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Effect of Post-harvest Temperature on Potato Piece Rot in Relation to Suberin and Periderm Development

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ABSTRACT

As the important pathogens of potato storage diseases, *Fusarium solani*, *F. reseum*, *F. oxysporum*, and *Erwinia carotovora* were isolated from rot potato tubers. The cut potato pieces of the three cultivars, Epicure, Irish Cobbler, and Superior were held in moist chambers of 4°, 14°, 24°, and 34°C for 1, 3, 5, and 7 days and then rated for suberin and periderm development. The cut potato pieces thus treated were inoculated with the four organisms and held at 24°C for 9 days and then rated for decay.

As the temperature and period of holding increased, more suberin and periderm were developed with decrease in decay. Although there were differences in pathogenicity of the organisms, varietal reaction and protective barrier development, the effect of temperature and holding period had greater importance for decay prevention. At 4°C within 7 days of holding period the potato pieces developed no protective barrier with severe decay. It is required to avoid placing cut potatoes directly in cold storage of the low temperature. At 34°C the pieces developed abundant protective barriers even though decay occurred in somecases. Practically no decay was found with moderate protective barrier development after 3 days and 5 days at 24°C and 14°C, respectively. Since the potato pieces decayed occasionally during the holding period when they were held at the higher temperature, the holding at 14°C for longer than 5 days is considered to be feasible for prevention of storage rots.

INTRODUCTION

In accordance with national requirement of increased potato production for a partial substitution of staple food grains such as rice, wheat, and barley with potatoes in Korea, researches in the field have been intensified since a few years ago. Nearly four-fifth of the potato cultural area is of spring potatoes of which

harvest time falls in July. During the subsequent storage period of warm and humid summer the high incidence of tuber rots is hindering the development of potato industries in Korea.

Han et.al. (7) reported in potato storage experiment that 2.90% to 5.48% of the tubers decayed during the five months period from July to November in 1973, while the percentages of decay ranged from 3.48 to 11.52 depended on different types of storage facilities during the same period in 1975 according to Yoon and Son.(24). They found also that the tubers decayed as much as 39.42% to 44.65% when potatoes they purchased at downtown markets were included in the experiment. The survey made by the author on diseases and other damages of harvested potatoes during the summer of 1976 showed that more than 5% may have been lost due to *Fusarium* species and *Erwinia carotovora.* (unpublished data).

In the United States of America, the decay of harvested potatoes caused by *Fusarium* species alone was 3.75% for the 5 years average from 1922 to 1926. The decay of potatoes was assumed much greater when it was added with such decay as caused by other pathogenic organisms includiug *Erwinia carotovora.* (16, 18). *Fusarium sulphureum*(*F. roseum*) and *F. coeruleum*(*F. solani*) were invariably associated with decay of tubers including those planted as seed, but were able to produce only minor lesions on stolons and stems. *F. trichothecioides*(*F. roseum*) was reported as strictly a storage parasite incapable of infecting plants but able to attack any subterranean part of living plants especially fully grown tubers. (20) *Erwinia carotovora* and *E. atroseptica* have been reported incurring the most serious tuber rots among the bacterial species. (5, 16)

Cold storage and refrigeration are used practically in Korea as well as in other countries in order to prevent activities of the decay organisms and preserve the fresh appearance of potatoes in transit and storage. When the low temperature facilities are employed, the temperature of tubers may be around 4.5°C at which skinned and injured tubers are considered generally neither dry nor decay. Under commercial handling, such potatoes may be exposed to higher temperatures often prevailing in market channels. Even if the tubers may appear uninjured when removed from the temperature, rots may become pronounced at the high temperatures. (15, 21)

As the prestorage treatment for prevention of potato storage rots, many workers (1, 3, 13, 14, 18, 21) have referred to suberization and wound periderm development as protective barrier in relation to effect of temperature and relative humidity. Largely because of its practical significance, the protective barrier in potato tubers has been the subject of frequent investigations. Among the early studies of protecive barrier development, atmospheric moisture is reported essential for the protective barrier formation and that suberization initiated before the periderm development which prevented the invasion of decay organisms.

Priestley and Woffenden (13) found that within a period of 12 to 36 hours at room temperature the walls of cells in close neighbourhood of the cut surface appeared darker due to a deposit of suberin upon them. Artschwager(2, 3) reported that the development of suberin was slowest at 2.5°C and became more rapid as the temperature was increased up to 21°C. Smith and Smart (18) found that the development of suberin and periderm was more pronounced on potato slices held at the temperature range of 21°C and 27°C than those held at lower temperature.

Langerfeld (10) reported that infection by *Fusarium coeruleum* and *F. sulphureum* was more frequent at much lower temperature than at 10°C or 15°C and frequently decreased with time elapsing between wounding and inoculation, and rapid spread of decay occurred as soon as the tubers attained a high temperature. Ali et.al. (1) found that the largest difference in the rate of suberization and periderm development was attributed to the difference in temperature at which tubers were stored after cutting, and lesser difference was observed between potato varieties.

In practices, the large amounts of potatoes are damaged by skinning, cutting, and bruising during the period of harvesting, grading, transporting, handling and storing. Since the decay organisms are present in field soil or tuber surface, the damages incurred may bring the contaminated soil in contact with the exposed inner tissues of tubers where the organism

grow and cause serious decay when environmental conditions are favorable. (10, 18, 21).

With the objective to prevent potato tuber rots during storage period, the effect of diverse temperatures for varying periods on decay of cut potato pieces of the three cultivars was studied by inoculation with the four decay organisms in relation to suberin and periderm development.

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MATERIALS and METHODS

Isolation of *Fusarium* species and *Erwinia Carotovora*

Isolations were made from rot tubers of potato cultivar Irish Cobbler that were harvested at the experimental field plot of the Horticulture Experiment Station in Suweon in the end of October 1975 and stored in a low temperature storage of approximately 4°C during the subsequent winter.

Fusarium solani, *F. roseum*, and *F. oxysporum* were isolated by plating 0.2ml aliquots of a series of dilution from water suspension of spores taken from the colonies developed on lesions onto potato dextrose agar(PDA) buffered at PH 3.1 with phosphate buffer as done by Worf and Hagedorn(23). Their identifications were followed by the methods of Snyder and Hansen(19), Toussoun and Nelson(20), and Matuo (12).

Erwinia carotovora was isolated by using the selective medium of Kado and Heskett(9) containing 10g arabinose, 5g casein hydrolysate, 7g LiCl, 3g glycine, 5g NaCl, 0.3g $MgSO_4 \cdot 7H_2O$, 50mg sodium laulyl sulfate, 60mg bromthymol blue, 100mg acid fuchsin, and 15g agar per liter of distilled water. The medium was adjusted to PH 8.2 with 1 normal NaOH before autoclaving and had PH 7.0 after autoclaving. The identification was made by following Bergey's manual (4) along with tests of Gram staining, pathogenicity on carrot root and potato tuber, and electron microscophy.

Treatment of potato tubers prior to inoculation

Potato tubers of the 3 cultivars, Epicure, Irish Cobbler, and Superior that were harvested at the experimental plots of the Horticulture Experiment Station in Suweon in the beginning of July 1976 were shared and kept in a 4°C storage and used according to necessity.

The tubers were scrubbed in tap water several times and surface disinfected by soaking in 1% NaOCl for about 3 minutes and then dried in the air. They were cut with an ethanol flamed knife into quarter pieces, put in moist chambers made of plastic containers that were containing wet cotton and covered with aluminium foil, and placed in 4 incubators of 4°C, 14°C, 24°C, and 34°C for 1, 3, 5, and 7 days before inoculation of the decay organisms or investigation of suberin and periderm development. Three samples were taken and rated for each of the treatments.

Inoculation

Each of the 3 *Fusarium* species was cultured on potato dextrose ager in an incubator of 24°C for 5-7 days. Cultural disks of 4mm in diameter with agar were cut out from the advancing edges of the culture in petri dishes of 9 cm diameter with a buisket cutter. The isolate of *Erwinia carotovora* was cultured on nutrient agar of the petri dishes in the same incubator for 48 hours. The disks of the same type carrying approximately 2.5×10^5 bacterial cells were cut out with the buisket cutter that was dipped in ethanol and flamed.

At the end of each of the holding periods, the cut tuber pieces of the 3 cultivars kept in the moist chambers were taken out and inoculated by placing the disks with cultural surface downward on the cut potato pieces. They then were put in moist chamber of 100% relative humidity and placed in an incubator of 24°C for 9 days until rating of decay. For the

rating the numerical scale of 0–5 system was used. (Fig.1).

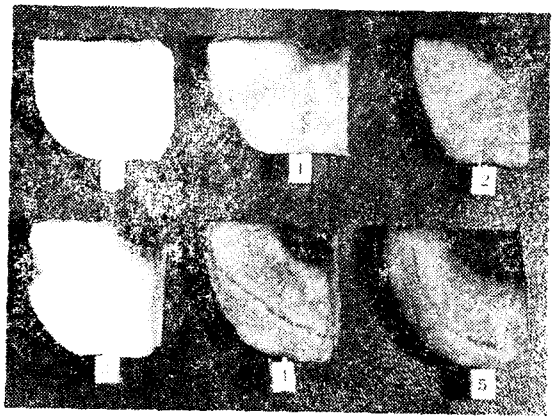

Fig. 1: Decay index in millimeters ot depth penetrated into the cut potato pieces: 0: none, 1: less than 2.5mm, 2:2.6–5.0mm, 3:5.1–7.5 mm, 4:7.6–10.0mm, and 5:above 10mm.

Suberin and periderm development

After holding the cut potato pieces in the moist chambers for each of the periods, the tissue blocks of 0.5 x 0.5 x 1.0cm were cut out from the corresponding location of the cut pieces to that of inoculated ones, fixed in formalin acetic acid, dehydrated in ethanol and xylene series, and then embedded in paraffine of melting point 52°–54°C as described by Johansen(8), and Sass(17).

Sections of 15μ thickness were cut from these blocks with a rotary microtome, placed in distilled water for about 20 minutes, stained with 1% gentian violet as described by Smith and Smart(18), and then examined under microscope for rating suberin and periderm development. Suberized areas were stained purple or blue whereas nonsuberized areas remained hyaline or colorless. Numerical ratings were made with the suberin index that 0:none, 3:outer cell walls stained dark extending about two cell layers deep, 5:outer cell walls stained dark extending three or more cell layers deep, 1, 2 and 4:intermediates. Periderm was rated by estimation of cambium like cells newly developed, of which the index was as followings. (Fig. 2).

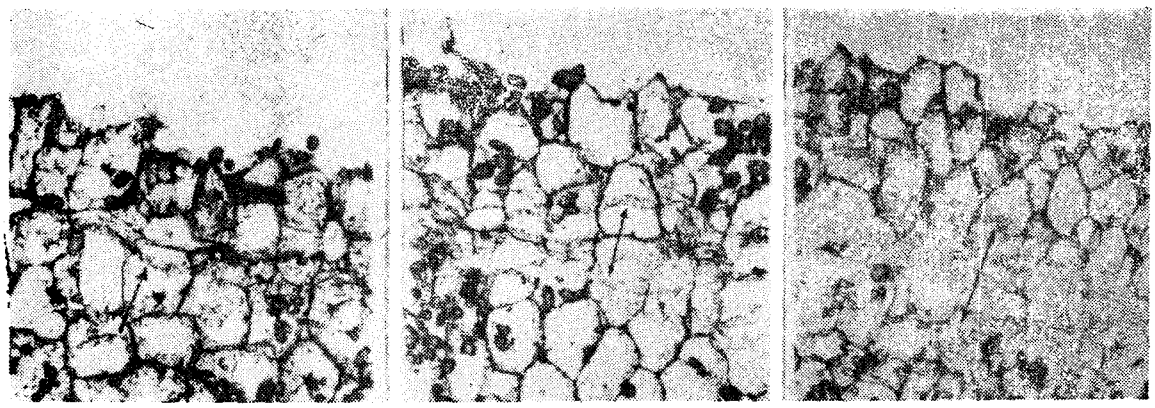

Fig. 2: Periderm index: 0:none, 1:dividing cells 1 or 2 layers deep irregularly distributed, 2:dividing cells 2 or 3 layers deep continuous. 3 : dividing cells 3 or more layers deep continuous

RESULTS

Decay

At the holding temperature 4°C: Decays were most serious compared with those held at the other temperature levels. Tte higher the temperature the lower became the decay caused by the subsequent inoculations. There was no distinct difference with the average rating 3.6 throughout the holding periods. Among the 4 decay organisms, *Fusarium roseum* caused the most decay followed by *Erwinia carotovora*, *F. solani*, and *F. oxysporum*. No remarkable difference in decay was observed among the cultivars.

At the 11°C:After 3 days of holding, decay was reduced to 1.7 in the average rating. Afer 5 days, none of the cultivars was decayed by *F. oxysporum*. Epicure and Irish Cobbler was not decayed by *F. solani* while Superior decayed. *Erwinia carotovora* caused decay on Epicure and Superior but did not on Irish Cobbler. All of the cultivars decayed by *F. roseum* after the same period as above. After 7 days, none of the organisms was able to cause decay on any o

the cultivars.

At the 24°C: After one day of holding, decay was markedly reduced although all the cultivars were susceptible to the decay organisms. After 3 days, Epicure and Superior were susceptible to *F. roseum*. After 5 days and longer period, no cultivars decayed by any of the organisms.

At the 34°C: After one day, decay was further reduced to 2.4 in the average rating from 3.6 of the 4°C. After 3 days or longer period, there was no decay regardless of the organisms or of the cultivars. At this high temperature, however, decay occurred in some cases during the holding period prior to the inoculation.

Suberin and periderm development

At the holding temperature 4°C: The cut potato pieces showed no suberin development until after 5 days except in Irish Cobbler. After 7 days, suberin was detectable in all of the cultivars. Irish Cobbler showed relatively rapid or more suberin development than the other varieties. No periderm was developed in any of the cultivars regardless of the holding period. After one day of holding, periderm was not developed regardless of the holding temperature.

At the 14°C: After one day, the tuber pieces of all the cultivars showed comparatively more suberization in cell walls of the outer layers than that was developed after 7 days at 4°C. However, there was no dividing cells of periderm development in any of the cultivars. After 3 days, suberization was increased 3 folds or more over that developed for one day at the same temperature, and the dividing cells appeared irregularly in the cells of the second or the third cell layers from the cut surface. After 5 days, suberin development was still restricted within one cell layer deep from the cut surface with the average rating 2.2 for the 3 cultivars. At this stage, the dividing cells increased and began to join each other forming an intermittent layer. After 7 days, suberization was extended 2 cell layers deep with the color darkened. The new layers of dividing cells became continuous in a few layers at about the third cell layer from the cut surface.

At the 24°C: After one day, suberization become more than double of that developed at 14°C for the same period. After 3 days, it was extending beyond one cell layer deep with the average rating 2.3 which was a little more than that developed at 14°C for 5 days. The dividing cells of periderm were more than those appeared after 5 days at 14°C but less than those appeared after 7 days at this low temperature. After 5 days, suberization was developed approximately 2 cell layers deep from outside layer of the darker color becoming lighter inwardly. The dividing cells became continuous in a few layers forming the wound periderm which was inereased further in accordance with increase in the period of holding. After 7 days, suberization was still increased to the average rating 4.3 covering approximately 3 cell layers deep. The rating of periderm reached 2.4 in the average for the 3 cultivars of which Irish Cobbler showed the most and Superior the least and Epicure was intermediate in suberization.

At the 34°C: After one day, suberization was higher over that developed at 24°C for the same period. After 3 days, it was increased to the average rating of 2.8 covering approximately 2 cell layers deep. The dividing cell layers of periderm were more than those developed for the same period at 24°C but less than those developed after 5 days at this low temperature. Suberization was covering more than 2 cell layers in Irish Cobbler after 5 days but remained within 2 cell layers in Epicure and Superior.

Decay and the protective barriers

Decays were most severe by supsequent inoculation with the four organisms when there was little suberin or no periderm development as in case of holding temperature 4°C throughout the periods of holding. Suberin alone before the development of periderm was still effective for reduction of the decay as in cases of after one day of holding regardless of difference in temperature.

As the temperature and period of holding prior to inoculation was increased, more suberin and periderm were developed whereas the decays by the four species of organisms were decreased. Effect of temperature on suberin and periderm development or on decay of the potato pieces was greater than that of the organisms or of the cultivars.

As the coefficients of correlation between the ratings for decay and suberization showed −90 to −93 while those between suberization and periderm development were +98, the development of suberin

Table 1: Decay ratings[a] of potato pieces held for 9 days at 24°C after inoculation with the 4 decay organisms, and suberin and periderm ratings[b] after 1, 3, 5, and 7 days holding periods at the 4 different temperatures prior to inoculation:

Holding days prior to inoculation	Organism or Protective barrier	The pieces of potato cultivars held at indicated temperature prior to inoculation[c]															
		4°C				14°C				24°C				34°C			
		E[b]	I	S	Av.	E	I	S	Av.	E	I	S	Av.	E	I	S	Av.
1	*F. solani*	3.2	3.1	3.4	3.2	2.8	2.6	2.9	2.8	2.5	2.3	2.6	2.5	2.2	2.0	2.4	2.2
	F. roseum	4.7	4.4	5.0	4.7	4.2	3.9	4.5	4.2	3.8	3.4	4.0	3.7	3.2	2.9	3.5	3.2
	F. oxysporum	2.3	2.2	2.4	2.3	2.0	1.9	2.1	2.0	1.6	1.5	1.7	1.6	1.3	1.2	1.4	1.3
	E.carotovora	4.2	3.9	4.4	4.2	3.7	3.4	4.0	3.7	3.4	3.1	3.5	3.3	2.7	2.5	3.0	2.7
	Average	3.6	3.4	3.8	3.6	3.2	3.0	3.4	3.2	2.8	2.6	3.0	2.8	2.4	2.2	2.6	2.4
	Suberin	0.0	0.0	0.0	0.0	0.3	0.5	0.2	0.3	0.7	1.0	0.4	0.7	0.9	1.2	0.6	0.9
	Periderm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	*F. solani*	3.3	3.0	3.5	3.3	1.4	1.1	1.6	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	F. roseum	4.6	4.4	5.0	4.7	2.5	2.0	2.9	2.5	0.4	0.0	0.8	0.4	0.0	0.0	0.0	0.0
	F. oxysporum	2.3	2.1	2.5	2.3	0.7	0.4	1.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	E. carotovora	4.2	3.7	4.4	4.1	2.0	1.8	3.2	2.0	0.0	0.0	0.2	0.1	0.0	0.0	0.0	0.0
	Average	3.6	3.3	3.9	3.6	1.7	1.3	1.9	1.7	0.1	0.0	0.3	0.1	0.0	0.0	0.0	0.0
	Suberin	0.0	0.0	0.0	0.0	1.2	1.6	1.0	1.3	2.3	2.7	2.0	2.3	2.7	3.2	2.4	2.8
	Periderm	0.0	0.0	0.0	0.0	0.5	0.6	0.4	0.5	1.0	1.2	0.9	1.0	1.2	1.4	1.1	1.2
5	*F. solani*	3.2	3.0	3.4	3.2	0.0	0.0	0.4	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	F. roseum	4.7	4.4	5.0	4.7	0.6	0.2	1.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	F. oxysporum	2.4	2.2	2.5	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	E. carotovora	4.1	3.9	4.4	4.1	0.4	0.0	0.7	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Average	3.6	3.4	3.8	3.6	0.3	0.1	0.5	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Suberin	0.0	0.1	0.0	0.0	2.1	2.6	1.8	2.2	3.3	3.8	2.7	3.3	3.8	4.4	3.3	3.8
	Periderm	0.0	0.0	0.0	0.0	0.9	1.0	0.8	0.9	1.7	2.0	1.5	1.7	1.9	2.3	1.8	2.0
7	*F. solani*	3.2	3.1	3.4	3.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	F. roseum	4.6	4.4	5.0	4.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	F. oxysporum	2.4	2.2	2.6	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	E. carotovora	4.2	3.8	4.4	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Average	3.6	3.4	3.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Suberin	0.1	0.2	0.1	0.1	2.7	3.3	2.5	2.8	4.3	4.8	3.7	4.3	4.5	5.0	4.0	4.5
	Periderm	0.0	0.0	0.0	0.0	1.3	1.5	1.2	1.3	2.4	2.8	2.1	2.4	2.7	3.0	2.3	2.7

a) Decay index: 0:none, 5:above 10 millimeters penetrated, 1-4: intermediates.

b) Suberin index: 0:none, 5:more than 3 cell layers stained dark, 1-4: intermediates.
Periderm index: 0: none, 3:dividing cells 3: or more layers deep continuous, 1-2: intermediates.

c) Based on rating of 3 samples.

and the development of decay were closely related each other in negative direction while suberization and periderm development were closely related positively. (Table 2). The coefficients of determination showed that 80% to 87% of the variation in decays were associated with variation in development of suberin. The coefficients of determination between suberization and periderm development indicated that 96% of the variation in the two variables was concurrent. these results imply that the development of suberin is closely accompanied by the development of periderm both of which are highly effective in preventing the decays caused by the four decay organisms.

Table 2: Correlation of average decay ratings of potato pieces held for 9 days at 24°C after inoculation with the 4 species of decay organisms, and average of comparable suberin and periderm ratings after 1, 3, 5, and 7 days of holding periods at 4°, 14°, 24°, and 34°C:

Factors correlated	Correlation coefficients	Coefficients of determination
Decay by *Fusarium solani* and Suberin	−0.91	−0.83
〃 〃 *roseum* 〃	−0.93	−0.87
〃 〃 *oxysporum* 〃	−0.90	−0.80
〃 *Erwinia carotovora* 〃	−0.92	−0.85
Suberization and Periderm development	+0.98	+0.96

DISCUSSION

As the temperature increased from 4°C to 34°C, the protective barrier development increased steadily in spite of the occasional decay at the higher temperature while there was no remarkable difference in the rate of suberin, periderm, and decay development according to the cultivars and the organisms. The effects of temperature on suberin development are contradictory to those of Artschwager (2) in the respect that increase in temperature from 21°C to 30°C appeared to have no effect on the rate suberization. At the all temperature levels differences were shown in the rate of suberization and periderm development in the present study.

Within 7 days of holding period, 4°C was too low for the potato pieces to develop the protective barrier that could protect from invasion of the decay organisms. This is similar to the findings of the previous workers (2, 22) that suberin development did not appear at 2.5°C until after 5 days with periderm development appeared after 9 days at 7°C. Furthermore, Smith and Smart (18) and Weiss et. al. (22) found that the potato pieces held at low temperatures between the above two began to show little development of the protective barrier even after 10 days with serious decay by various *Fusarium* species including *F. trichothecioides*, *F. coeruleum*, and *Erwinia carotovora*. Therefore, it is obvious, placing freshly harvested potatoes directly into a storage of such a low temperature has to be discontinued in order to prevent storage rots.

When the potato pieces were held at 34°C for 3 days, the protective barrier developed with no decay by the organisms. The present study is generally similar to the study by Weiss et. al. (21) that the wound healing was complete after one day at approximately 35°C with no decay in spite of the difference in holding period. Greater importance, however, lies in the point that the author found occasional decay during the holding period at this high temperature prior to inoculation. Similar cases were reported by Artschwager and Starrett (3) and by Weimer and Harter (21) from their study with sweetpotatoes that at higher temperature the roots decayed before they could conduct investigation on the protective barrier development. The result may have been due to some organism already inhabited in the cut potatoes were able to grow faster than the development of protective barrier if it were not of physiological nature. Further investigation may be required for identification of the causal organism or clarification of the physiological aspect of the tubers at this high temperature.

Holding the potato pieces at 24°C for about 3 days

was experimentally effective for prevention of decay based on the present study. The author, however, considers this temperature is so favorable for the organisms on the cut tuber surfaces as to grow abundantly that serious decay may be induced by any slight injuries that may be incurred subsequently. Lauritzen (10) and Smith and Smart (18) reported that various fungal species as well as bacterial species grow most rapidly at the range of 21°C and 29°C which is favorable also for development of the protective barrier. Since the harvest time of spring potatoes occupying most of the annual production in Korea falls in the early summer days, the temperature lower than 20°C is not readily available without construction of storage facilities for the special purpose. Therefore, in case it is inevitable to hold the harvested potatoes at a temperature within the optimum range, it is considered that an extreme care must be paid to avoid destruction of the developed protective barrier by handling for storage.

The potato pieces held at 14°C for 5 days showed almost no decay even though the protective barrier development was relatively less than that at the higher temperature for the comparable period. Similar results were reported by Ali et. al. (1) and other investigators (18, 22) that the rate of suberization and periderm development was inhanced with no decay when the wounded potatoes were kept at various temperature between 10°C and 16°C for varying period compared between 0°C and 7°C. Because 14°C is not only out of the optimum temperature range for growth of the various decay organisms but also sufficient for development of the protective barrier, the author considers it will be effective for application in the potato industries to prevent the tuber rots. Since the temperature during the harvest period in Korea is so higher than the required that construction of special facilities wili be necessary to lower the temperature down. As the causal organisms of the potato tuber rots were identified in the present study, further investigation of another mechanism of decay between the host and parasites may be useful in developing an improved method of the tuber rot prevention.

As conclusion, in order to prevent potato tuber rots during storage period, direct cold storage or refrigeration needs to be avoided while it is recommendable to hold the harvested or cut and wounded tubers at the prestorage temperature of approximately 14°C for a period longer than 5 days.

摘 要

감자 貯藏病으로서 重要한 *Fusarium solani*, *F. roseum*, *F. oxysporum* 및 *Erwinia carotovora* 를 分離 同定하고 收穫後에 供試品種 Epicure, Irish Cobbler, 및 Superior의 塊莖을 切斷하여 4°, 14°, 24°, 및 34°C 各 溫度의 濕室에 1, 3, 5, 및 7日間 豫置한 後 suberin 및 periderm 形成을 檢鏡하였다. 그리고 위와 같이 處理한 塊莖에 4種의 病原菌을 接種하여 9日間 定置한 後 腐敗度를 調査하였다.

豫置溫度가 높을 수록 또 그 期間이 길어짐에 따라 保護膜으로서의 suberin 및 periderm 形成이 增加하였으며 腐敗는 減少되었다. 供試菌種間의 病原性, 品種에 對한 反應, 保護膜 形成에도 差異가 있었으나 豫置溫度 및 期間의 效果가 腐敗防止에 더 重要하였다. 4°C에서는 7日以內의 豫置期間에 保護膜은 거의 形成되지 않았으며 腐敗는 甚하였고 34°C에서는 大體로 이와 反對였다. 그러므로 切傷감자를 바로 4°C에 冷藏함은 避하여야 할 것으로 본다. 24°C에서 3日 14°C에서 5日이 지나면 腐敗되지 않았으며 suberin 및 periderm 形成은 中程度였다. 高溫에서는 豫置 期間中에 塊莖이 腐敗되는 수도 있으므로 그 適溫을 避하여 14°C에 5日 以上 豫置한 後에 貯藏하는 것이 實用的이라 生覺된다.

LITERATURE CITED

1. Ali, S.A., Nelson, D.C.and T.P. Freeman 197 Suberization and periderm development in Nor chief and Red Pontiac potatoes. Am. potato J 52: 201-209.
2. Artschwager, E. 1927 Wound periderm formatio in the potato as affected by temperature an humidity. J. Agric. Res. 35(11): 995-1000.
3. Artschwager, E. and R.C. Starrett 1931 Suberiz tion and wound periderm formation in sweetpota and gladiolus as affected by temperature ai relative humidity. J. Agric. Res. 43(1): 353-36
4. Buchanan, R.E. and N.E. Gibbons 1974 Burgey manual of determinative bacteriology. 8th ed. T Williams and Wilkins Co, Baltimore. 1246p.
5. Boyd, A.E.W. 1972 Potato storage diseas

Reprint from Rev. Plant Pathol. 51: 297–321.

6. Gorodetskii, V.S. 1971 The effect of temperature on the resistance of different potato variedry rot. Tr. NII Kartof. kh-va. 1971(8): 228–232.
7. Han, P.J., Lee, S.J.and Y.K. Min 1973 Experiments on potato storage (in Korean). p.355–359. In annual report of research, Inst. Agric. Eng. and Util., ORD, Korea.
8. Johansen, D.A. 1940 Plant microtechnique. McGraw Hill Publish Co, New York. 523p.
9. Kado, C.I. and M.G.Heskett 1970 Selective media for isolation of *Agrobacterium*, *Corynebacterium*, *Erwinia*, *Pseudomonas*, and *Xanthomonas*. Phytopathology 60: 969–976.
10. Lauritzen, J.I. 1935 Factors affecting infection and decay of Sweetpotatoes by certain storge rot fungi. J. Agric. Res. 50(4): 285–329.
11. Langerfeld, E. 1973 Einfluss der temperatur auf den befall von Kartoffelknollen durch pilze der gattung *Fusarium* Lk. Potato Res. 16: 224–233.
12. Matuo, T. 1972 Taxonomic studies on phytopathogenic *Fusaria*. Ann. Phytopathol. Soc., Japan. 38: 167–169.
13. Nielsen, L.W. and J.T. Johnson 1974 Post harvest temperature effect on wound healing and surface rot in sweetpotato. Phytopathology 64: 967–970.
14. Priestley, J.H. and L.M. Woffenden 1923 The healing of wounds in potato tubers and their propagation by cut sets. Ann. Appie. Biol. 10: 96–115.
15. Radtke, W. and A. Escande 1973 Pathogenicity of strains of a collection of *Fusarium* species on cultivars of *Solanum tuberosum*. Universidad Nacional de la Plata. 49(1): 61–80.
16. Ramsey, G.S, Wiant, J.S. and M.A. Smith 1949 Market diseases of fruits and vegetables, Potatoes. USDA miscellaneous publication 98: 1–60.
17. Sass, J.E. 1966 Botanical microtechnique. The Iowa St. Univ. press. 228p.
18. Smith, W.L. Jr. and H.F. Smart 1955 Relation of soft rot development to protective barriers in Irish potato slices. Phytopathology 45: 649–654.
19. Snyder, W.C. and H.N. Hansen 1940 The species concept in *Fusaria*. Am. J. Botany 27: 64–67.
20. Toussoun, T.A. and P.E. Nelson 1968 A pictorial guide to the identification of Fusarium species. The Penn. St. Univ. Press. 47p.
21. Weimer, J.L. and L.L. Harter 1921 Wound cork formation in the Sweetpotato. J. Agric. Res. 21: 637–647.
22. Weiss, F., Lauritzen, J.I. and P. Brierly 1928 Factors in the inception and development of *Fusarium* rot in stored potatoes. USDA Tech. Bull. 62: 34p.
23. Worf G.L. and D.J. Hagedorn 1961 A technique for studying relative soil population of two *Fusarium* pathogens of garden peas. Phytopathology 51: 805–806.
24. Yoon, I.H. and Y.K. Son 1795 Experiments on potato storage(in Korean) p. 349–359. In annual report of research, Inst. Agric. Eng. and Util., ORD, Korea.