium solani Durieu & Montagne is the causal agent of silver scurf of potato tubers. Silver scurf is considered a storage disease of potatoes, although infection often takes place before harvest (Schultz 1916; Mooi 1968; Carnegie *et al*. 2003). Symptoms are readily observed on washed, infected tubers (Jellis and Taylor 1977). During prolonged storage, excessive moisture losses in tubers may result from increased permeability of the infected periderm (Lennard 1968; Mooi 1968; Jellis and Taylor 1977). Losses due to silver scurf have increased in North America and Europe since *H. solani* developed resistance to thiabendazole (TBZ) and other benzimidazole fungicides that have been used as postharvest and seed-piece treatments on potato tubers (Hide *et al*. 1988; Merida and Loria 1990). In the United States, TBZ was commonly applied to potato tubers before storage to control Fusarium dry rot and likely provided control of silver scurf until resistance developed. No fungicide is currently registered for control of silver scurf in the United States, and cultural control strategies are inadequate (Rodriguez *et al*. 1996). Alternative fungicide treatments are needed for the management of silver scurf.

Erwinia spp., *E. carotovora* subsp. *atroseptica* (van Hall) Dye and *E. carotovora* subsp. *carotovora* (Jones) Bergey, Harrison, Breed, Hammer, and Huntoon, are the principal causal organisms of soft rot in North America (Molina and Harrison 1977; de Boer 2002). Shallow necrotic spots

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on the tubers result from infections through lenticels. Rotting tissue is usually odourless in the early stages of decay, but a foul odour develops as secondary organisms invade the infected tissue (de Boer and Kelman 1978; Campos *et al*. 1982; Peltzer and Sivasithamparam 1985; Gudmestad *et al*. 1988).

Fusarium sambucinum (Fuckel) is the most common pathogen causing dry rot of stored potatoes in Europe and North America (Boyd 1972; Seppanen 1989). Tuber infection occurs at wound sites; shallow lesions are visible as small brown areas after approximately one month of storage. The diseased portion usually has a wrinkled, sunken appearance, and in advanced stages, tufts of white mycelium of the fungus may be apparent. Tubers may completely rot and shrivel, eventually becoming mummified with continued storage (Robinson and Ayers 1953; Boyd 1967; Boyd 1972). Crop losses due to dry rot average about 6% of total stored tubers, but losses up to 25% have been reported (Chelkowski 1989; Carnegie *et al*. 1990; Stevenson *et al*. 2001). Control of dry rot has generally been accomplished by a combination of procedures, which include avoiding damaging tubers during harvest, promoting tuber suberization (skinset) after harvest, and applying fungicides (O'Brien and Rich 1976). The fungicide TBZ is currently the only post-harvest fungicide registered for dry rot control on potatoes (Murdoch and Wood 1972; Leach and Nielsen 1975; Hide and Bell 1980; Powelson *et al*. 1993). Recently, tolerance to TBZ has been found in many *F. sambucinum* strains across the United States, Canada, and Europe (Tivoli *et al*. 1986; Powelson *et al*. 1993; Desjardins *et al*. 1993; Kawchuk *et al*. 1994; Platt 1997; Peters *et al*. 2001).

Preventing potato spoilage during storage is of great economic concern to the industry (Tsai *et al*. 2001). Most of the registered treatments are disinfestants; they work as surface sterilants and are not curative. Chlorine dioxide, ozone, and hydrogen peroxide (H_2O_2) have been shown to effectively retard the progress of storage diseases (Afek *et al*. 1999; Olsen *et al*. 2000; Afek *et al*. 2001; Norikane *et al*. 2001; Tsai *et al*. 2001; Kirk 2002; Al-Mughrabi 2005a, 2005b, 2006). These products represent good means of preventing potato spoilage during storage in combination with good storage management practices including temperature and humidity control.

StorOx (27% H_2O_2, BioSafe Systems Inc, Glastonbury, CT, USA) is a broad-spectrum disinfestant that works by oxidising fungi and bacteria, and has been used successfully during fruit and vegetable storage (Aharoni *et al*. 1994; Fallik *et al*. 1994; Afek *et al*. 1999). Hydrogen peroxide was effective in reducing the progress of potato early blight when applied in storage after harvest (Al-Mughrabi 2005a), and was also effective *in vitro* against late blight and pink rot pathogens of potatoes (Al-Mughrabi 2005b, 2006). StorOx can be used in potato storage in several ways. Firstly, it may be used to sanitize the storage area and equipment that comes in contact with the potatoes, i.e., the walls, floors, bin pilers, etc. Secondly, it may be used as a piler application to treat potatoes as they are being loaded through the bin piler just prior to storage. Thirdly, it may be injected into the storage humidification system through the plenum pipes for spot treatments (Anonymous 2000).

Growers have traditionally managed storage diseases of potatoes, at least in part by treating tubers with TBZ before entering storage. In the 1990s, resistance to TBZ in *H. solani* and *F. sambucinum* became widespread in North America (Merida and Loria 1994a, 1994b; Secor *et al*. 1994). No other options for post-harvest disease management have proven to be sufficiently efficacious. H_2O_2 has been used in the USA for some time. However, data proving its efficacy in suppressing potato storage diseases is lacking. Therefore, H_2O_2 was chosen for this study in order to examine its effect on: (1) the progress of primary storage diseases, including silver scurf, Fusarium dry rot, and soft rot, and; (2) potato quality characteristics, including glucose and sucrose content and fry color.

MATERIALS AND METHODS

Potato cultivars

The trials were conducted in 2001 and 2002. Two potato cultivars 'Shepody' and 'Norland', which are known to be susceptible to storage diseases (Sturz *et al*. 2004), were used (Elite II, Bon Accord Elite Seed Farm, New Brunswick, Canada).

Inoculation

Healthy potatoes were wounded (in the case of *Helminthosporium solani*, tubers were not wounded), placed in plastic mesh bags, and then sprayed with conidial suspension of *Fusarium sambucinum*, *Helminthosporium solani*, or a bacterial suspension of *Erwinia carotovora* subsp. *carotovora* to facilitate infection. *H. solani* was grown on V8-Juice Agar for 4 weeks. The inoculum was prepared by washing culture plates with sterile distilled water (SDW). The conidial suspension was adjusted to 1×10^4 conidia mL^{-1} with SDW using hemacytometer counts of conidia. *Fusarium sambucinum* was grown on Potato Dextrose Agar (PDA) (Difco Laboratories, Detroit, Michigan) medium for 2 weeks. The inoculum was prepared by washing culture plates with SDW. The conidial suspension was adjusted to 1×10^5 spores mL^{-1} with SDW using hemacytometer counts of conidia. *Erwinia carotovora* subsp. *carotovora* was grown on Nutrient Agar (NA) (Difco Laboratories, Detroit, Michigan) medium for 1 week, and a bacterial suspension containing 1×10^7 CFU mL^{-1} was prepared. Tubers were completely wetted with inoculum suspension at a rate of 12.5 mL kg^{-1} of potatoes. One pathogen was used on each bag of tubers. Tubers were allowed to dry before the next suspension was applied.

Experimental setup

The tubers were not treated with pesticides or sprout inhibitors before testing. Each 3-kg sample of tubers was placed in a plastic mesh bag; 162 bags were used for each cultivar, making a total of 972 kg of potatoes for the whole experiment. The bags were arranged in a layer, with approximately 91 kg of potato tubers per pallet box. Pallet boxes were 1.22 m long, 1.22 m wide and 1.07 m high.

The pallet boxes were each divided into two portions with a wooden divider. Eighteen 3-kg bags of 'Shepody' potatoes were placed in one portion, and eighteen bags of 'Norland' were placed in the other portion of the box. Each pallet box represented one experimental unit. Three units were set one on top of the other to simulate a pile of potatoes in a storage area. The bottom pallet box was placed on a pallet 0.31 m above the floor level and at the center of the plenum. A 3.8-L household humidifier (Model 631, Sunbeam Corp., Canada) was connected to a timer (Model N1507, Noma, Canada) and placed under the 0.31 m high pallet on the floor next to the plenum. The humidifier was calibrated to emit 1 L of mist per 8 h. The three boxes, including the pallet on the floor, were covered with clear plastic sheets and secured using staples and tape. The top of the uppermost box was also covered with a plastic sheet.

StorOx (27% H_2O_2), a clear, colourless liquid with a pungent odour (freezing point, -30°C; specific gravity, 1.09; pH, 1.33; solubility, complete) was supplied by BioSafe Systems, CT, USA. Three treatments were included in this experiment: a control (tap water); 1:100 v/v H_2O_2 to water; and 1:50 v/v H_2O_2 to water. Each treatment was set in a separate storage bin to prevent cross contamination. Bins were set at 10°C, with 90+% relative humidity (RH) and airflow of 0.035 m^3/min/4536 kg of potatoes. Each treatment was applied as a mist using a separate humidifier at a rate of 1L/8 h. Airflow was turned on at the same time as the humidifier to allow the mist to spread through the samples. Treatments were applied daily for 2 weeks (8 h/day), and then once per week (8 h) for the duration of the experiment.

Test strips supplied by the manufacturer were used to test the spread of the H_2O_2 through the samples. The strips were moistened with distilled water and then assembled on one end of a wire flag. The end with the strip was then inserted into each part of the pallet boxes. The change in colour to blue indicated the spread of H_2O_2 treatments in each box. This procedure was repeated each

time a treatment was applied. One bag of potato tubers per pathogen (a total of 3 bags of 3-kg each) were sampled before treatment application, and then at 2, 4, 8, 12, and 16 weeks after application.

Disease assessment

Ten tubers were randomly taken from each bag and individually assessed for severity of dry rot, soft rot, or silver scurf. The remaining tubers in each sample were used to assess fry colour and sucrose and glucose content. The severity of dry rot and soft rot (% tuber surface diseased and depth of internal necrosis) (Ayer and Robinson 1954), and silver scurf (% tuber surface diseased) was assessed.

Glucose and sucrose assessment

A modification of the Sowokinos and Preston (1988) method was followed using a Yellow Springs Instrument (YSI) model 2700 Select Biochemistry Analyzer. A minimum of five tubers were selected and 200 g of perimedullary tissue was removed from each tuber (longitudinal, from basal end to apical end). The sample was then passed through a juicer with 300 mL of distilled water and allowed to settle for 5 min. Two 4-mL samples were taken from the supernatant. In one sample, 4 mL of glucose stock solution (500 mL distilled water + 15 g sodium sulphate dibasic + 5 g sodium phosphate monobasic) was added. In the second 4-mL sample, 4 mL of sucrose stock solution (500 mL distilled water + 15 g sodium sulphate dibasic + 5 g sodium phosphate monobasic + 4 g invertase) was added. The glucose samples were read using the analyzer and the values were converted from g/L to % glucose by multiplying the readings by a factor of 0.43. The sucrose samples were left for 15 min before they were read, and the values were converted from g/L into mg/g fresh weight sucrose.

French-fry color assessment

Fry colour was not assessed for 'Norland' because it is not a French fry cultivar. Ten potatoes from each 'Shepody' sample were sliced and the central slice (longitudinal, from basal end to apical end; 0.64 cm thick) of each tuber was kept for testing. Using a disc cutter, 5.08-cm diameter discs were cut from this central piece. Discs were then rinsed with cold water, dried with paper towel and placed in fry baskets. The discs were fried at 190.6°C for 2.5 min. The samples were allowed to cool for 1 min, dried of oil residues and then placed on an Agtron and covered with a metal cup. The colour was then assessed and recorded according to the USDA fry colour chart on a scale of 0–4 (Anonymous 1988).

Statistical analyses

A modified split-split-plot design with the three treatments randomly assigned to three storage bins, each with three boxes on a single pallet was followed. These nine boxes served as the whole-plot experimental units; replicate boxes were taken within each treated storage bin. Cultivar tubers were randomized to either side of each box (split-plot treatments). A sample of 10 tubers was randomly selected at six sampling dates (0, 2, 4, 8, 12, and 16 weeks after treatment) from each side of every box, and represents the split-split-plot sampling units. Observations were taken on each of the 10 tubers for each measured trait and were averaged prior to the statistical analysis, making a total of 108 experimental units (3 treatments × 3 replicates × 2 cultivars × 6 sampling dates). Percentage data for soft rot, dry rot and silver scurf were transformed to angles prior to the analysis of variance (ANOVA).

The partitioning of the variance among the 108 units in the ANOVA followed the split-split-plot design; the means for the factorial effects and their standard errors were calculated.

To describe the response for each cultivar and treatment over storage duration, a parallel curve analysis was conducted with the underlying response estimated by a cubic spline function (GenStat Committee 2000). Like multiple linear regression, a series of models were fitted to the experimental combinations to explain the differences among the cultivar-treatment combinations over time; i.e., a single curve, parallel curves, and parallel curves with trends for each cultivar-treatment combination. Tests of significance were used to select the simplest model to explain the differences over time. The curves of the simplest model for each variate are presented in a graph with the factorial means and their standard error; transformed variates are shown on the transformed scale with arithmetic labels on the axes. Estimated mean values derived from parallel curve analyses were used in the results section. The experiment was repeated and data were pooled.

RESULTS

Effect of H_2O_2 on the development of Fusarium dry rot

A highly significant difference was noted among H_2O_2 treatments (P<0.001) and cultivars (P<0.001) with regards to the level of infection with Fusarium dry rot, averaged over a period of 16 weeks of storage (**Table 1**). The application of H_2O_2 reduced the disease severity. The severity of dry rot for the cultivar 'Shepody' in the control treatment after 16 weeks of storage was 13.3%, compared with 7.7 and 5.2% in the 1:100 and 1:50 H_2O_2 treatments, respectively. Similarly the severity of dry rot for 'Norland' cultivar in the control treatment after 16 weeks of storage was

Table 1 Mean squares and significant differences among hydrogen peroxide (H_2O_2) treatments, potato cultivars, storage dates and their statistical interactions.

		Mean Squares					
Source	**d.f.**	**Dry Rot [a] (angles)**	**Silver Scurf (angles)**	**Soft Rot (angles)**	**Glucose (%)**	**Sucrose (mg/g)**	**Fry Colour [b] (USDA 0-4)**
Among boxes							
Treatment (T)	2	219.05** [c]	378.40**	81.04**	0.0010	0.0404	0.6280
Residual	6	4.78	26.31	2.440	0.0012	0.1076	0.1511
Between sides of boxes							
Cultivars (C)	1	215.38**	259.92**	9.390	1.0827**	2.1588**	NA [d]
T × C	2	4.39	33.44	21.44	0.0002	0.0400	NA
Residual	6	5.15	15.26	15.33	0.0012	0.0801	NA
Within box sides							
Date (D)	5	166.47**	4324.87**	32.06*	0.0119**	0.4610**	1.5931**
T × D	10	21.75**	123.38**	14.70	0.0030*	0.0791	0.1973*
C × D	5	68.50**	507.89**	18.03	0.0015	0.3950**	NA
T × C × D	10	8.3	39.43**	3.62	0.0022	0.0538	NA
Residual	56	7.92	12.95	7.733	0.0014	0.0650	0.0851
Total	103						

[a] Percentage data for soft rot, dry rot and silver scurf were transformed to angles prior to the analysis of variance (ANOVA).
[b] The colour was assessed and recorded according to the USDA fry colour chart on a scale of 0–4, with 1 being the best colour and 4 extremely dark.
[c] ** Significant at 1%; * Significant at 5%.
[d] NA= Data not available.

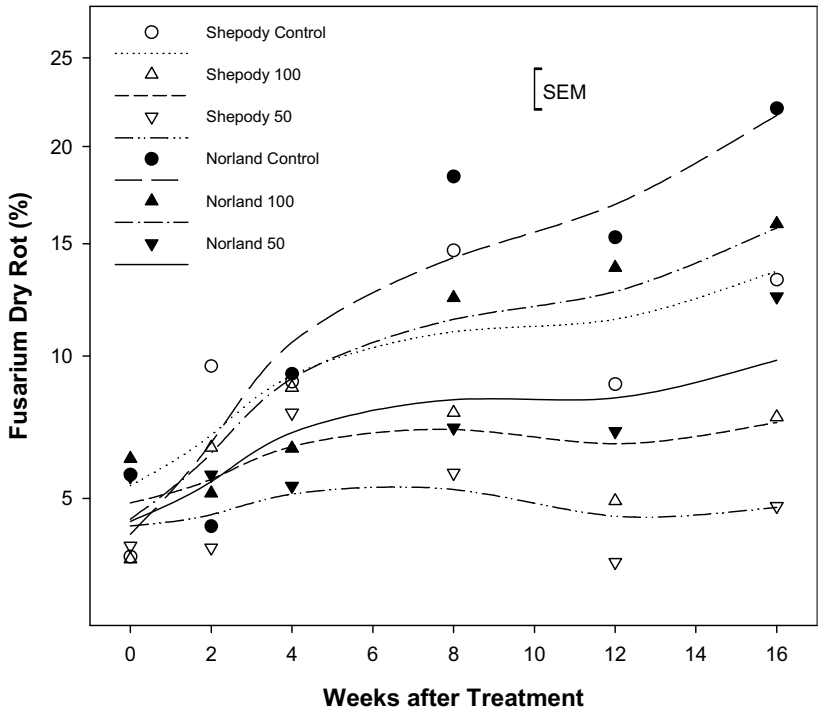

Fig. 1 Effect of hydrogen peroxide (H_2O_2) on percent severity of Fusarium dry rot that developed over 16 weeks of storage of the potato cultivars 'Shepody' and 'Norland' at 10°C and 90+% RH. Control = untreated; 100 = hydrogen peroxide 1:100; 50 = hydrogen peroxide 1:50. SEM, standard error of the mean. See **Table 1** for ANOVA results.

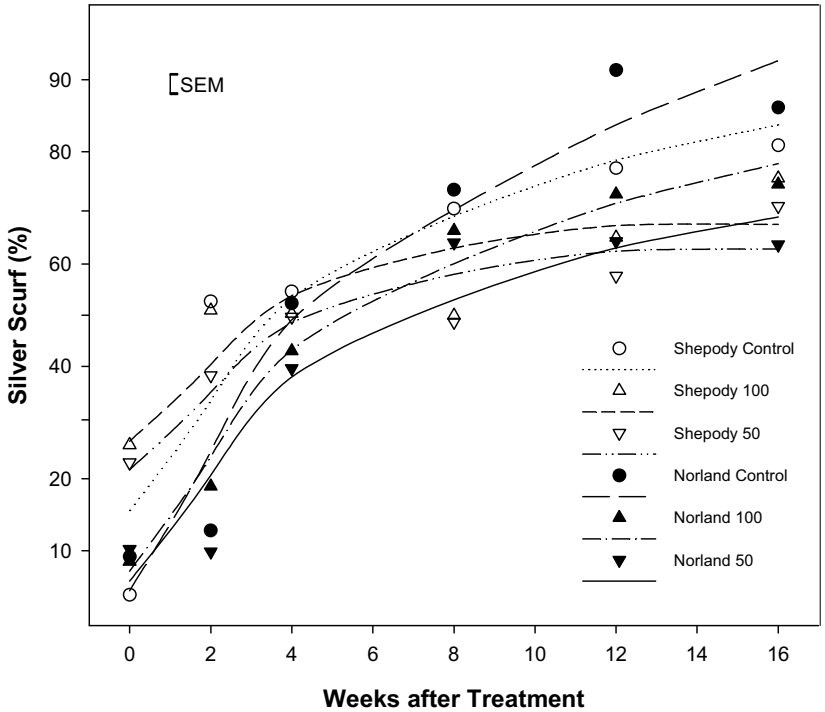

Fig. 2 Effect of hydrogen peroxide (H_2O_2) on percent severity of silver scurf developed over 16 weeks of storage of the potato cultivar 'Shepody' and 'Norland' at 10°C and 90+% RH. Control = untreated; 100 = hydrogen peroxide 1:100; 50 = hydrogen peroxide 1:50. SEM, standard error of the mean. See **Table 1** for ANOVA results.

22.3%, compared to 16.2 and 10.0% in the 1:100 and 1:50 H_2O_2 treatments, respectively (**Fig. 1**).

Effect of H_2O_2 on the development of silver scurf

A highly significant difference was observed among H_2O_2 treatments (P=0.006) and cultivars (P=0.005) with regards to the level of infection with silver scurf over a period of 16 weeks of storage (**Table 1**). Disease severity was reduced when H_2O_2 was applied. For the cultivar 'Shepody', severity of silver scurf in the control treatment after 16 weeks of storage was 84.0%, compared to 68.8 and 63.0% in the 1:100 and 1:50 H_2O_2 treatments, respectively. In the case of 'Norland', severity of silver scurf in the control treatment after 16 weeks of storage was 92.0% compared to 78.0 and 69.0% in the 1:100 and 1:50 H_2O_2 treatments, respectively (**Fig. 2**).

Effect of H_2O_2 on the development of soft rot

The level of soft rot infection differed significantly among H_2O_2 treatments (P<0.001) over a period of 16 weeks of

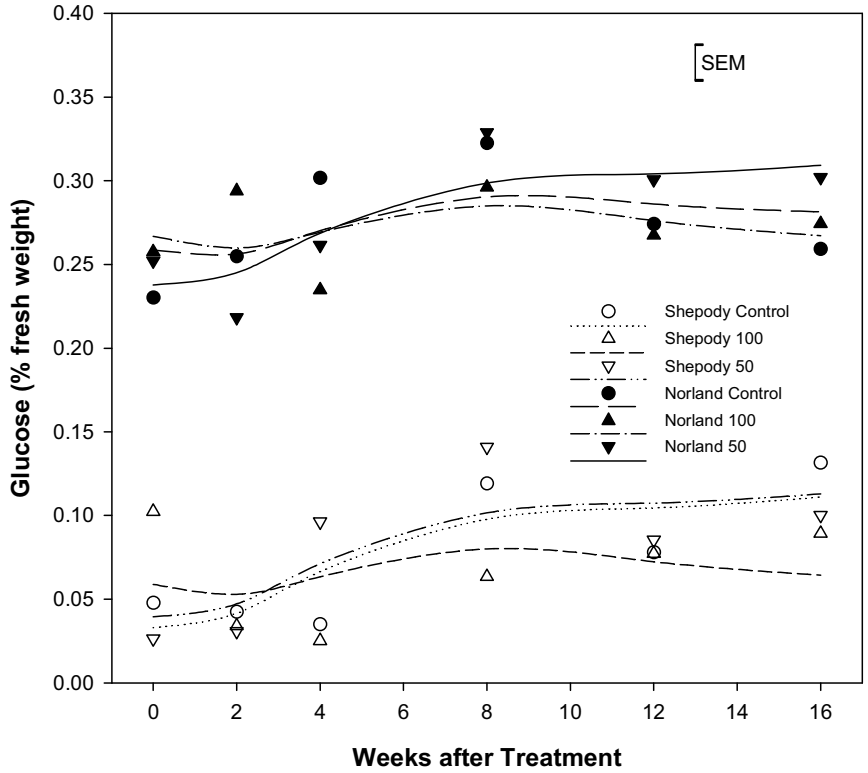

Fig. 3 Effect of hydrogen peroxide (H_2O_2) on glucose content (% fresh weight) over 16 weeks of storage of the potato cultivar 'Shepody' and 'Norland' at 10°C and 90+% RH. Control = untreated; 100 = hydrogen peroxide 1:100; 50 = hydrogen peroxide 1:50. SEM, standard error of the mean. See **Table 1** for ANOVA results.

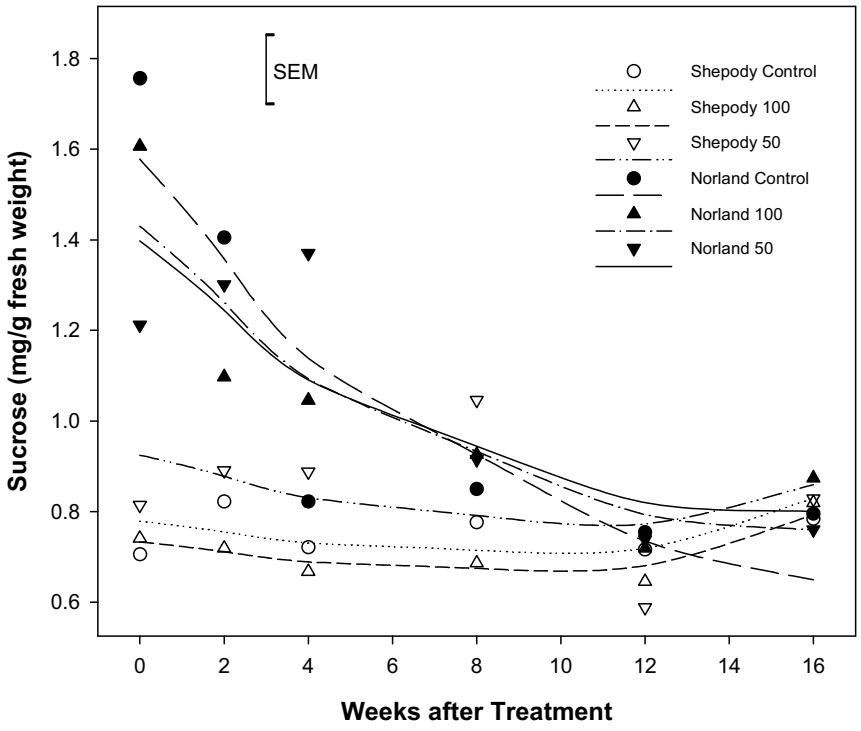

Fig. 4 Effect of hydrogen peroxide (H_2O_2) on sucrose development (mg/g fresh weight) over 16 weeks of storage of the potato cultivar 'Shepody' and 'Norland' at 10°C and 90+% RH. Control = untreated; 100 = hydrogen peroxide 1:100; 50 = hydrogen peroxide 1:50. SEM, standard error of the mean. See **Table 1** for ANOVA results.

storage (**Table 1**). The severity of soft rot was reduced when H_2O_2 was applied. Relative to untreated tubers, soft rot severity was 1.4 % and 2.3 % less in tubers treated with 1:100 and 1:50 H_2O_2, respectively, after 16 weeks of storage. In the case of 'Norland', soft rot was 4.2% in the control after 16 weeks of storage as compared with 0.8 and 0.3% in tubers treated with 1:100 and 1:50 H_2O_2, respectively.

Effect of H_2O_2 on potato glucose levels

The difference in glucose levels detected over a period of 16 weeks of storage was not significant among treatments (P=0.469) and was significant among cultivars (P<0.001) (**Table 1**). With 'Shepody', glucose content of the H_2O_2-treated potatoes was closer to the 0.1% standard level (0.11, 0.08, and 0.12% fresh weight for control, 1:100, and 1:50

treatments, respectively). Although the glucose level for 'Norland' was higher than that of 'Shepody' (0.29, 0.28, and 0.32% fresh weight for control, 1:100, and 1:50 treatments, respectively), it was not influenced by treatment (**Fig. 3**). In general, H_2O_2 did not seem to have any adverse effects on glucose amounts during storage.

Effect of H_2O_2 on potato sucrose level

Results indicated no significant difference among H_2O_2 treatments (P=0.702) and a significant difference among cultivars (P=0.002) with regards to the level of sucrose in potatoes over a period of 16 weeks of storage (**Table 1**). For 'Shepody' and 'Norland', H_2O_2 treatment did not have an adverse effect on the sucrose level over 16 weeks of storage (**Fig. 4**).

Effect of H_2O_2 on potato French-fry color

No significant difference among treatments was detected for fry colour measured over a period of 16 weeks in storage (**Table 1**). Fry colour was not assessed for 'Norland' since this variety is not used for French fry production.

DISCUSSION

Mechanical harvest can cause injury to potato tubers through bruising, cracking, abrasion, and cutting of the protective periderm of tubers. Tubers harvested at cooler temperatures are more prone to damage due to shatter bruising (Mathew and Hyde 1997). These types of damage can allow fungal and bacterial pathogens to enter and infect tubers (Lulai 2001; Maher and Kelman 1984). Potato farmers try to reduce the amount of damage at harvest through equipment calibrations and harvesting when pulp temperatures are above 10°C, but despite this effort, damage can occur.

One method of reducing disease presence in seed potatoes is to use disinfestants and cooler storage conditions to slow down infection or subsequent disease development (Iritani and Sparks 1985; Loria 2001). Broad spectrum disinfestants will only disinfest or reduce inoculum load on the surface of the tuber (Schisler *et al*. 2000; Loria 2001). The fungicide thiabendazole (TBZ) was used a postharvest treatment to prevent the development of silver scurf and dry rot. Recently, the causal organisms of silver scurf and dry rot have developed resistance to TBZ (Nolte 2000; Schisler *et al*. 2000). H_2O_2 has been used successfully to control post harvest rots on apples, pears, carrots, bananas, melons, strawberries, lettuce, cantaloupe, and for surface sterilization in processing and production operations (Aharoni *et al*. 1994; Simmons *et al*. 1997; Colgan and Johnson 1998; Gulati *et al*. 2001; Ukuku and Sapers 2001).

In storage facilities, H_2O_2 products have been used for potato, sweet potato, prune, and grape to control disease organisms (Forney *et al*. 1991; Simmons *et al*. 1997; Afek *et al*. 1999; Afek *et al*. 2001). The present study deals with the effects of H_2O_2 on potato diseases and quality parameters under storage conditions.

The cultivars 'Norland' and 'Shepody' were chosen because they are susceptible to common potato storage diseases. The results in the current study suggest that H_2O_2 can significantly retard the development of Fusarium dry rot, silver scurf, and soft rot. The product did not adversely affect glucose or sucrose levels in potatoes stored over a 16-week period. Similar results have been documented for treatment with chlorine dioxide (Harrison and Franc 1988) and ozone (Hibben and Stotzky 1969; Xu 1999; Krupa *et al*. 2001; Palou *et al*. 2001; Suslow 2001). Reducing the risk of disease during the initial stages of storage is crucial to maintain product quality and prevent further pathogen development.

Kirk (2002) compared the effectiveness of Purogene® (chlorine dioxide) (2% Chlorine Dioxide, Bio-Cide International Inc, Norman, OK) and StorOx (H_2O_2) treatments in controlling dry rot, soft rot, and late blight pathogens and their associated secondary infections. The application of these sanitary agents reduced the potential for tuber breakdown in storage. The results obtained in the present study are in agreement with these conclusions.

Potato pathogens on the surface of tubers could potentially be controlled by adding disinfestants to humidification water. In this experiment, emitting H_2O_2 through a humidifier in storage proved to be effective. Although our results indicate that this method was successful, other proposed methods include application to tubers on the piler immediately after harvest and before storage. Norikane *et al.* (2001) studied the efficacy of using water treated with chlorine dioxide and H_2O_2 in the storage facility's humidification system to control the growth of dry rot, soft rot, and late blight pathogens.

The ability of H_2O_2 to spread throughout a potato pile was not an issue in this experiment as H_2O_2 was forced to move through the pallet boxes. Furthermore, new devices have been developed to address this problem. For example, fogging systems operated by an air compressor can produce a very fine mist that can easily be forced through a potato pile. As an alternative to using test strips, oxidation-reduction (O.R.) sensors that can be installed at various depths of a potato pile are now available to monitor the distribution of the chemical. Concerns about chlorine dioxide use by the potato industry include potential odour, respiratory discomfort, and metal corrosion (Apel 1993). Experiments with chlorine dioxide gas applications to potato piles indicated that concentrations above 1 ppm were extremely corrosive to facilities and equipment (Olsen *et al*. 2003). Ozone gas has a very short half-life and therefore must be manufactured on site and used immediately. It is also highly corrosive (Palou *et al*. 2001). Both chlorine dioxide and ozone have to be manufactured on site and require special setup and equipment. H_2O_2, on the other hand, does not require preparation, activation or special equipment for setup. Household humidifiers can be used to emit the diluted product. Compared to chloride dioxide and ozone, H_2O_2 is less harmful to humans, environmentally safe, less corrosive, and does not require activation

Reducing disease losses cannot be achieved by using chemicals alone. Best management of potato tuber diseases requires additional strategies which include: (1) avoid heavily infected seed lots; (2) use an appropriate seed treatment to reduce soil-borne and seed-borne inoculum; (3) plant in rotated sites, as soil-borne inoculum is likely to decrease in the absence of potato tubers; (4) harvest fields in a timely manner to minimize the disease level before harvest; (5) store tubers at the lowest temperature possible, given the market requirements; (6) ventilate storages to prevent condensation and dead air spaces; (7) reduce the relative humidity where practical, although doing so may increase losses to black spot, shrinkage, and pressure bruising; and finally (8) storage facilities should be cleaned, pressure-washed, and treated with a disinfectant before newly harvested tubers are placed in them (Merida and Loria 1994a&b; Merida *et al*. 1994; Rodriguez *et al*. 1996; Olivier *et al*. 1998; Olivier and Loria 1998).

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