BUL 725

Preventing Potato Bruise Damage

Michael Thornton
Professor, Department of Plant Sciences, University of Idaho, Parma Research and Extension Center

Nora Olsen
Professor, Department of Plant Sciences, University of Idaho, Kimberly Research and Extension Center

Contents

University of Idaho Extension

Introduction

BRUISING COSTS THE US POTATO INDUSTRY an estimated hundreds of millions of dollars annually. Most of the cost of bruising is eventually passed back to the grower in the form of lower prices, reduced demand, and increased storage losses. Bruising costs the potato industry because it

- increases storage losses due to shrinkage and disease;
- increases labor costs for sorting and inspecting;
- increases the cost of the raw product through greater trim losses;
- lowers the quality of the final product;
- decreases shelf life; and
- reduces the appeal of fresh potatoes to wholesale and retail customers.

Types of Bruise

There are four major types of potato bruise damage: skinning, blackspot bruise, shatter bruise, and pressure bruise (Figure 1). The first three result from the potato hitting objects, such as equipment, dirt clods, rocks, or other tubers during harvesting and handling operations; pressure bruise results from the interaction of pile weights and tuber dehydration. A single tuber can have multiple types of bruise damage.

Skinning

Skinning or “feathering” often results from handling immature potato tubers, which can scuff and rub off the skin. Tubers with skinned areas that have turned dark because of exposure to wind, sunshine, or dry air may be unacceptable for the fresh market.

Ideal tuber maturity can be achieved by scheduling an adequate amount of time between vine kill and harvest.

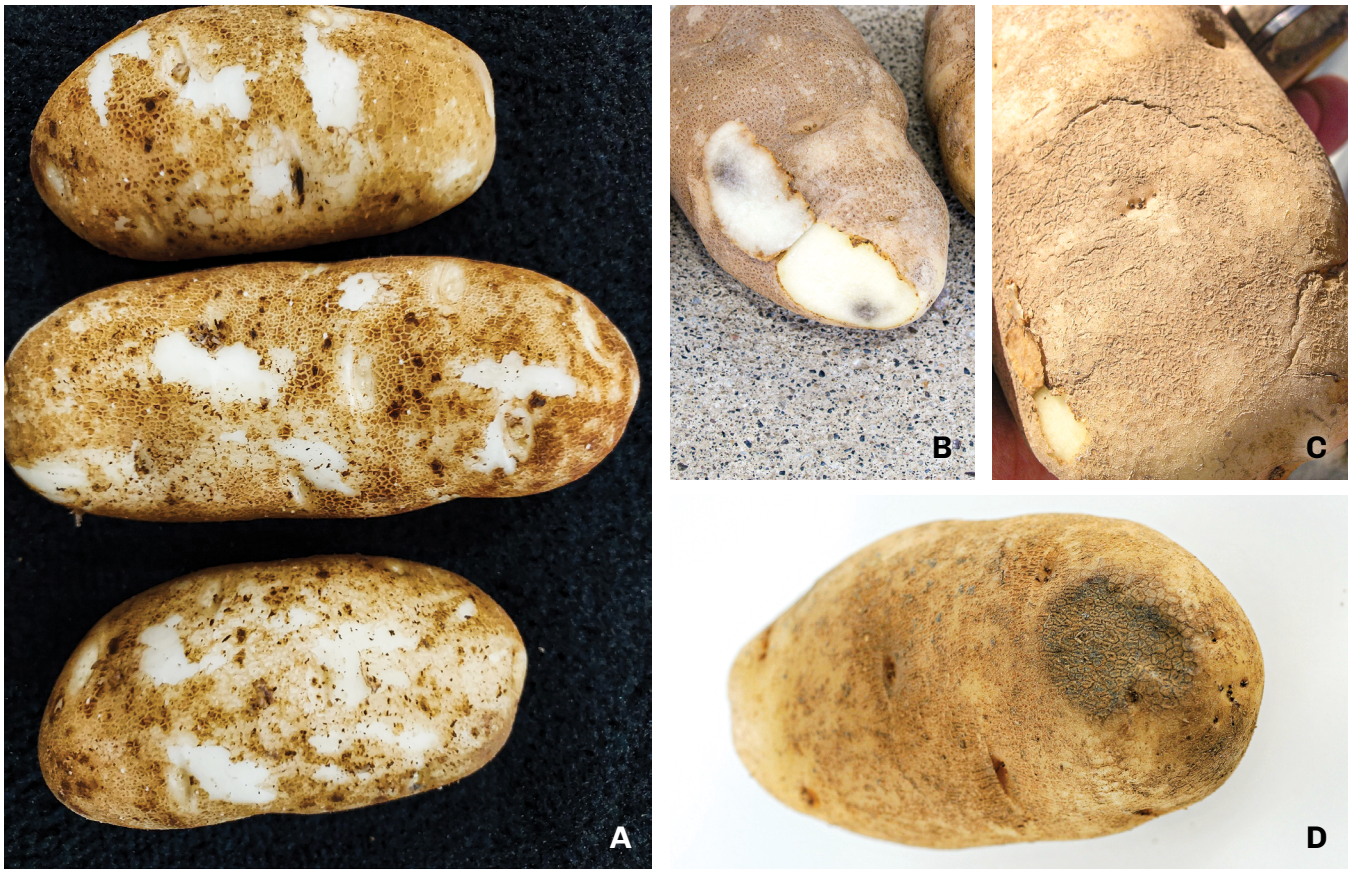

Figure 1. Types of bruise that occur on potatoes. **A**, Skinning; **B**, Blackspot bruise; **C**, Shatter bruise; **D**, Pressure bruise.

The time required for tuber maturation and skin set is influenced by environment, variety, plant vigor, fertility, and the presence and severity of foliar diseases. It also depends upon how immature the plants were at the time of vine kill and the method of vine kill.

Blackspot Bruise

Blackspot bruise occurs when a potato tuber impacts against another object with enough force to damage cells in the tissue just beneath the skin—without breaking the skin of the tuber—meaning that blackspot bruises can be seen only after peeling the potato. Within a few hours, the damaged tissue starts to turn pink; 3–6 hours after the impact (depending on temperature and variety) it turns dark gray to black in color. Full-color development of a blackspot bruise can take 24–48 hours.

One of the interesting facts about blackspot bruise is that it tends to be more common on the stem (stolon) end compared to the bud end. Figure 2 shows a Ranger Russet potato that was impacted with the same amount of force on both the stem and bud end. The stem end developed a lot of black pigment, resulting in the formation of a dark bruise. Bruising the bud end caused the formation of a white knot bruise with little pigment formation. The difference is due to the physical and chemical differences between the two ends (stem-end cells are older, larger, higher in starch, and higher in the compounds that form the pigment).

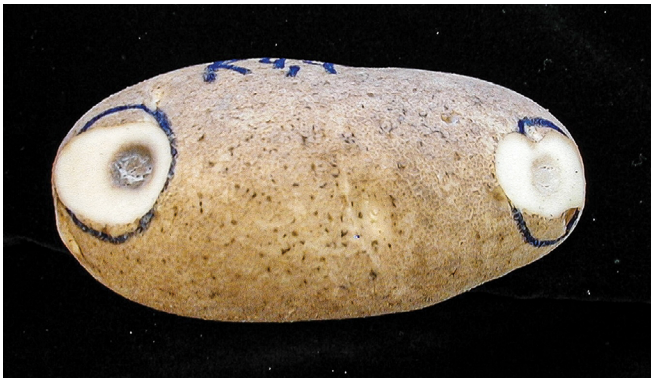

Figure 2. Bruised Ranger Russet potatoes illustrating the difference in susceptibility on the stem compared to bud end.

Shatter Bruise

Shatter bruise develops when impacts cause cracks or splits in the potato tuber skin. When impacts are severe, the cracks may extend into the underlying tissue. Superficial ones that just break the surface of the skin are often referred to as "thumbnail cracks." These can seriously degrade the appearance of fresh-market potatoes, especially for tubers exposed to low humidity in storage or after packing. Diseases such as Fusarium dry rot and bacterial soft rot easily invade tubers with shatter bruise.

In contrast to blackspot bruise, shatter bruise tends to be more common on the bud end of the tuber. It is also associated with high-impact force (large drops) cold tuber temperatures, and crisp (fully hydrated) tubers.

Pressure Bruise

Pressure bruise develops in storage, causing a flattened or depressed area on a potato tuber. It is often associated with tuber dehydration (water loss) caused by low soil moisture before harvest and/or by inadequate humidification of ventilation air in storage or under or over ventilation in storage. Once relieved of the pressure and exposed to oxygen, the tissue under the depressed area turns dark gray to black. Potatoes with pressure bruises may not be acceptable for the fresh market.

Bruise Prevention at Harvest

An integrated approach maximizes the percentage of bruise-free potatoes. Research indicates that the major factors that determine whether a potato will bruise or not include variety susceptibility, tuber pulp temperature, and impact force.

Variety Susceptibility

Potato varieties differ substantially in susceptibility to blackspot and shatter bruise. Consequently, adjust management strategies for each variety to maintain high bruise-free percentages. For example, lowering the impact height during harvest and handling operations help to lower the bruise incidence for varieties such as Russet Burbank, Ranger Russet, Teton Russet, and Umatilla Russet. For cultivars more sensitive to blackspot bruise, such as Clearwater Russet and Dakota Russet, other tactics, such as warmer pulp temperatures at handling, may be critical to integrate with lowering drop heights to maximize the percentage of bruise-free tubers.

Tuber Pulp Temperature

Generally, as tuber temperature increases less bruising occurs. Pulp temperatures between 50^0F and 60^0F are considered best for harvesting and handling tubers. Colder tuber temperatures increase the risk for blackspot and shatter bruise.

Soil and tuber temperatures in a specific field are important considerations in deciding the best time to harvest potatoes. Soil temperatures in individual fields may vary from regional soil temperatures due to soil water and organic matter content, soil texture, slope, aspect, and localized environmental factors. Therefore, checking pulp temperatures with a thermometer is essential for determining when to start and stop harvest each day.

Impact Force

There is a direct relationship between the force of impacts that occur during handling potatoes and the amount and type of bruise damage that occurs. Lessening impact forces is a tangible action that can be done by 1) harvesting under appropriate soil moisture conditions, 2) operating handling equipment to maintain a full, even flow of material, and 3) reducing drop heights and adding padding and cushioning.

Soil Moisture

If soil is dry, irrigate lightly before harvest to soften the clods so they break apart rather than scrape against tubers in the harvester. Dry, sandy soil separates too rapidly from tubers on the primary conveyor, reducing the total load (soil and tubers) on the conveyor. A light irrigation to moisten the soil can partially overcome problems with excess soil separation. If irrigation is not an option or is not used, increase the forward speed of the harvester to increase the load of tubers and soil on the primary and secondary conveyors.

Conversely, when soil is too wet at harvest, the total load of soil on the conveyors increases. Excessive soil can be eliminated by using shakers to increase bed agitation, but this also increases tuber damage. A better option: decrease the forward speed of the harvester to reduce the soil load on the primary and secondary conveyors.

Harvester Operation

Evaluations have shown that bruising is minimized when conveyors are kept full of potatoes or both potatoes and soil (conditions on the right side of Figure 3). Underloading of conveyors occurs when the harvester ground speed is too slow for the conveyor speeds. Increasing ground speed by shifting the tractor transmission to a higher gear speeds up harvest, increases and smooths out the flow of tubers through the harvester, and reduces tuber damage. As a rule of thumb, run the primary between 1.0 and 1.2 times faster than the tractor ground speed on sandy soils and between 1.2 and 1.5 times the tractor speed on heavy soils. The chain-speed to ground- speed ratios should allow some soil to carry over the transition from the primary to the secondary conveyor, where it will act as a cushion to reduce bruising. Whenever possible, operate the primary conveyor without shakers engaged. If shakers must be engaged, use hydraulic ones regulated by the tractor operator.

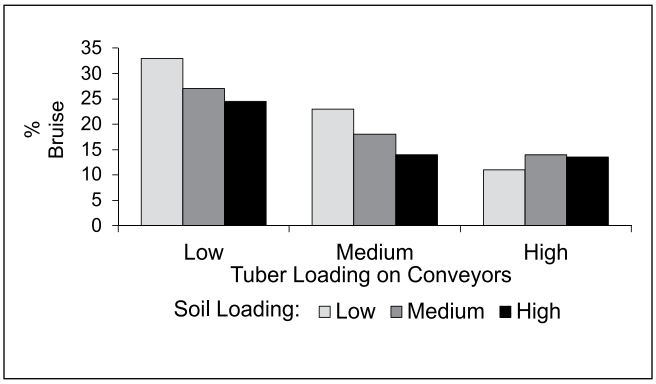

Figure 3. Relative bruise level when chains are full of soil or tubers (high) versus medium or low loading on the chains. Redrawn from Hyde G. M., R. E. Thornton, J. A. Francis, and R. E. Hermanson. 1990. "Potato Harvester Chain Speed Adjustment." Extension Bulletin 1558. Washington State University.

After the primary conveyor there is no need to carry soil; set the rest of the conveyors from the secondary onward at speeds that result in equipment filled with tubers. Individual conveyors are often set at the wrong speed relative to the speed of the preceding or following conveyor. Adjust the speed of the individual conveyors to each other and to the forward speed by changing the conveyor sprockets.

Windrower Operation

Advantages of windrowing potatoes include more efficient use of harvester capacity and an increase in harvesting efficiency (acres per hour) at a lower cost when compared to the operation of an additional harvester. The use of windrowers to increase the flow of material into the harvester also reduces bruise damage because it increases tuber volume on the primary and subsequent conveyors. However, this benefit is sometimes not realized because windrowers can be operated in a manner that increases bruising. Using the same concept of matching chain speed to ground speed to fill conveyors to capacity also reduces bruise damage caused by windrowers.

Harvester Modifications

In addition to operating the harvester in a way that fills the conveyors to capacity, equipment modifications can further reduce potato bruise by reducing the number and severity of impacts. Indeed, the greater the drop, the larger the bruising force, and the more likely a bruise will occur. Considerable bruising develops after drops exceed 6 inches—especially after the primary and secondary conveyors, where little to no soil remains to cushion the impact.

Blade Position

Place the blade and primary bed nose cone rollers so that potatoes flow onto the upper surface of the conveyor rather than bumping into the front (Figure 4). If bulldozing and spillage occurs due to the steep angle of the blade, elevate the front of the blade and lower the front of the harvester to achieve the desired digging depth. In some cases, proper alignment of the front of the primary and the rear of the blade can be achieved by lowering the nose cone rollers of the primary conveyor. Match the blade design to the soil type, soil condition, presence of plant roots (especially alfalfa and weeds), and depth

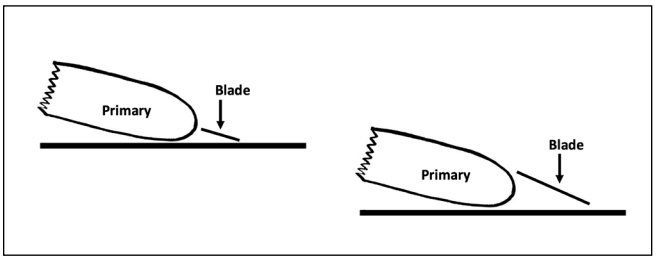

Figure 4. Angling the digger blade into the front of the primary conveyor (left) jams tubers into the chain. Aligning the blade tangent to the primary (right) causes less bruising.

of the tubers. Improper blade design, a dull blade, or one that is not scouring freely can interfere with the material's ability to move smoothly through the front of the harvester, increasing the amount of tuber spillage around the sides of the primary conveyor.

Conveyor Chain Patterns

Chain links are available with many link patterns and with various types of coatings. A mixed chain pattern (for example, three down and one straight) creates a pocket-like configuration that improves tuber flow by reducing the tendency of potatoes to roll back.

Most coatings work on a similar principle, with soft materials absorbing some of the impact from potatoes as they fall onto the chain. Impact-absorbing coatings reduce the soil-elimination capacity by decreasing the space between links, a factor to consider when determining chain pitch (the space between the links on a conveyor). Durability is also an important consideration when determining which chain coating best suits a particular operation.

Roller Diameter

All rollers on an individual conveyor should have the same diameter, except where variation in roller size is used to lower drop height between conveyors. Roller size and mounting location should be such that humps in the conveyor bed are minimized to prevent tuber rollback. Using small conveyor bed rollers and head shaft sprockets minimizes the height and slope of the conveyor, resulting in reduced drop height and tuber rollback. Replace worn rollers as needed.

Primary Support Bar Padding

On harvesters with split primary conveyor beds, cover the center support bar with padding to reduce impacts and to move potatoes away from the chain link ends. This modification is especially important when using a windrower in conjunction with the harvester because a large portion of the tubers flow onto the center of the primary conveyor. Replace this cushioning frequently because it tends to wear out rapidly.

Secondary Conveyor

Installing a sloped deflector on each side of the harvester where tubers are discharged from the primary conveyor onto the secondary conveyor diverts tubers away from the sides of the deviner and secondary conveyers. Modifying the position of the deviner chain (see next section) causes the links to perform the role of flights. Doing this, along with removing flights from the secondary chain, further reduce the drop height from the primary conveyor onto the secondary conveyor.

Deviner

Bruising frequently occurs on harvesters and windrowers when tubers strike the links of the deviner chain, causing the tubers to bounce or tumble several times before falling onto the secondary conveyor. Hence, cover the deviner chain links with cushioning material. To minimize bouncing, tumbling, and rollback on the secondary conveyor, remove or reposition the first one or two sets of deviner rollers so that the front part of the deviner chain rides on top of the secondary chain. In this position, the deviner links act like flights part way up the secondary conveyor (Figure 5). A prerequisite to this modification is that the deviner and secondary chains must move at the same speed, which may require changing the sprockets of the secondary or deviner. Another option is to eliminate the deviner chain and install a blower between the secondary and the rear crossover to remove vines. Air from the blower can also improve the distribution of tubers on the rear crossover.

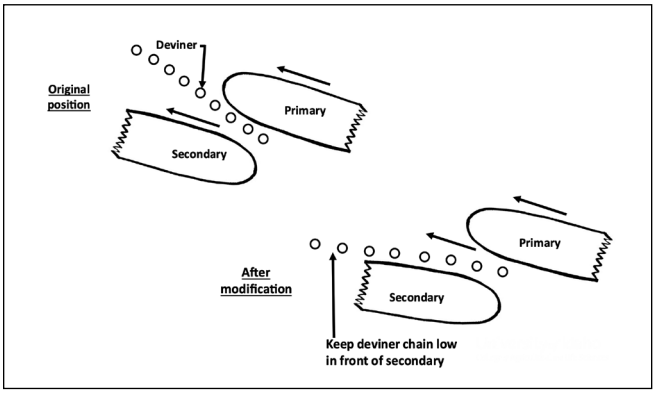

Figure 5. Modifying the position of the deviner chain so that it rests on the secondary conveyor reduces tuber damage.

Rear Crossover Padding

Because the relatively long drop from the secondary to the rear crossover is combined with a change in tuber flow direction, substantial tuber damage can occur at this transfer point. To reduce bruising, cover the rear crossover chain with a material that

provides maximum cushioning. Another place of injury on older harvesters is the inside corner where the off-load end of the rear crossover meets the side elevator conveyor. If the load and distribution of tubers are not correct, tubers can get caught and severely damaged in this corner. Resolve the problem by installing a padded shield to cover the corner or by extending the rear crossover so the head shaft aligns with the inside edge of the side elevator conveyor chain.

Side Elevator

The length and slope of a side elevator conveyor often result in tuber rollback and injury. Flights placed at 12–16-inch intervals in the chain help reduce rollback more effectively than flights placed farther apart. Flights that are stiffer or heavier at the place where they extend over the belted or hooked portion of the chain help reduce rollback of tubers along the side of the conveyor. An alternative is to use a mixture of link patterns to create a pocket to carry potatoes and reduce tuber rollback. Eliminating the flights on the side elevator allows raising the lower end under the discharge end of the rear crossover. Removing the flights on the side elevator conveyor also allows lowering the drop from the top of the side elevator onto the clod eliminator or boom.

Clod Eliminator

All clod eliminator tables are potential sites of injury. Regardless of the roller type, tubers can bruise when they bounce, roll, or tumble while on the clod eliminator table or when they off-load onto the next conveyor. The amount of bruising depends much more on rotation speed than on roller design. The correct roller speed is one that moves tubers at least the same flow rate as the side elevator conveyor without tuber bouncing. Angling the clod eliminator table slightly down toward the boom conveyor also aids in the flow of tubers across the table.

Boom

Utilizing a mixed pattern of chain links reduces tuber rollback on the boom conveyor. Alternatively, install flights every 12–16 inches. The harvester operator should keep the drop from the end of the boom to the tuber pile in the truck as low as possible without the end of the boom touching the pile.

Bruise Prevention Following Harvest

Successful bruise prevention programs should not focus solely on the harvesting operation. A significant amount of bruising injury can occur during truck unloading, sorting, and piling.

Unloading the Truck

Manage the truck-unloading conveyor to maintain a constant and uniform flow of potatoes onto the receiving equipment. It may be necessary to change the motor pulley size to achieve the desired unloading speed.

Stinger Position

Keep the receiving end of the stinger as close as possible to the truck unloading belt to reduce the drop distance for potatoes as they are unloaded. Some stingers may need remodeling, such as repositioning the chain shield or cutting down the edge of the receiving bowl, in order to sufficiently minimize the drop height from the truck unloading belt to the stinger.

Even-Flow Bin

Even-flow bins provide a good way of keeping a constant volume of potatoes flowing into the storage filling equipment. The speed of the rest of the equipment can then be set at a rate that ensures operation at full capacity when there is a constant flow of potatoes.

Soil Elimination

Ideally, eliminate most of the loose soil and small clods on the harvester. Large clods are difficult to separate from tubers without causing bruise damage and often end up in the load unless manually removed. However, labor shortages, increasing labor costs, and safety and efficiency issues are forcing many potato-harvesting operations to search for alternatives to manual sorting. Mechanical methods such as roller tables and air separators are being used to eliminate soil, clods, vines, corncobs, and rocks. These methods are effective for removing tare material from potatoes, but they also may contribute to bruising if not properly operated.

Piler

Adjust the piler chain or belt speed so that the piler operates at full capacity with an even flow of potatoes, which reduces the effective drop height at transfer points. Keep the piler boom as close as possible to the potato pile. A common mistake is to move the boom away from the pile to allow time to accomplish other tasks. Inattention increases potato damage from longer drops; results in a greater tendency for portions of the pile to slide down; and makes it more difficult to keep the boom continuously close to the top of the pile. Progressive or stepwise piling reduces the amount and distance of rollback and keeps the top of the pile more uniform (Figure 6).

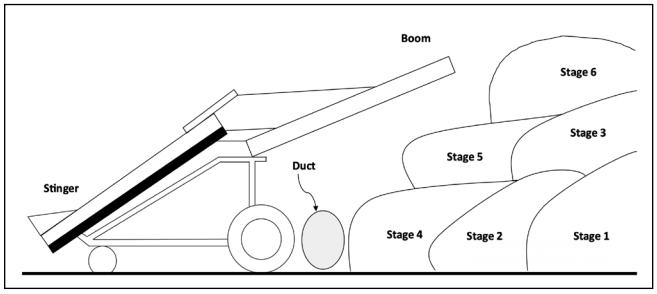

Figure 6. Piling potatoes in stages reduces bruising due to rollback on the face of the pile.

Reducing Effects of Bruise Damage During Storage

Shatter bruise increases the potential for tuber decay and weight loss because broken skin no longer provides a protective barrier against pathogens and water loss. Proper storage management is critical for rapid wound healing, which reduces the consequences from shatter bruise and skinning. Wound-healing conditions include 95% or more relative humidity and temperatures above 50°F. While wound healing is more rapid at higher temperatures, the rate and amount of decay also increase significantly. Free moisture on tuber surfaces restricts availability of oxygen and slows or halts the wound-healing process. Wound healing is complete in 1-2 weeks under proper conditions.

Research shows that bruise susceptibility and severity change slightly during storage. For example, blackspot bruises sustained at harvest may gradually increase in severity with time in storage. In contrast, the risk of shatter bruise occurring during unloading from storage decreases with time in storage.

Bruise Prevention in Packing Operations

Grading and packing operations can increase bruise in fresh-market potatoes. A high level of bruise may lead to rejection of shipments at their destinations and lost sales because of dissatisfied customers. Adjusting equipment and handling operations to minimize tuber injury during packing is the best way to reduce losses during shipment. Most modifications recommended for packing operations involve simple techniques already used to reduce bruising during harvest.

Run Equipment at Capacity

Bruise occurring during the packing operation is often associated with the underloading of conveyor belts, elevator chains, and sizing rollers. Fill conveyors to capacity by slowing belt speeds or by increasing volume and by matching the speeds and capacities of each conveyor to ensure a constant stream of potatoes throughout the packing line. Even-flow bins provide a good way of keeping the volume of potatoes flowing into the equipment at a constant level.

Reduce Drops

Considerable bruising occurs where drops are greater than 6 inches, especially when the drop area is located on belting supported underneath by a hard metal roller or plate. Moving the metal roller or support plate just a few inches (to allow potatoes to fall onto an unsupported portion of the belt) reduces bruising. An alternative is to install a padded ramp between conveyors, allowing the potatoes to slide down to the next conveyor rather than fall the entire distance. A hanging drape made of thin belting strips slows the speed of the potatoes as they slide down the ramp (Figure 7). Steeply inclined conveyors with flights generally cause damage because of the extra clearance required between flighted conveyors and

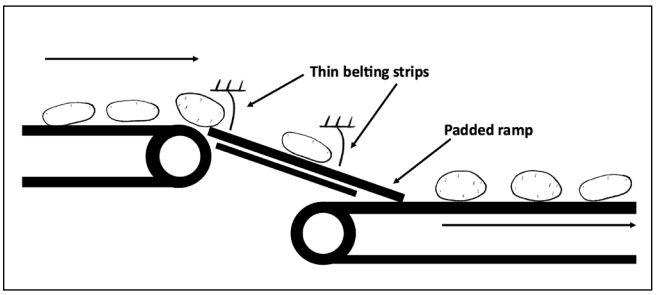

Figure 7. A cushioned ramp reduces the impact force experienced by potatoes as they move between conveyors.

the tendency of the flights to throw potatoes onto the next belt. Using shorter flights or hugger belts reduces this problem. Excessive drop heights are also often found where potatoes are loaded into even-flow bins. Reduce bruising in even-flow bins by always keeping them full and using an automatic height sensor on the loading conveyor.

Stacking Pallets

Bruising may also occur at the end of the packing line when workers stack bags or boxes onto pallets. Packaging material provides very little protection for tubers that are dropped more than several inches onto concrete surfaces. Lower the drop height when dropping the first layer of boxes onto concrete or a plastic slip or add some cushioning material to the hard surface (e.g., wooden pallet).

Use Cushioning

Cover all areas where potatoes strike a hard surface in the packing line with cushioning material fastened with round-headed, nonprotruding fasteners. The cushioning material should be thick enough to absorb the weight of the potato tuber and to prevent it from striking the hard surface underneath. Closed-cell foam materials are recommended because they readily absorb energy and resist moisture uptake. Use cushioning material with a durable surface. Frequently check for wear and replace the material as needed.

Warm Potatoes before Moving

Cold potatoes are more susceptible to bruise injury. Because tuber pulp temperatures typically warm only a few degrees during packing, warm potatoes coming out of cold storage to at least 45°F before handling them.

Bruise Detection

To identify harvesting or handling equipment that causes tuber injury or to isolate problem locations on individual pieces of equipment, measure and monitor tuber bruise damage. There are two different approaches to bruise detection: directly measuring bruise damage on tuber samples and evaluating equipment with an impact recording device. More details on each of these approaches is available in University of Idaho Extension Bulletin 966 (2020), Monitoring Tools for a Potato Bruise Prevention Program.

Educate

Preventing potato bruising is the responsibility of everyone in the potato industry. All people involved with growing, harvesting, packaging, or shipping potatoes should be educated about their role in minimizing bruising. Producers, packers, and shippers should train employees about what they can do to minimize potato bruise damage. This publication, along with other educational materials such as bulletins and videos available online, can be used to train employees about handling potatoes to minimize damage, particularly www.uidaho.edu/cals/potatoes/bruise-management.

Acknowledgment

The original version of this bulletin was published in 1991 and revised in 1998 as part of a bruise-reduction campaign by members of the **National Potato Anti-Bruise Committee of the Potato Association of America**. In this revision, the authors relied heavily on the original content developed by William Bohl, Roger Brook, Gary Franc, Leigh Morrow, Michael Thornton, Robert Thornton, and Glenn Vogt.

BUL 725 | Published August 1991 | Revised September 2024 | © 2024 by the University of Idaho