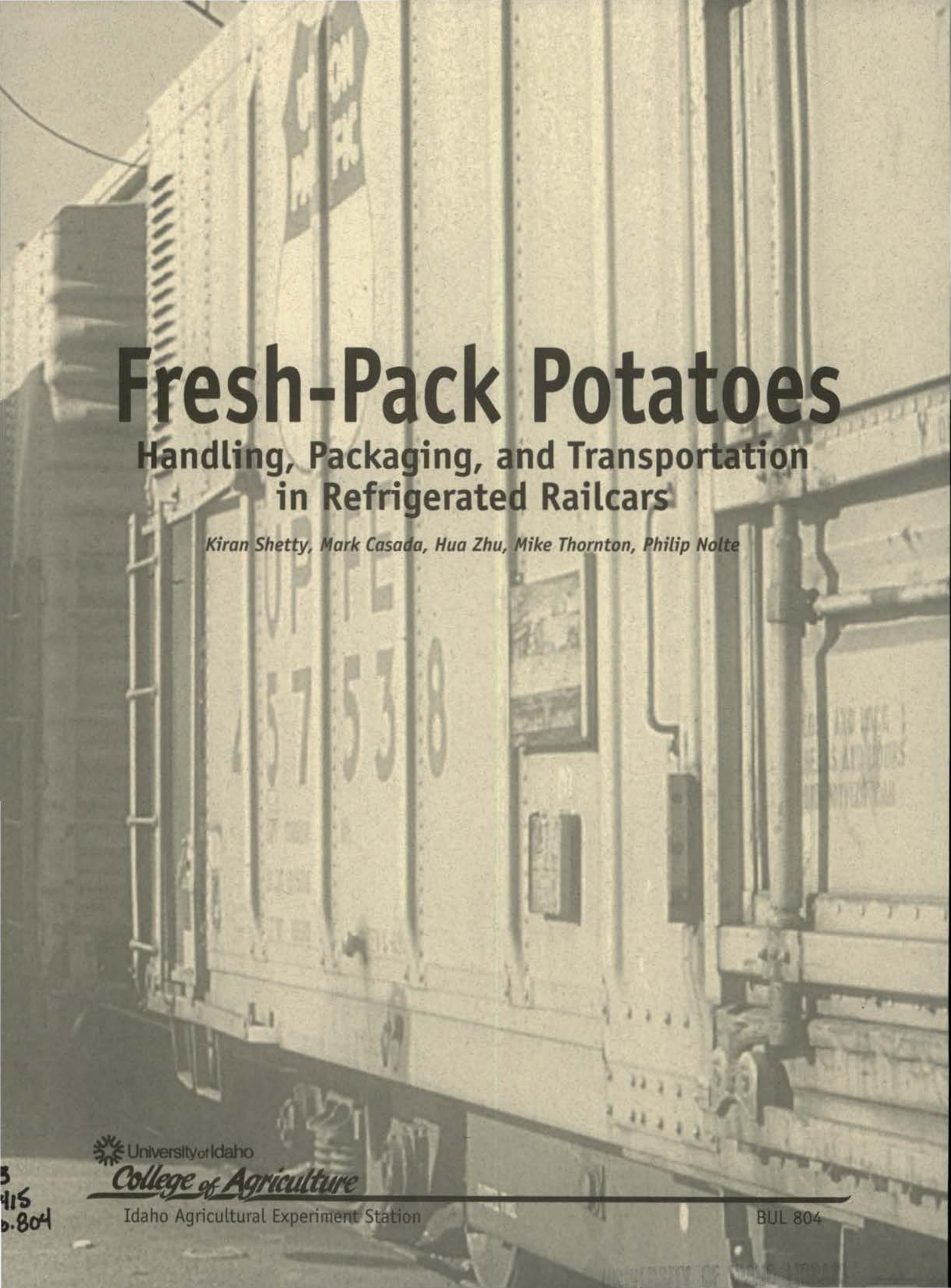

Fresh-Pack Potatoes

Handling, Packaging, and Transportation in Refrigerated Railcars

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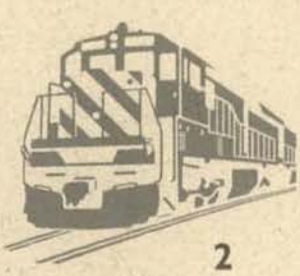

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Handling, Packaging, and Transportation in Refrigerated Railcars

Introduction

Fresh-pack or table-stock potatoes hold a major market share of the United States potato industry. In Idaho alone, roughly 37 million cwt of fresh-pack potatoes are marketed every year. The success of the fresh market is largely due to the efficient transportation and distribution systems currently in place.

The primary modes of transportation of fresh-pack potatoes to terminal markets and distribution centers across the United States are refrigerated railcars and trucking systems. Refrigerated railcars are in use for long hauls (over 2,000 miles) and are generally the preferred mode of transportation for large, single-commodity loads because of their relatively low freight charges.

An average 12,000 carloads of potatoes are shipped via refrigerated railcars each year, carrying an estimated 1.4 billion pounds of fresh potatoes.

Railcar shipment procedures have steadily improved from bulk loading and top-ice cooling systems to palletized and ventilated mechanical refrigeration systems. However, there are occasional problems in the methods of handling, lading, transporting, and delivering the product. This publication outlines the physical, physiological, and pathological problems encountered in the transportation and marketing of fresh-pack potatoes in refrigerated railcars and suggests solutions.

Bruising and its implications for the quality of fresh-pack potatoes

The type, amount, and severity of the bruises inflicted to potatoes during harvest, handling, storage, packaging, transportation, and delivery can significantly impact quality. It is impossible to eliminate all bruising, but proper procedures minimize bruising and related problems.

Blackspot bruising

Blackspot bruising, or BSB, results in internal bruises for which there is no external evidence. BSB is probably the most important bruising problem for the receiving market because the internal bruises are unacceptable to consumers. BSB occurs when potatoes strike handling equipment or other potatoes or when they are dropped on the floor or any other hard surfaces.

What is a potato?

In the context of handling and transporting potatoes for the fresh or table-stock market, it may be worthwhile to examine the composition of this product and elaborate on the different procedures and conditions they require during the entire chain of fresh marketing. A potato is botanically a "tuber" and therefore an underground plant structure (figure 1). The original epidermis, or outer skin layer of the developing tuber, is replaced by a much thicker skin called the periderm. Lenticels, or breathing holes, form in the periderm by the production of a loose mass of cells under the stomata of the original epidermis.

Tissues of the potato tuber have the ability to form periderm even after the potato is detached from the plant, provided satisfactory temperature and humidity conditions are maintained. This is called "wound healing" and is a very important defense mechanism against invading disease organisms.

The tuber possesses buds, or "eyes," that house the apparatus for sprout growth. Each bud is capable of producing a full potato plant after completing a period of dormancy, or rest. The length of dormancy varies among varieties. Within a variety it is determined by cultural and environmental factors prior to harvest and the storage conditions thereafter.

Thus, the potato is a living entity that is capable of respiration, transpiration (releasing water), and reproduction. Respiration is an important metabolic process that allows the release of energy through the breakdown of starch. During this process, the tuber generates heat, which becomes an important consideration for storage and transportation of potatoes. Cool temperatures are required to slow the process of respiration and maintain tuber quality.

The potato tuber is roughly made up of 80 percent water and 20 percent starch and is capable of losing internal water if subjected to low relative humidity. When potatoes lose excessive moisture they shrink and may become unmarketable. Sprouting significantly increases water loss in stored and transported potatoes. Sprouting will also diminish the nutritive quality of the potato. Therefore, sprout inhibitors are required after potatoes pass their dormant phase.

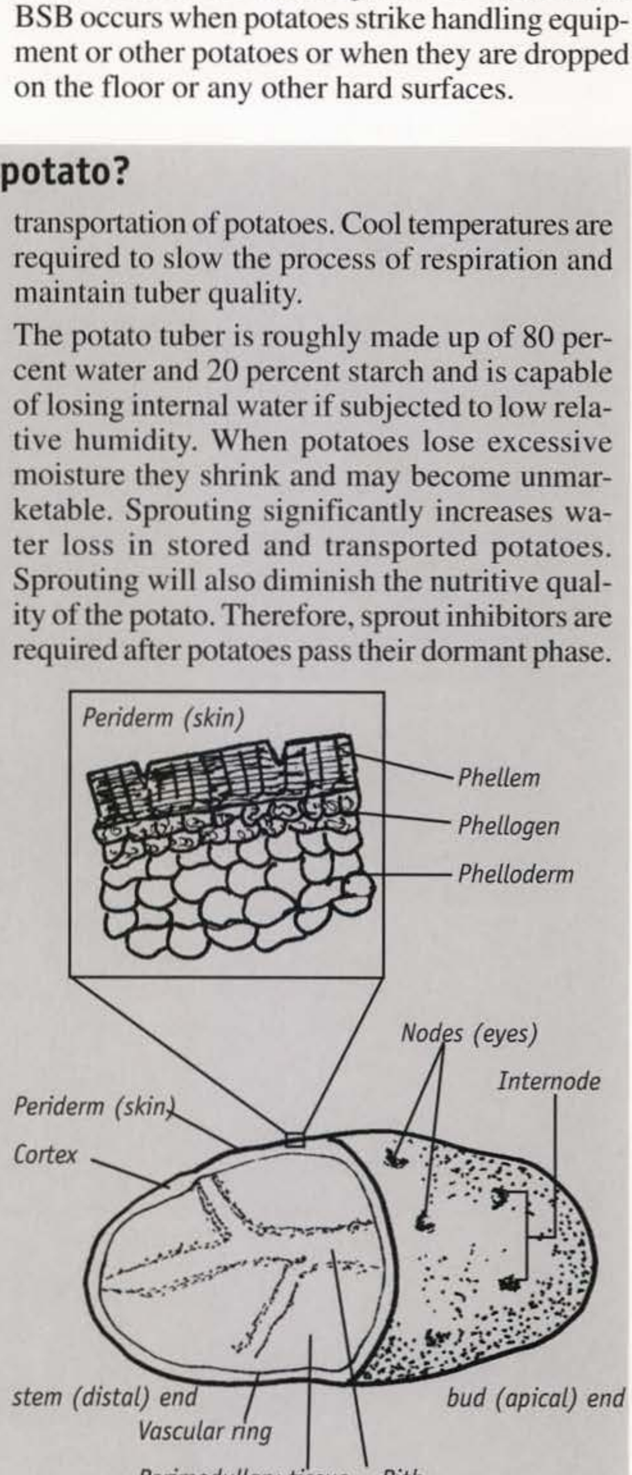
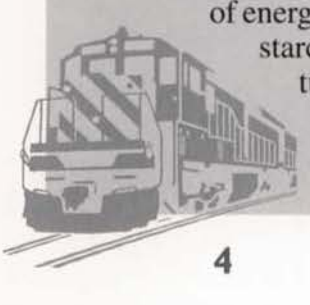


Figure 1. Anatomy of a potato tuber



The name "blackspot" describes the grayish or black tissue coloration that occurs within 24 to 48 hours of impact. The black pigment is melanin produced in the cells by the biochemical reaction of phenol substrates like tyrosine with the enzyme polyphenol oxidase. This internal bruise does not require an opening in the tuber skin. The reaction takes place because of the impact, which mixes the substrates and the enzymes. Blackspot generally occurs beneath the vascular ring in the perimedullary tissue of the potato.

The intensity and severity of the coloration depends primarily on the impact itself as well as on certain tuber and environmental characteristics. Tuber factors that determine the severity of BSB are temperature, hydration level of the cells, size and shape of the whole tuber, potato variety, cultural practices, and maturity of the potatoes. Handling factors that determine the severity of BSB are drop heights, impact surfaces, impact angle, and the amount of cushioning.

Shatter bruising

Impacts that tear and open the skin and underlying tissue of the potato are known as shatter bruises. These injuries may be difficult to see at first, but become visible after the injury dries. Shatter bruises serve as entry points for many postharvest pathogens that initiate disease during packing and develop during transportation. Shatter bruises require a long wound healing time compared with scuffing injuries (discussed below).

Potatoes are extremely susceptible to shatter bruises when the pulp temperature drops below 45°F. In a recent survey, about 40 percent of the potatoes that ran through packing lines at 45°F or below were inflicted with at least one shatter bruise. Generally, potatoes with high water content (more crisp tubers) are more susceptible to shatter bruises than are limp tubers.

Three to five new shatter bruises per tuber have been noticed in poorly managed packing lines. Packing operations that have reduced drop heights and added more cushioning material in drop areas have significantly reduced shatter bruises on tubers during handling.

Scuffing

Scuffing is a peeling or abrasion of the skin that does not penetrate internal tissue. Potatoes generally have a better ability to heal scuffing injuries than shatter bruises and, therefore, scuffed tubers are less likely to decay. However, under low-humidity conditions, excessive scuffing will aggravate water loss from the potatoes.

In packing operations, most scuffing injuries take place at the point where potatoes are unloaded. In a packing operation with a well-calibrated conveying system, only about 10 percent of the potatoes are scuffed. Potatoes run directly out of the field need to be mature with proper skin-set to avoid scuffing injuries.

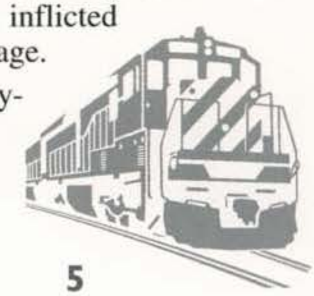
Pressure bruising

Pressure bruising takes place in storage and usually affects tubers at the bottom of the potato pile. This problem is primarily due to overloading in combination with low humidity. Pressure bruises are flattened or sunken areas on the tuber surface. The affected tissue will lose moisture and become highly susceptible to blackspot bruising. The affected areas are also prone to infection by dry rot and soft rot.

Physical and environmental conditions that affect bruising

The ability of potatoes to withstand bruising or wounding varies from the time they are harvested until they are removed from storage. Generally, freshly harvested potatoes are highly hydrated and susceptible to shatter bruises. Tubers removed from storage will have undergone 4 to 10 percent shrinkage, depending on the length of storage time as well as the temperature and relative humidity in storage, and will be better able to withstand shatter bruising than at the time they were harvested. However, it is still imperative that potatoes be handled carefully so that new bruises are not inflicted during removal from storage.

In addition to the level of hydration, temperature also affects the bruising poten-



tial of tubers. Generally, the best handling temperatures for potatoes are 45° to 65°F. The 45°F minimum is a familiar mandatory requirement for freshly harvested potatoes, which are mixed with clods and rocks, increasing the risk of bruising.

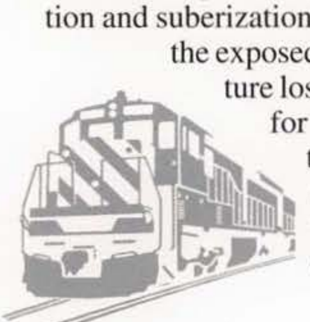
Tuber pulp temperatures out of storage will depend on the storage set temperature and the conditions after removal. The 45°F minimum temperature also applies to potatoes removed from storage. Cooler temperatures are unacceptable for handling because they cause potatoes to bruise very easily. In general, potatoes must be handled and transported out of storage with care, reducing drop heights and avoiding rough handling.

Wound healing and its importance in preventing diseases

To understand the wound-healing process, it is helpful to consider the structure of the skin, or periderm, of a potato tuber. The epidermis of the underground stem tissue is replaced by the periderm where the tuber forms. Periderm can also form in response to wounding or bruising that exposes the internal potato tissue to pathogen entry. The phellem, or cork, is the protective outer surface of the periderm. It contains dead, suberized cells when the potato tuber is mature. Suberin is a lipid-derived polymer that is the protective component of the periderm.

When the potato tuber is shatter bruised or scuffed, the exposed tissue become vulnerable to infection by certain bacteria and fungi. When injured, the tuber initiates a wound-healing response that is regulated by the amount of oxygen available, the temperature (ideally 55°F), and the relative humidity. Although wound healing is rapid at temperatures above 55°F, the risk of infection by bacteria and fungi also correspondingly increases.

The first response in wound healing is lignification and suberization during which suberin seals the exposed tissue. This prevents moisture loss and limits the opportunity for bacteria and fungi to enter the wounded area. This process is usually completed within one to three days if conditions are favorable.



Once suberization is complete, a series of new cells are constructed below the affected area, resulting in formation of wound periderm. The wound periderm is essentially a new skin to close the wound. This may take one to two weeks.

Again, the rate of wound periderm formation is controlled by environmental conditions during storage. When potatoes are washed and packed wet, free moisture may interfere with the process of wound healing, thus providing more opportunity for pathogens to enter shatter bruises.

A recent study found a significant difference in the abilities of shatter bruises and scuffing injuries to resist bacterial infection. When shatter bruised and scuffed potatoes were infected by a high concentration of soft rot bacteria (*Erwinia carotovora* subsp. *carotovora*), the shatter bruised potatoes developed substantial decay in the bruised area within two to three days at temperatures above 50°F, whereas the scuffed potatoes were not infected at all. This is because scuffing injuries tend to dry out faster than shatter bruises. In addition, more oxygen is available at the surface for faster wound healing.

In a shatter bruise, the wound remains wetter longer, restricting oxygen availability to the injured cells and slowing down the cell-division process to produce the wound barrier. This could provide ample time for soft rot infection. It is important that packing operations that have a high risk of shatter bruising first reduce this problem or, at a minimum, include a mandatory drying step before the potatoes are packed. (See "Guidelines to Minimize Soft Rot Decay in Fresh-Pack Potatoes.")

Unloading and holding requirements at the packing center

Potatoes subjected to extreme temperature fluctuations become stressed and will be affected physiologically. These temperature changes will break tuber dormancy and initiate sprouting as well as impair wound healing. Therefore, during trucking, potatoes should be tarped and not subjected to extreme cold or warm temperatures as they are brought into the packing operation. In addition, the delivery time should be as short as is practical.

Data collected from packing operations indicate that most potato scuffing injuries take place at delivery points. In some operations, drop heights from self-unloading trucks to the receiving conveyors exceed the bruising threshold of 6 inches. Scuffing appears to be the primary injury at these points and may be caused by exposed rough edges on worn and torn handling equipment. Appropriate drop heights and proper pad maintenance (frequent reinforcement of padding material) at the receiving points will minimize scuffing.

Some packing operations are equipped with holding bins to receive large loads. The turnover rate of potatoes from these bins may vary and will depend on the run-times of the packing operations. Pulp temperatures of potatoes tend to increase 2° to 4°F if the potatoes are retained for more than 24 hours. This increase takes place because the potatoes release heat during respiration. In addition, the holding bins are not equipped with airflow systems and therefore it is not possible to vent the heat away.

This temperature increase may be reduced to a negligible level if the turnover rate is increased. In situations where potatoes are delivered at pulp temperatures at or above 50°F and then held for more than 24 hours in holding bins, the potato temperatures can increase to 55°F or more, which will increase the risk of disease development.

Diseases of fresh-pack potatoes and management strategies to minimize problems

Most potato postharvest diseases and shrinkage are classified as conditional defects—defects that change from the point of origin to the distribution centers. In contrast, quality defects do not change during transportation and marketing. Quality defects include sunburn or greening, growth cracks, and several internal disorders. Blackspot bruises and shatter bruises are defects that can fall under either of these categories depending on when the injury occurred.

The major conditional defects—those due to diseases—are caused by a group of pathogenic bacteria and fungi. Bacteria are a diverse group of single-celled microorganisms. The majority of bacteria range in size from 0.5 to 5 microns, and they come in different shapes. Bacteria can reproduce rapidly when provided the right host and environment. Warm and wet conditions generally favor the growth and reproduction of bacteria.

Bacteria can spread easily through soil, water, equipment, and tuber contact. They can enter the potato tuber through wounds or through natural openings such as lenticels. Slimy soft areas, often accompanied by a foul smell, are symptoms of bacterial infection on potato tubers. Two common bacterial storage diseases in potatoes are soft rot and ring rot.

Fungi can exist as a single cell, but in most cases they are multicellular—made up of more than one cell. One typical multicellular structure is a mycelium. A mycelium consists of filaments known as hyphae, which arise from a germinating spore.

Fungal hyphae can enter a potato tuber through a wound, a natural opening, or sometimes through the skin of the potato. Fungi, unlike plants, lack chlorophyll for making food and are therefore parasites on living hosts or saprophytes on dead, decaying organic matter. Fungi prefer wet and warm conditions for their growth, development, and reproduction, and these conditions become important considerations in potato storage disease management.

The bacteria and fungi causing conditional defects share certain general infection and distribution characteristics that can be addressed to reduce problems:

1. *Availability of inoculum in the environment*. Sufficient numbers of organisms must exist in proximity to the potatoes to initiate an infection. Therefore, practicing good sanitation can minimize the availability of microorganisms to start an infection at times when other conditions are favorable for the diseases. Use of labeled disinfectants also reduces pathogen availability and the chances of tubers being infected.
2. *Pathway for infection by the microorganism*. Most disease microorganisms need a pathway through the potato's protective periderm. The major pathway is shatter bruises. Excessive overlading pressure also promotes infection by causing pressure bruising and, perhaps, encourag-

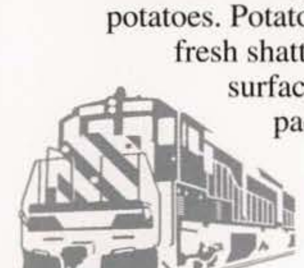
Figure 2. Soft rot decay of tubers is characterized by wet, mushy internal tissue.

Figure 3. Dry rot decay of tubers is characterized by black and white, crumbly internal tissue.

ing penetration through the lenticels. Avoiding shatter and pressure bruises will greatly reduce the possibility of infection from most diseases. Silver scurf may require only a pathway to the outside of the potato; however, bruising will increase problems from silver scurf.

3. *Environmental conditions*. An infected tuber may not suffer significant damage if environmental conditions do not allow the microorganism to survive or proliferate. The major controllable environmental conditions affecting microorganisms are temperature and humidity. Temperatures must not exceed 50°F and should be kept at 45°F or below during any holding that is longer than a few hours.

   A relative humidity that discourages growth of most microorganisms would harm potatoes by causing excessive dehydration. However, it is important to avoid any occurrence of free moisture, which would significantly promote growth of the microorganisms on the surface of potatoes. Potatoes that are likely to have fresh shatter bruises must have their surfaces dried before being packed.



Soft rot

The major bacterial disease of fresh-pack potatoes is soft rot. It is caused by the bacterium *Erwinia carotovora* subsp. *carotovora*, a facultative anaerobe that thrives in the low-oxygen environment that can occur on a wet surface. This pathogen can invade lenticels and wounds directly or cause secondary infections in areas that were previously infected by other diseases. Externally, infected areas may appear tan to dark brown with a water-soaked texture to the skin, while internal tissue is wet, mushy, or creamy (figure 2). The affected areas have a definite border separating them from the healthy tissue. A foul odor accompanies the infections.

Infection of tubers can begin in the field in areas where other diseases exist or in water-soaked areas of the field. In storage, bacterial soft rot may infest areas of the potato pile where other diseases exist, supported by inadequate air movement or excessive condensation of free moisture.

Soft rot bacteria can be carried into packing operations and can provide a source of inoculum in the wash water to infect healthy potatoes. This problem can be aggravated if potatoes are shatter bruised, packed wet, and subjected to warm holding and transit conditions without adequate ventilation air. If favorable conditions persist, these infections can spread internally and from one potato to others in close proximity.

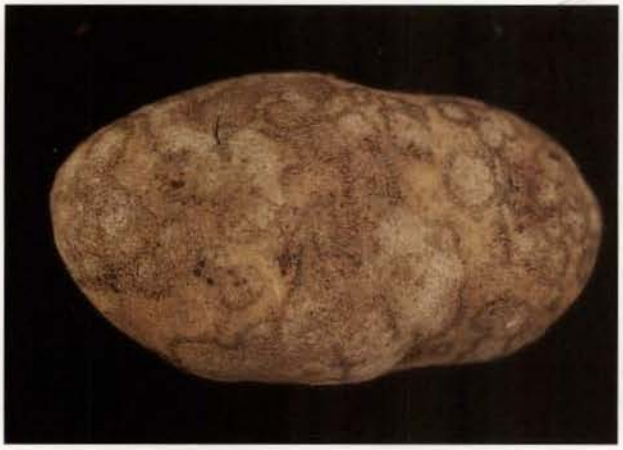


Figure 4. Silver scurf secondary lesions after tuber removal from storage.

Figure 5. Silver scurf primary lesions before tuber storage.

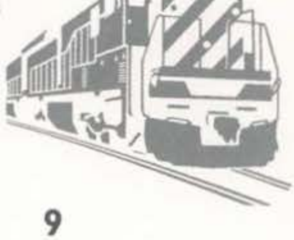
Important factors causing soft rot of fresh-pack potatoes

1. Substantial inoculum in wash water can result in infection of healthy potatoes. Inoculum is constantly replenished by washing potatoes that carry the disease from storage.
2. Shatter bruises inflicted during sorting and packing can open infection sites on the skin of the potatoes. One shatter bruise about 0.5 inches in length can allow infection by soft rot bacteria.
3. Packing potatoes with pulp temperatures above 50°F and subsequently holding them for more than one to three days at temperatures above 50°F favors soft rot decay.
4. The highest amount of soft rot develops in potatoes that are shatter bruised and packed wet. This is particularly evident in potatoes that are packed in poly bags and subsequently repacked in bailers. High overlading pallet pressure also increases the chances of soft rot infection.

Guidelines to minimize soft rot problems in fresh-pack potatoes

1. Eliminate and discard soft rot and other disease-carrying potatoes before the washing procedure at the packinghouse.
2. Add clean water periodically in the wash area, and if the water is recycled incorporate a labeled disinfectant prior to the start of a new cycle (appendix 1).
3. Avoid shatter bruising potatoes along the packing line. Provide extra cushioning pads in high-impact areas. Evaluate the packing line for adverse locations using the instrumented sphere and correct any problems.
4. Dry potatoes before packing, and maintain pulp temperatures between 45° and 50°F during packing to minimize bruising. Keep palletized loads between 40° and 45°F in a well-ventilated area.

   If potatoes are brought into packing houses at pulp temperatures above 50°F, include a cooling step immediately after packing, or place them immediately in transport cars that are precooled



to 40°F with adequate air flow. This procedure is especially critical if potatoes are treated with sprout inhibitors (CIPC) during packaging because CIPC prevents wound healing of fresh shatter bruises.

The only way to inhibit soft rot development in potatoes packed too warm is cooling potatoes immediately to below 45°F. A cooling platform or tunnel with a forced refrigerated air system should be considered for cooling potatoes that are packed too warm. Refrigerated railcars are designed to hold potatoes at the desired transport temperature, not to cool warm potatoes. However, it may be possible to take advantage of the railcar's refrigeration capacity to help cool potatoes that are moderately warm. Railcar set-point temperatures that optimize the cooling of potatoes, while avoiding freezing problems, are shown in table 1.

5. Treating washed potatoes with labeled chlorine-based disinfectants that are insensitive to pH changes can help prevent new soft rot infection (appendix 1).

6. Lading and distribution of palletized count cartons or bailers should ensure adequate air movement through the stack of potatoes inside the refrigerated railcar. An improper lading pattern of the count boxes and bailers (with no airflow chimneys) results in the cooling air flowing around the outside of the packages rather than through the packages. This causes the thermostat to prematurely reduce output from the refrigeration system.

7. While loading cars do not run the refrigeration system for long periods with the doors open because water from the environment and the potatoes will cool and freeze on the cooling coil, reducing the initial refrigeration capacity during transport. Load as quickly as possible, then close the doors.

8. Slip sheets and supporting material within and between pallets of packed potatoes must not interfere with air movement from the ceiling of the railcar through the stack of potatoes and out the bottom. Modify (or remove) slip sheets to open central and

Table 1. Optimal set-point temperatures for potatoes loaded warm in refrigerated railcars (summer conditions).

Initial pulp temperature	Set-point temperatures for continuous air circulation		Set-point temperatures for cycling air circulation	
	Minimum	Maximum	Minimum	Maximum
(°F)	(°F)	(°F)	(°F)	(°F)
45	38	43	38	41
47	38	43	38	41
49	37	41	37	39
51[a]	36	39	36	38
53[a]	36	36	36	36
55 or above[b]	*** ***Potatoes will not reach a safe temperature in time to avoid disease damage*** ***			

[a]Temperatures above 50°F may cause problems; precooling to below 50°F is desirable.

[b]Temperatures of 55°F and above are dangerous; precooling to below 50°F is recommended.

Note: These set-point temperatures were calculated based on data for summer railcar shipments from Idaho to New York with pulp temperatures measured for the tubers loaded last (doorway section).

peripheral air passages so that air distribution is uniform within the stack of potatoes.

9. Refrigerated railcars should ensure equal distribution of air along the ceiling plenum. Increasing the air capacity of the refrigerated car can provide the flexibility to ventilate large loads of potatoes.

10. Clean and sanitize refrigerated railcars prior to shipping new loads of potatoes.

11. Temperature and humidity probes that continuously record product temperature and air humidity at both ends of the car will aid in determining transit conditions. Most convenient are microchip recording devices with an external probe for temperature. Tuber pulp temperatures are good indicators of changes in the postharvest quality of transported potatoes.

Also, a sample of potatoes from the doorway area of each carload should be set aside for recording initial product temperatures. Use a microchip recording device or another type of temperature probe.

12. Base decisions on potato pulp temperatures, not air temperatures. Pulp temperature is the most important indicator of potato condition. However, in a potato pile there will usually be a minimal difference between the temperatures of the pulp and surrounding air (although the temperature near the exit for the airflow can be much warmer than the supplied cooling air).

In a well-ventilated railcar, there will be packaging materials that cause greater temperature variation, but pulp temperatures should only lag behind air temperatures by a few hours at most if there is adequate air circulation through the pile. (Again, air and pulp temperatures at the farthest point from the cooling coils, the bottom B-end of the car, can be much warmer than the supplied cooling air.)

Dry rot

Dry rot in potatoes is caused by the fungus *Fusarium sambucianum*. Generally, this disease can be detected under a bruised area. Infected tuber tissue is black and white with a crumbly decay (figure 3). Spread inside the tuber is irregular, but there are distinct walled-off areas between healthy and diseased tissues. The external surface of the affected areas can be sunken and wrinkled. When conditions are favorable— moist and warm— inside the packs, this disease can invite bacterial soft rot as a secondary infection.

Usually this fungus infects potatoes during harvest and handling operations, before the potatoes are washed, sorted, and packed. However, a new infection can originate during sorting and packing if the potatoes are bruised.

The initial infection and spread of the fungus may be slow at packing and shipping temperatures (45° to 50°F). Later, when the potatoes are received and distributed in marketing centers, this disease can seriously affect packaged potatoes and may progress significantly in the supermarkets and after the consumer buys and stores the potatoes.

Guidelines to minimize dry rot decay in fresh-pack potatoes

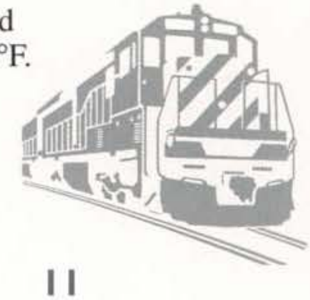
1. Because this disease begins before or during storage, remove dirt and debris when preparing the potatoes for storage. Cure potatoes for 2 to 3 weeks at a temperature of 55°F and 95 percent relative humidity before cooling them to 45°F for long-term storage.

2. When removing potatoes from storage, do not subject them to new bruises. Discard potatoes that show excessive dry rot decay before running potatoes through a packing line.

3. Avoid bruising during the packing operation.

4. Before packing, treat potatoes with a 500 ppm chlorine solution then dry them to inhibit new infection.

5. Store and ship packed potatoes at 42° to 45°F.



Silver scurf

Silver scurf is a fungal disease caused by the fungus *Helminthosporium solani.* The disease is characterized by silvery lesions on the skin of the potato (figure 4), with substantial thickening of the skin in the affected areas. Red potatoes usually lose the red pigment in the affected areas. The fungus does not affect the interior of the potato.

This disease usually results from poor production and storage management practices. In some cases this disease is noticeable at harvest (figure 5), but in practice this disease usually increases after harvest and affects marketability of potatoes four to five months after harvest. Fresh-pack potatoes can lose additional market value if the infection increases in count cartons and bailers. Humid, wet conditions and temperatures above 55°F will increase the infection inside the packages.

The fungal spores can contaminate handling and packing equipment. In this case, healthy potatoes can be infected during packing operations. However, a new infection takes several weeks to express symptoms on the surface of the potatoes.

Guidelines to minimize silver scurf disease of fresh-pack potatoes

1. Follow all proper cultural practices, including the use of certified seed and appropriate seed treatments.
2. Clean and sanitize the potato storage prior to storing new potatoes (appendix 1).
3. To reduce new infections in storage, treat potatoes with chlorine disinfectants at 500 ppm directly on the potatoes and ensure adequate air movement through the pile.
4. Cure fresh-pack potatoes at around 50°F for 2 to 3 weeks then cool them to 40° to 42°F for long-term storage. Avoid free moisture from condensation in storage.
5. Avoid bruising potatoes when placing them into storage and when removing and handling them.
6. To reduce the spread of old infections and prevent new infections during marketing, apply labeled disinfectants at 500 ppm chlorine before the potatoes are packed and follow with a drying process.
7. Periodically clean and decontaminate packing lines.
8. Pack potatoes dry and place them in an environment where the pulp temperatures remain at or below 45°F during holding and shipping.

Summary and conclusions

Potatoes must be handled with care to avoid bruising, which provides a pathway for infection. Disinfecting handling facilities—including the maintenance of clean wash water—will reduce the available load of microorganisms and reduce infections. Pack potatoes at temperatures between 45° and 50°F. Finally, temperatures during transportation should be cool (45°F or less) and the potato surfaces should be dry so diseases cannot proliferate.

Disinfectants for potato storage and handling

		Potato Storage & Handling Equipment		Potato Storage Facility Water*			
Product	Rate/Concentration	Porous	Non-Porous	Direct	Indirect	Fruit Dips	Comments
Q-halt (Platte) EPA Reg No 42198-3-34704	0.5 oz product/ 1 gal water		X				Pre-cleaned surfaces only, with a minimum of 10 minutes contact.
PQ-57 (ISK Biotech) EPA Reg No. 1022-490-50534	1% Solution	X	X				
T-Chlor (Thatcher Co) EPA Reg. No. 9768-7	100-600 ppm. Rates vary depending on application site and method.		X				Can be applied directly on potatoes prior to storage
Vanguard Calcium Hypochlorite (Van Waters & Rogers) EPA Reg. No. 748-217-550 & 748-138-550. Vanguard Plus EPA Reg. No. 748-239-550 & 748-296-550.	Rates highly variable depending on application site and method.	X	X			X	Can be applied directly on potatoes prior to storage. When used as a fruit dip, fruit must be rinsed with potable water after treatment.
Calcium Hypochlorite Compounds (PPG) Indu-chlor EPA Reg. No. 748-239 Indu-chlor Calcium Hypochlorite Tablets EPA Reg No. 748-138.	Rates highly variable depending on application site and method.	X	X		X	X	Can be applied directly on potatoes prior to storage. When used as a fruit dip, fruit must be rinsed with potable water after treatment
Water Sanitizers (45 products registered in Idaho)					X		Contact Idaho Department of Agriculture for list (208-332-8590)
Super Chlor EPA Reg No. 37982-20001-21164	Rates variable depending on site and method.	X	X			X	Can be applied directly on potatoes prior to storage. When used as a fruit dip, fruit must be rinsed with potable water after treatment
Oxine Sanitizer EPA Reg No. 9804-1	3 1/4 oz w/1 Tbsp. citric acid	X	X		X		Surface must be pre-cleaned with detergent & potable rinse.
Olin Corp Pool Choice Granular, EPA #1258-1069; HTH granular, EPA #1258-1069; HTH tablets, EPA #1258-969; CCH granular, EPA #1258-427; Constant Chlor granular, EPA #1258-1069; HTH Duration capsules, EPA #1258-808; Pulsar capsules, EPA #1258-808	Rates highly variable depending on application site and method.	X	X		X	X	Can be applied directly on potatoes prior to storage. When used as a fruit dip, fruit must be rinsed with potable water after treatment
Klorman Chlorinator	Rates highly variable depending on application site and method	X	X		X	X	Can be applied directly on potatoes prior to storage. When used as a fruit dip, fruit must be rinsed with potable water after treatment

Comments on Appendix 1, June 12, 1998

Source: Idaho Department of Agriculture

* This is not the same as a potable water treatment

1. This represents the disinfectants registered for use in Idaho—for questions about other federally registered products contact the Idaho Department of Agriculture (208-332-8590).
2. Products need to be registered yearly, due to the annual expiration of all pesticides on December 31. To confirm a disinfectant's registration, contact the Idaho Department of Agriculture (208-332-8590).
3. Always follow product label directions and handling precautions.
4. Always pre-clean surface to be treated.

Appendix 2

U.S. table-stock grade tolerances (percent)

1. U.S. Extra No. 1

Total defects	5
Including for bacterial wilt, ring rot, late blight, soft rot, wet breakdown, or freezing	2
Included in the 2%: for soft rot, wet breakdown, or frozen	1/2

2. U.S. No. 1

Total defects	8
Including not more than	
External defects	5
Internal defects	5
Or for bacterial wilt, ring rot, late blight, soft rot, wet breakdown, or freezing	3
Included in the 3%: for soft rot, wet breakdown, or frozen	1

3. U.S. Commercial

U.S. Commercial consists of potatoes that meet the requirements of U.S. No. 1 grade except for the following:

(a) Free from serious damage caused by:
- (1) Dirt or other foreign matter,
- (2) Russet scab, and
- (3) Rhizoctonia

(b) Increased tolerances for defects

(U.S. Commercial cont.)

Total defects	20

Including not more than10% that fail to grade U.S. No. 2, including therein 6% external defects and 6% internal defects, of which not over 3% may be affected by freezing, southern bacterial wilt, ring rot, late blight, soft rot, or wet breakdown, including therein not over 1% frozen or affected by soft rot or wet breakdown.

4. U.S. No. 2

Total defects	10
Including not more than	
External defects	6
Internal defects	6
Bacterial wilt, ring rot, late blight, soft rot, wet breakdown, or frozen	3
Included in the 3%: for soft rot, wet breakdown, or frozen	1

Appendix 3

Standards of weight range for designated count cartons

	Range		
	Count	Average count[1]	Weight (oz.)
Larger then 50 size	10 percent over or under	5 percent over or under	15 oz. or larger
50 size	45-55	48-53	12-19
60 size	54-66	57-63	10-16
70 size	63-77	67-74	9-15
80 size	72-88	76-84	8-13
90 size	81-99	86-95	7-12
100 size	90-110	95-105	6-10
110 size	99-121	105-116	5-9
120 size	108-132	114-126	4-8
130 size	117-143	124-137	4-8
140 size	126-154	133-147	4-8
Smaller than 140 size	10 percent over or under	5 percent over or under	4-8

[1]Applicable to lots.

Note: The following tolerances, by weight, are provided for potatoes in any lot that fails to meet the weight range for the designated count:

(a) not to exceed 5 percent for undersize; and
(b) not to exceed 10 percent for oversize.

Potatoes packed in cartons (except when used as a master container) shall be U.S. No. 1 or better grade and conspicuously marked as to size. However, potatoes of U.S. Extra No. 1 grade shall be no smaller than 110 size nor larger than 60 size.

Inspection. Except when relieved of such requirement pursuant to appropriate standards.

No handler shall handle potatoes unless such potatoes are inspected by either the Idaho Federal-State Inspection Service or Oregon Federal-State Inspection Service and are covered and accompanied by a valid inspection certificate, numbered notesheet, or Shipping Clearance Report: Provided. That a valid inspection certificate, numbered notesheet, or shipping clearance report is not required to accompany positive lot identified potatoes.

Potato Bruise Prevention Videos

A series to help reduce potato bruising from farm to market

(Each tape includes both English and Spanish language versions.)

#1: The Harvester. Close-up and slow motion scenes follow potatoes from the moment they come out of the ground until they drop into the truck. Footage shows exactly what happens to potatoes on poorly maintained harvesters, then shows you how to correct problems. 24:00 min.

#2: Harvester Chain Adjustment. Learn how to calculate chain speeds and synchronize chains to specific ratios by changing sprockets. Computer animation and live action combine to show you these important formulas for minimizing bruise. 27:30 min.

#3: Handling. Demonstrates techniques to minimize bruise as potatoes are moved in and out of storage, transloaded, and prepared for seeding.

#4: Preventing Bruising in Fresh-Pack Warehouses. Shows nine steps for reducing bruising in fresh-pack warehouses. Includes optimum temperatures, machine setup, and repair. Geared toward managers and warehouse employees.10:00 min.
(Includes posters in English and Spanish. Extra posters $5.00 for shipping and handling)

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